VILNIUS UNIVERSITY
BUSINESS SCHOOL

SUSTAINABLE CORPORATE FINANCE AND INVESTMENTS PROGRAMME

Ieva Vitaitytė

THE FINAL MASTER THESIS

VEIKSNIŲ, DARANČIŲ ĮTAKĄ INVESTICINIAM PAJAMINGUMUI, NUSTATYMAS BALTIJOS ŠALIŲ KOMERCINIO NEKILNOJAMOJO TURTO RINKOJE	***DETERMINATION OF INDICATORS INFLUENCING INVESTMENT YIELDS IN THE BALTIC COMMERCIAL REAL ESTATE MARKET***

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(Name, surname, academic title, scientific degree of the supervisor)

Vilnius, 2023

SUMMARY IN ENGLISH

VILNIUS UNIVERSITY BUSINESS SCHOOL

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DETERMINATION OF INDICATORS INFLUENCING INVESTMENT YIELDS IN THE BALTIC COMMERCIAL REAL ESTATE MARKET

Supervisor – Prof. Dr. Tadas Gudaitis.

Master thesis was prepared in Vilnius, 2023.

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This research aims to determine factors that influence commercial real estate (CRE) investment yields in the Baltic States, given infrequent comparable transactions. Traditional models use risk-free rates, risk premiums, and rent measures to predict yields. However, many other macroeconomic, market, and sustainability indicators are proven to be important and enhance forecasting power. Considering factors that have historically significantly affected CRE yields globally, the research aims to create models relevant to the Baltic market using the ordinary least squares time-series regression. The analysis uses monthly data over 2016-2023. GDP, Covid-presence, rents, and certified sustainable stock impact prime office yields. In retail, prime yield is determined by GDP, unemployment, Covid-presence, and investment volumes. The retail model has a positive constant term, signaling heightened investment risk, ceteris paribus. Following that, the research recommends separating traditional retail from multifunctional projects. Inflation, FDI, GDP, rents, investment volumes, and certified stock matter in the industrial yield analysis. Based on the short-term modeling and available forecasts, the Baltic office and industrial yields are expected to decrease, while the retail yields should see an upward trend. Investors should consider the lagged effect of some indicators when engaging in CRE transactions. The classical yield

formula is invalid in the Baltics, assuming a more comprehensive selection of explanatory variables. The tested novel sustainability feature adds sales premium in the office and industrial segments. Baltics should be considered a single CRE investment market to comprehend the region's competitiveness. The author's approval is required for publication of the research results.

SUMMARY IN LITHUANIAN

VILNIAUS UNIVERSITETO VERSLO MOKYKLA

TVARIŲ VERSLO FINANSŲ IR INVESTICIJŲ PROGRAMA

IEVA VITAITYTĖ

VEIKSNIŲ, DARANČIŲ ĮTAKĄ INVESTICINIAM PAJAMINGUMUI, NUSTATYMAS BALTIJOS ŠALIŲ KOMERCINIO NEKILNOJAMOJO TURTO RINKOJE

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Dėl retai vykstančių lyginamųjų sandorių regione šiuo moksliniu darbu siekiama nustatyti veiksnius, darančius įtaką investiciniam pajamingumui Baltijos šalių komercinio nekilnojamojo turto (NT) rinkose. Tradiciniai modeliai naudoja nerizikingą grąžos normą, rizikos premiją ir nuomos kainas prognozuojant tolesnį komercinio NT pajamingumo vystymąsi, tačiau naudojant platesnį spektrą makroekonominių, komercinio NT rinkos ir tvarumo veiksnių galima pasiekti tikslesnes investicinio pajamingumo prognozes. Išanalizavus veiksnius, kurie veikia komercinio NT pajamingumą kitose šalyse, šiuo moksliniu darbu siekiama sukurti modelį, kuris būtų aktualus Baltijos šalių rinkoms, naudojant mažiausių kvadratų metodo laiko eilučių regresiją. Tyrimui naudoti mėnesiniai 2016-2023 m. duomenys. BVP, pandeminiai suvaržymai, nuomos kainos ir sertifikuotų pastatų kiekis rinkoje daro įtaką aukščiausios kokybės biurų pajamingumui. Mažmeninės prekybos segmente, pajamingumas yra nustatomas BVP, nedarbingumo, pandeminių suvaržymų ir investicijų kiekio pagalba. Mažmeninės prekybos modelis turi pozityvią konstantą, kuri signalizuoja didėjantį rizikingumą segmente, nekintant kitiems veiksniams. Dėl šios priežasties, ateityje atliekamuose tyrimuose rekomenduojama atskirti tradicinius prekybos centrus nuo daugiafunkcinių projektų. Infliacija, tiesioginių užsienio investicijų srautai, BVP, nuomos

kainos, investicijų kiekis ir sertifikuotų pastatų dalis rinkoje yra aktualūs analizuojant pramonės segmentą. Modeliuojant trumpalaikes pajamingumo vystymosi prognozes, Baltijos šalių biurų ir pramonės pajamingumas turėtų sumažėti, o mažmeninės prekybos segmento – augti. Investuotojai turėtų atkreipti dėmesį, kad kai kurių veiksnių poveikis gali būti pavėluotas. Klasikinė pajamingumo formulė yra neaktuali Baltijos šalyse, kuomet analizuojamas platesnis spektras kintamųjų. Naujai įtrauktas tvarumo kintamasis prideda pardavimo kainos premiją biurų ir pramonės segmentuose. Baltijos šalys turėtų būti svarstomos kaip vientisa komercinio NT investicijų rinka, siekiant suprasti regiono konkurencingumą. Darbo rezultatų publikavimas yra galimas tik gavus autorės sutikimą.

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ABBREVIATIONS LIST

BLN – Billion

BPS – Basis Points

CEE – Central Eastern Europe

CPI – Consumer Price Index

CRE – Commercial Real Estate

ESG – Environmental Social Governance

EU – European Union

EUR – Euros

FDI – Foreign Direct Investment

GDP – Gross Domestic Product

GFC – Global Financial Crisis

HICP – Harmonized Index of Consumer Prices

KPI – Key Performance Indicators

LTV – Loan-to-Value

MAST – Marketable, Ascertainable, Stable, Transferable

MLN – Million

NOI – Net Operating Income

OLS – Ordinary Least Squares

PP – Percentage Point (1 pp = 100 bps)

RE – Real Estate

REIT – Real Estate Investment Trust

SLB – Sale-Leaseback

SQM – Square Meters

UK – United Kingdom

USA – United States of America

USD – United States Dollars

WAULT – Weighted Average Unexpired Lease Term

INTRODUCTION

Relevance. After many years of sustained economic growth, the timing of this publication coincides with the recently passed global pandemic and ongoing geopolitical tensions in Eastern Europe. Due to recent turbulences, markets faced not only record-high inflation and interest rate hikes but also a repricing in commercial real estate (CRE) properties, changing yields, and dropping investment volumes. However, as opposed to the global financial crisis (GFC), featured by non-performing debt obligations and a liquidity crisis (Sornette & Woodard, 2010), different market forces currently weigh on CRE pricing movements. Therefore, it is important to examine which factors bear the highest explanatory power for CRE attractiveness changes, measured via CRE investment yields, and to what extent. It remains a highly under-researched question (mainly due to data limitations). Especially in the absence of liquidity and evidence-based transactions in the Baltic states, CRE experts tend to judge the yield forecasts based on intangible market sentiment and educated guesses. Hence, this publication provides CRE professionals with a quantitative method for yield determination and forecasting relevant to current real-world events. This paper helps to understand CRE yield drivers to enable investors to make informed decisions and asset allocations. Due to significant information asymmetry in CRE, wrongly perceived sentiment can lead to deflation in property values and changes in risk appetite (Cheung & Lee, 2021). Thus, studies suggest that capturing yields may improve the explanatory power of the market sentiment (Heinig & Nanda, 2018).

Novelty. The novel feature of this study is the data on the CRE sector. Most researchers focus on the residential market, while much fewer studies take the CRE market into the spotlight (Heinig & Nanda, 2018) since such data is not accessible via public statistical databases. Moreover, this study spotlights the Baltic States, seeking to evaluate what CRE investors and funds should consider when entering this region and pursuing the transaction. To the best knowledge, no similar analyses have been performed in the Baltic States. The paper also examines whether sustainability is among the primary driving forces for future investments in the context of the enrollment of European Union (EU) non-financial reporting regulations and taxonomy framework (Fidler et al., 2023; Mangialardo et al., 2018).

Subject matter. CRE investment markets are highly illiquid, and transactions are lengthy. Thus, CRE pricing determination may be lagged. Although classical models usually consider risk-

free rates, risk premiums, and rent measures to determine the fluctuations in market-level yields, in recent years, many additional characteristics have been spotlighted, which are said to improve the explanatory power of the models. Increasing attention is now paid to sustainability dimensions.

Problem statement. Which factors, considering macroeconomic, CRE market-specific, and sustainability variables, are the most important in determining the CRE investment yields in the Baltics? Based on the derived formula, the analysis aims to determine what metrics should be considered in forecasting CRE yields in the region.

Objective. To discover factors that historically have significantly affected CRE yields in the Baltic States and, in line with the examined theoretical and methodological scholars' literature, perform the short-term yield modeling based on the future forecasts of the market.

Tasks. This paper intends to (1) analyze existing academic literature on CRE market fundamentals and identify relevant factors affecting CRE investment transactional yields across global markets, (2) review research models employed in similar academic studies, and select an appropriate research method for investigating factors that have a significant impact on CRE yields in the Baltic States, (3) develop a robust econometric research model, which identifies statistically significant variables that impact office, retail, and industrial yield movements in the Baltic market, and perform the yield modeling, (4) perform a discussion why particular factors influenced the development of yield figures in the Baltic States, and (5) propose recommendations what should be considered when engaging in the CRE investment activity in the Baltics.

Research methods. The study uses macroeconomic data from public databases and CRE investment market data from CBRE Baltics, an affiliate of the largest globally (based on 2022 revenue) CRE advisory and investment firm – CBRE. The company collects regular information on the Baltic CRE yields based on transactional evidence, ongoing deal negotiations, observed investors' sentiment in the market, or directional evidence from the counterpart economies (i.e., Poland and the Nordics). The ordinary least squares (OLS) time-series regression analysis is used as the primary tool to determine whether and how office, retail, and industrial yields could be explained considering macroeconomic, CRE market, and sustainability variables picked throughout a systematic analysis of scientific literature. Statistical analyses and regressions are done in Gretl software, while short-term forecasted yield interpolation is conducted in Excel.

Practical value. The derived mathematical equations for office, retail, and industrial yields could be used to conceptualize the risk appetite in the Baltic CRE market. Yields allow investors to compare returns across different property types in various geographies, and the formula for the Baltic region enables investors, developers, and funds to make informed decisions when expanding their Baltic CRE portfolios. The findings are also relevant to the RE advisory and valuation agencies that report the market-level yields based on directional evidence from the counterpart economies or educated guesses upon the lack of comparable transactions. The analyzed sample covers monthly data from January 2016 until September 2023, which is almost twice as large as the rule-of-thumb time-series sample of 50 observations, ensuring the reliability of the findings. The obtained R-square metrics within OLS time-series models are also deemed reliable for the study with the real-life dataset, ranging between 0.3 and 0.5. Several limitations could be traced down to the information flow imperfections and data frequencies.

Structure of the paper. Section one reviews the previous research, examining the CRE sector, its pricing, and determinants for yield value, establishing the precedent for picking the relevant variables for the research model in this study. Section two describes the research methodology applicable to this paper, presents dependent and independent variables, and traces the reliability and limitations relevant to this analysis. Section three establishes the empirical models, analyzes which factors help explain CRE yields in the Baltic markets, discusses the findings, and performs the short-term future yield modelling.

1. THEORETICAL PART OF COMMERCIAL REAL ESTATE YIELDS AND RELATED INDICATORS

The first part of the study takes a closer look at the existing academic literature and extensively considers various factors that influence CRE yield development across global markets. This part summarizes the main CRE terms and definitions, presents existing CRE classification patterns and valuation concepts, overviews the key CRE yields' determinants, and establishes solid grounds to consider a range of macroeconomic, CRE market, sustainability, and transaction-related indicators for further CRE yield analysis.

1.1. Commercial Real Estate Concept, Key Terms, Market Players

CRE refers to an asset class concerning cash-flow-generating properties. The CRE investment market is highly illiquid, as transactions do not happen regularly and take time to be settled. As noted by Ghent et al. (2019), deals are concluded infrequently and irregularly, making the pricing dynamics more intricate to evaluate. CRE properties are mostly transacted in private deals, most frequently concerning a single buyer and seller, which contributes further to the argumentation that it is tricky to retrieve the data on pricing and trading on CRE (Ghent et al., 2019), and it takes a relatively longer time to sell such assets (Van Dijk & Francke, 2021). However, despite illiquidity, CRE assets are an effective hedging tool against inflation, well-balancing risk-return tradeoffs (Kołodziejczyk et al., 2019). Another popular way to look at CRE is to define it as a market for space, which is a production component necessary to produce other goods and services (Morri & Benedetto, 2019; Van Dijk & Francke, 2021).

Although the actual holding period of the CRE investment largely depends on various factors, such as investors' horizon, "market conditions, regulation, transaction costs and tax, types of property, lease length, and investment style" (Amédée-Manesme et al., 2016, p. 2), by a rule of thumb, CRE is a long-term commitment, especially if the asset in question is a customized property or involves significant transaction costs (Kołodziejczyk et al., 2019). To put it in years, a long investment horizon in literature is usually defined as a 5-10-year period (in some papers, even up to 20 years), which is considered optimum to earn returns on cash proceeds. Besides generating cash flows from rent, properties bear a terminal value which provides investors capital return upon the sale, given the market circumstances at the point of exit (Kołodziejczyk et al., 2019).

Although CRE assets are deemed to be illiquid, the 1986 Tax Reform Act resulted in an expanding share of CRE being held via real estate investment trusts (REIT) in the United States of America (USA) (Ghent et al., 2019). This financial instrument empowers market players to own a fraction of CRE assets without purchasing, managing, and financing the properties. REIT is a publicly traded investment vehicle that has become increasingly popular among individual and corporate investors, who purchase shares of the REIT and receive a portion of the rental income generated by the underlying properties. Rather than owning the assets, REITs are liquid market instruments traded publicly. Researchers consider REITs a long-term investment strategy tool (Feng et al., 2022), providing efficient portfolio diversification opportunities suitable for risk-averse individuals (Famara Badji et al., 2021). However, due to the nature of the research question, this study focuses hereinafter on professionally managed and owned CRE market.

In literature, two clashing opinions could be found when evaluating CRE as an investment vehicle: while some perceive it negatively (Chambers et al., 2019; Tuzel, 2010; Yousef, 2019), others argue that it improves the investment portfolio (Christensen, 2017; Eichholtz, 1996; O'Mara, 1999). The summarized list of advantages and disadvantages is in Table 1.

Table 1

Disadvantages and advantages of CRE as a portfolio diversification instrument

Disadvantages	Advantages
1. Low depreciation of assets (Tuzel, 2010)	1. Reputational advantages (O'Mara, 1999)
2. In the long-term, returns are not attractive (Chambers et al., 2019)	2. Clear KPIs (Christensen, 2017)
3. Mandatory local market knowledge (Kołodziejczyk et al., 2019)	3. Diversification across sectors and geographies (Kołodziejczyk et al., 2019; Morri & Benedetto, 2019)
4. Regulatory restrictions (Yousef, 2019)	4. Lower correlation with other financial instruments (Eichholtz, 1996)
5. Illiquid and vulnerable to cyclicality (Ghent et al., 2019; Yousef, 2019)	5. Stable cash flows (Ghent et al., 2019)
6. Complex management (Morri & Benedetto, 2019)	

Source: compiled by the author based on research

Tuzel (2010) discusses that the depreciation of assets is low, leading to the fact that high real estate (RE) holdings expose investors to vulnerability and "bad productivity shocks" (p. 2). Hence, CRE could be perceived as a riskier investment opportunity than other forms of capital,

with existing empirical evidence of investors requiring a premium of around 3-6% annually (Tuzel, 2010). In addition, according to Chambers et al. (2019), the rental income growth for significant properties is limited. The study suggests that operating costs shrink the CRE net yields by 20-30% and lead to the income being more volatile, providing limited potential for long-term capital gains (Chambers et al., 2019). Yousef (2019) also stated that in the United Kingdom (UK), RE funds have regulatory restrictions on the diversification of assets, which increases the likelihood of financial distress. Besides that, RE assets are illiquid and "vulnerable to cyclicality", which may provide higher exposure to market risk (Yousef, 2019, p. 111). Morri & Benedetto (2019) also outline that CRE portfolios require active management, which may cause difficulties for many distinct types of properties in different geographies. Especially as outlined by Eichholtz (1996), many local factors in play influence CRE investment decisions.

On the other hand, the literature states that a trade-off exists between drawbacks and benefits (Morri & Benedetto, 2019). CRE plays not only an essential financial role in the portfolio but could be a strategic business element. CRE is a long-term, evident commitment that may improve investors' reputations (O'Mara, 1999). Christensen (2017) argues that risk management and competitive advantage are set as the key performance indicators (KPIs) influencing institutional investors' decision-making in the post-GFC environment. To optimize the operational burden and achieve better portfolio results, CRE assets may serve well since, by nature, they have somewhat straightforward KPIs (Christensen, 2017). To maximize the return, diversification across sectors and geographies, especially for large portfolios, is necessary, with existing empirical evidence that nearly 30% of CRE portfolio risk could be eliminated with a five properties portfolio (Kołodziejczyk et al., 2019). Moreover, CRE produces stable cash flows (Ghent et al., 2019) and has a relatively lower correlation with other financial instruments than common stocks or bonds, which serves as a desirable risk diversification instrument (Eichholtz, 1996).

The market professionals engaged in CRE transactions can be classified into three categories based on their investment preferences: long-term capital investors that are looking for stable cash-flow generating properties, developers that stipulate value from the existing market conditions, and small individual buyers that seek either cash-flow or capital value growth (Kołodziejczyk et al., 2019). Large institutional investors usually look for prime properties (e.g., high-quality business centers, industrial or logistics properties, shopping centers) with stable cash

inflows and established tenancies. Development companies seek to acquire greenfield or brownfield investments that may require significant redevelopment to extract their total value. Meanwhile, small individual investors typically search for small properties that can generate income or be treated as speculative investments. Other factors that determine the types of investors could be the investment size and preferred RE sector.

Although it is possible to meet private individuals that own and operate CRE properties, institutional investors are most frequently involved in the transactions of such assets. Overall, the decision to secure CRE investment largely depends on the investors' utility function and its maximization, featured by the free cash flows generated by CRE asset and the terminal value of the portfolio (Amédée-Manesme et al., 2016). Utility function was initially established by Bernoulli (1738), where the expected utility from the investment was covered under the term of *moral expectation* (as cited in Schmidt, 2004). These days, the theoretical *moral expectations* are translated into the corporate risk management policies that define risk appetite. Professional investors can better manage cash-flow generating properties and have resources to regularly report on fair value of the properties (Kołodziejczyk et al., 2019), which could be costly to private individuals, considering that only licensed market professionals are qualified to determine CRE value. Institutional investors' involvement in the CRE market is driven by their ability to deploy significant capital, seek diversification benefits, align with long-term investment objectives, and leverage professional expertise. These factors align with the utility maximization approach, enabling institutional investors to optimize risk and return trade-offs and achieve their investment objectives in the CRE market.

Sector-wise, financial corporations are the most frequent holders of such assets, as CRE properties help diversify portfolios and guarantee stable cashflows. CRE assets mostly come across in the "portfolios of pension funds, life insurance companies, sovereign wealth funds, and other institutional investors" (Ghent et al., 2019, p. 1) but are rarely operated by the owner. Since local market knowledge is a must and an investment is perceived as an aggregate of "technical, social, economic, political, and behavioural factors" (Kołodziejczyk et al., 2019, p. 303), it is expected to involve consultancy agencies in market research, valuation or management advisory that help execute deals in line with the market. Especially since the potential for generating cash is the core

determinant for CRE investors, a thorough due diligence assessment is commonly required during the decision-making process (Kołodziejczyk et al., 2019).

CRE funds operate to raise money through cross-collateralized investments from cash-flow-generating properties (Levy, 2023). There are a few types of funds: closed and open end. A closed-end fund has a particular known date of operation, i.e., the set exit date when the vehicle expires, at which it has to ensure enough money to return to investors (Levy, 2023). In the meantime, open-end funds are the ones that do not have an end date, and properties pursue reevaluations periodically. Such open-end funds are a perpetual vehicle where the capital is raised constantly to support the deal-making. However, after the so-called locked period, investors could redeem their investments. Even though investors have an opportunity to exit, this is a non-tradeable investment vehicle. Eventually, the fund structure largely depends on the underlying investment strategy and preferred asset classes.

To sum up, CRE refers to a somewhat illiquid financial instrument requiring long-term commitment. Such properties are usually transacted via private deals, which makes access to pricing and trading data somewhat scarce. However, evidence suggests that such means of investment allow for exploiting stable cash flow, maintaining diversification benefits, and serving as an effective hedging tool. Parties that engage in CRE transactions most commonly concern long-term capital investors, developers, and small individual buyers.

1.2. Classification by Development, Transaction Type, and Asset Class

Development-wise, CRE projects are segregated to build-to-suit, build-to-lease, and speculative projects. Build-to-suit is a type of development where a property is designed according to the customized requirements of a single tenant (Ghent et al., 2019). Such developments most commonly feature a long-term lease agreement, as the property adheres to meet the unique needs of a tenant. Pirogova & Zasenko (2021) highlight that build-to-suit are mostly warehousing properties, combating the problem of increasing industrial vacancy rates in some markets. Another common type – build-to-lease projects – are designed to accommodate the needs of different occupiers and, thus, contain flexible floor plans, shared amenities, and common areas. Build-to-lease projects tend to have lower rental rates compared to build-to-suit schemes since they are not constructed to adhere to the specific needs of a single tenant. The third type of development – speculative projects – is a set of commercial properties designed without a specific tenant in mind.

Such a development method bears a higher risk but helps to achieve higher rental rates. Especially lately, the rental gap has encouraged a higher orientation toward speculative developments (Gillespie, 2020).

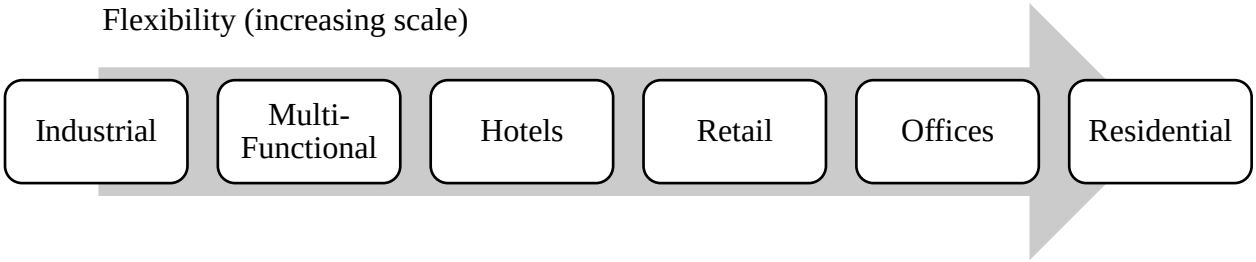
Another transaction type is the sale and leaseback (SLB) method. Large corporates usually prefer building customized premises from scratch (Ghent et al., 2019) instead of renting the existing stock. However, keeping such assets on the balance sheet may not be preferred by many businesses (leases longer than 1-year are recognized as finance leases, "with rent obligations shown on the balance sheet"), and companies may prefer to free that capital for operational or expansion purposes (Sanderson et al., 2019, p. 7). Thus, the way around is a SLB transaction, which involves finding a buyer for the building and, at the time of sale, signing a lease agreement with the future owner for an extended period (e.g., up to 30 years) (Wilson, 1953, as cited in Sanderson et al., 2019). As a rule of thumb, the SLB transactions are concluded with financially strong occupiers, where the long-term rental price corresponds to the above-market average. The buyer uses the rent proceedings to cover the debt obligations. CRE funds or large institutional investors are the typical buyers in such transactions, allowing them to have a stable income for a considerable period and avoid building and engaging in tenant searches. SLB transactions tend to bear lower risk, a cheaper debt cost, and a better leverage ratio (Sanderson et al., 2019). Due to the low-risk nature of this transaction, researchers state that SLB properties are expected to have a higher sale price with a lower yield as opposed to non-SLB transactions. To put it in numbers, Sanderson et al. (2019) found SLB deals to be traded at around 20% premium.

Traditional CRE classification is based on the functional categories. Office, retail, and industrial segments are considered the key ones (Ghent et al., 2019; Lamas & Romaniega, 2022; Sanderson et al., 2019), while the rest fall under the other non-core segments (e.g., rental residential, hotels, senior housing, privately built student accommodation). According to Kaklauskas et al. (2021), CRE investment characteristics by asset classes have historically evolved to enable investors, lenders, brokers, or other market players to assess the property in a timely manner. Classification by the asset classes is crucial because it helps to collect data, measure performance, and analyze portfolios (Wojewnik-Filipkowska et al., 2015). Nevertheless, as Morri & Benedetto (2019) argue, the current use of property may not necessarily match the possible best use of the property under existing regulations, given that redevelopment opportunities matter to an

investor. Figure 1 overviews redevelopment flexibility related to risk differential. This study will further rely on CRE classification by asset class and describes in more detail the definitions of each market sector in section 2.2 of the paper.

Figure 1

Increasing risk differential and CRE sectors' redevelopment flexibility



Source: compiled by the author based on Morri & Benedetto (2019)

However, alternative classifications also exist, including structure-related (i.e., buildings, infrastructure, land) or ownership-based (i.e., municipal, private) (Wojewnik-Filipkowska et al., 2015). In addition, Jackson & White (2005) proposed that classification by location and economic activity may matter to some investment strategies. Graham and Bible (1992) documented several primary factors that could determine the CRE grouping, including rental and occupancy rates, age, condition, quality, and location (as cited in Kołodziejczyk et al., 2019). Sehgal et al. (2015) suggested classification based on developers, location, and quality. In addition, Morri & Benedetto (2019) provide the understanding that CRE investments can follow the risk/return profile classification, distinguishing core investments (income-producing properties), value-added investments (existing properties subject to a potential value increase due to refurbishment), and opportunistic investments. The authors also outline that the classification used by the land registries is standard, where categorization follows the use of urban property units (Morri & Benedetto, 2019). The primary reason for grouping assets "is to maximize heterogeneity between the groups and homogeneity within the groups" (Jackson & White, 2005, p. 308).

According to Kaklauskas et al. (2021), different classification approaches do not infer that "classification lacks consistency" (p. 4) but rather imply that classification should support the analysis in question. Therefore, hereinafter, this paper will focus on the grouping of CRE properties by asset classes and geographical location due to the nature of the yields analysis, as

well as considering that these methods are the most prevailing in the literature (Jackson & White, 2005; Graham and Bible, 1992 as cited in Kołodziejczyk et al., 2019; Sehgal et al., 2015; Wojewnik-Filipkowska et al., 2015).

All in all, the most common CRE classification is based on asset classes and considers retail, office, and industrial segments as the primary segments. However, alternative classifications also exist, including development-based, structure-related, or ownership-based. Grouping assets enables effective data collection, measuring performance, and analysis of portfolios.

1.3. Key Valuation & Financing Terms

Valuers are qualified CRE market experts who assess the worth of the properties independently at a given point in time. For the price determination, many varying factors are taken into consideration, "including the location, asset quality, configuration and features, relative obsolescence, the tenant(s) covenant, lease, and so forth" (Carson, 2023, p. 4). Now, sustainability is emerging as another cornerstone in determining an asset's value. Carson (2023) argues that environmental, social, and governance (ESG) risks are commonly assessed implicitly through the analysis of comparable properties since sustainability is a long-term commitment that may not be fully reflected at a point in time. The author claims, however, that sustainability performance metrics (e.g., energy efficiency) or existing green certifications (which tend to drive higher rents and liquidity) can help monetarize sustainability.

Furthermore, the EU's Sustainable Finance Disclosure Regulations may affect funds' disclosure. Hence, increasing ESG consideration results in higher capital expenditure value, which could again help in pricing CRE properties fairly (Carson, 2023). Valuation usually arises from regulatory compliance or clients' individual concerns for the property value (Morri & Benedetto, 2019). The most common purposes include property transferring (i.e., mergers and acquisitions, initial public offerings), strategic transactions (i.e., financing, valuation), and economic feasibility (i.e., investment decisions) (Morri & Benedetto, 2019).

The notions of *price* and *value* tend to be used interchangeably. However, Clayton et al. (2021) discuss three different approaches to determining the worth of an asset: valuation, price, and investor appraisal. Valuation is based on an analysis of past transactions and provides a qualified market expert's opinion on the likely sales price. Conversely, price is the actual amount

received from selling the property in the market. At theoretical equilibrium, the property price should represent the present net operating income (NOI) value, which is then discounted at the property-specific risk-adjusted rate (Clayton et al., 2009). Finally, an investor's appraisal of worth describes forward income projections and capital appreciation over the holding period. Morri & Benedetto (2019) also provide the synthesis of various research papers on the general understanding of the term *market value*, which is said to require a competent expert's judgment at the valuation date where there are two interested independent parties (seller and buyer) and where a transaction is pursued following adequate marketing, having access to the complete information. Further in this paper, the term *price*, determined by transactional evidence, will be the core one considered in the investment yield analysis.

As CRE prices are substantial, loan exposure is supported by collateral. A helpful tool used to conceptualize the collateral's desirability is called the MAST framework. MAST stands for Marketable, Ascertainable, Stable, and Transferable. In the CRE context, the assets tend to be somewhat less marketable (as they appeal only to specific investors' needs), ascertainable (the qualified appraiser determines the accurate worth of the asset), relatively stable (no significant price fluctuations on the day-to-day basis), and somewhat easily transferable (no shipping costs to handover the assets, only discharge and re-registration). Thus, CRE represents a typically desirable collateral. Collateral assets that score high scores against these MAST criteria tend to command more flexible loan terms (e.g., more extended amortization periods, lower interest rates, and higher loan-to-value (LTV) coefficient). Even though CRE could be deemed to be a creditworthy industry, it is worth noting that LTV ratios depend on the creditworthiness of the borrower (Merton, 1974). The literature states that non-residential RE loans (i.e., office, retail, industrial) tend to be deemed as riskier and more uncertain (Mokas & Nijskens, 2019).

Even though Modigliani & Miller (1958) stated that the company value "is independent of its capital structure" (under the perfect market conditions) (p. 268), the matter is relevant in the CRE investment set-up. CRE investments are highly leverage-driven. The most obvious reason is that CRE represents excellent collateral that supports a higher leverage ratio (Morri & Benedetto, 2019; Yousef, 2019). Gan (2007) also confirms that collateral drives investment, with the estimated evidence that a 10% decrease in the value of the collateral leads to a 0.8% drop in the investment rate because collaterals help tackle informational asymmetries with external financing

parties. The author proves that if, throughout the market downturns, the value of RE assets fluctuates significantly, it leads to a smaller future credit availability. The effects could be cumulative (lower investments, lower future revenues, and eventually the lower value of further leverage inquiries) (Kashyap et al., 1993, as cited in Gan, 2007). When it comes to CRE being a highly leveraged industry, another possible explanation may relate to the pecking order theory (Myers & Majluf, 1984). The theory considers that companies have a pecking order of financing sources. First, they prefer to finance new projects with retained earnings, then with debt, and use equity as a last resort. When bringing this theory to the RE set-up, Yousef (2019) emphasizes that gains from CRE holding tend to be distributed to the owners. This is why in the CRE pecking order, debt is usually featured as a primary source, especially since RE companies tend to face lower costs of debt (Yousef, 2019).

The type of debt also matters. Ghent & Valkanov (2016) stated that loans for either development or redevelopment projects are not likely to be financed with securitized loans due to the substantial monitoring required. However, for sizeable projects, securitization may lead to lower idiosyncratic risk, risk-sharing benefits (Ghent & Valkanov, 2016), and a higher LTV ratio (Black et al., 2017). Ghent et al. (2019) further elaborates that certain CRE investors choose debt instruments from securitized lenders (i.e., financial institutions who create securities backed by cash flow from CRE) rather than balance sheet lenders (financial institutions that hold loans on their balance sheets and interact directly with the borrower) due to higher borrowing limits, not holding the borrower personally responsible for the loan, and fixed interest rates. However, such financing is not prevalent and can be relatively inflexible, with strict prepayment penalties and limited ability to change tenants without prior approval from the trustee (Ghent et al., 2019).

To reiterate, the worth of an asset is usually determined via one of the three approaches: valuation, price, and investor appraisal. The terms price and value are different notions, where the former is judged from the happened deal, while the latter is derived by a professional market expert based on the cash proceeds, location, and other operational property factors. Proven by the MAST framework, the acquisition of CRE properties is commonly supported by debt, as CRE assets serve as desirable collateral for financing institutions. Types of debt and loan terms depend on the type and size of the development, borrowing party, as well as prevailing market conditions.

1.4. Concept of Commercial Real Estate Yield and its Determinants

CRE returns tend to be decomposed into rental income yields (either nominal or real) and capital gains (property price changes) (Chambers et al., 2019). In relation to the financial characteristics of RE investments, Chambers et al. (2019) claim that investment capital gains tend to be misinterpreted. Therefore, as a rule of thumb, rental yields have become a standard determinant to define investment attractiveness and compare returns across different investment types. Gross rental yield metric is used to indicate the property's potential income return without considering expenses or costs associated with the ownership, while net yields take such expenses into account.

Existing literature defines *yields* as a ratio between NOI and the property's value (Kim et al., 2019) or as the annual rental income divided by the asset's current market value, showing how investors anticipate future return growth (McGrath, 2013). Based on the formula composition, the NOI from rent and the property's intrinsic value are critical in CRE investment decisions (Kim et al., 2019). In the absence of credit frictions, the expected annual NOI is computed as the present value of the projected NOIs, discounted at the asset-specific risk-adjusted rate (Duca & Ling, 2020). The primary benefit of using yields is that they allow comparing the returns across different property types in various geographies, as investors substitute across various investments to reach the desired rate of return (McGrath, 2013).

In essence, higher yields indicate that an investment property bears higher risk and may require a higher rate of return (Kim et al., 2019). Higher risks could arise from a less desirable geographic location, higher financing costs, or related issues that reduce properties' long-term value. Moreover, Kim et al. (2019) argue that higher CRE yields may be demanded in specific markets due to the market's relatively lower maturity. On the other hand, lower yields indicate that a market offers a more stable investment over the long haul. Ultimately, the decision to invest with higher or lower CRE yields depends on an investor's risk tolerance and investment strategy.

Rental yields are often used as a proxy for investors' sentiment. Thus, yields set expectations for investors on how the market value of a property may alter over time (McGrath, 2013). Rising yields indicate that the rate of return on a CRE investment has increased relative to its purchase price. When yields increase, the price of the property tends to decrease. It suggests that a weak market sentiment raises yields due to the higher perceived risk level and lower cash

flow growth (Sivitanides et al., 2001). And vice versa, when yields are on a downward slope, CRE prices are likely to increase, as investors are willing to accept a lower constant cash flow due to the lower risk. Yet, it is crucial to note that yield changes might be lagged due to market inefficiencies, including transaction costs, decision-making lengthiness, and due diligence investigations (Clayton et al., 2009).

However, the measurement of yields tends to incur certain limitations. Many existing empirical studies exclude the analysis of rental yields when evaluating investment performance or CRE transaction returns (Chambers et al., 2019). It relates to the matter that data on cashflows from such investments is usually confidential and proprietary, as yields are not "systematically or centrally recorded" (Chambers et al., 2019, p. 9). Researchers claim that another issue with measuring RE yields relates to the tendency of capturing contractual rental income instead of the realized one, which considers temporary voids, eventually resulting in exaggerated rental yields. Another drawback outlined in the literature is that the sample of income data usually considers different properties than the sample of transaction prices. Hence, when deriving the yield value, it is crucial to consider that income and price data may not necessarily rely on the same sources to compute yields and total returns (Chambers et al., 2019). As a result, measurement errors may occur, especially since underlying properties have distinct quality characteristics (Eichholtz et al., 2019). Besides, actual asset-level costs are not always accounted for by the investor, and it may significantly alter the net income from RE investment (Chambers et al., 2019).

In academic literature, there is a division between two types of sentiment measures on how the yields are captured. The first type is indirect measures that rely on economic metrics, liquidity indicators, trading volumes, interest rates, and alike (Heinig & Nanda, 2018). The second type is direct measures that involve primary research based on the market participants' judgment (Heinig & Nanda, 2018). This study uses the first method to establish the market prime yield computational formula. However, researchers studying the Czech Republic, Kenya, the USA, South Africa, the UK, and various Asian economies have employed different variables when estimating CRE yields in comparable research questions (summarized in Table A1).

As Akinsomi et al. (2018) point out, CRE does not exist in a vacuum and is interdependent on macroeconomic and capital markets performance. The literature argues that CRE yields tend to be non-linear and affected by behavioral and market-wide events (Akinsomi et al., 2018). When

determining the level of yields, traditional models consider the risk-free rate, expected rental income, and a risk premium (Heinig & Nanda, 2018; Heinig et al., 2020; Kim et al., 2019) (as per Equation 1):

$$Y_{r,t} = \beta_0 + \beta_1 Risk\ Free\ Rate_{c,t} + \beta_2 Risk\ Premium_{c,t} + \beta_3 Rent_{r,t} + \varepsilon_t, \quad (1)$$

where Y – yield, r –specific market (i.e., city or region), t – respective period, c – country, and ε_t – error term, incorporating non-considered time series or cross-sectional effects. However, there are contradictory views about which factors beyond that have historically succeeded in tackling the impact of CRE value changes (Mach, 2019). Macroeconomics, capital markets liquidity, CRE market fundamentals, and asset type seem to matter for CRE pricing (Cheung & Lee, 2021). It suggests a co-integrated relationship between yields and independent variables influencing CRE investment decisions. A detailed overview of assessed variables and academic conclusions on their expected effect on yields is discussed in the sub-sections 1.4.1-1.4.4 and summarized in Table A2.

In summary, traditionally, risk-free, risk premium, and rental rates have been taken into account when computing CRE yields. Yet, to improve the explanation of CRE pricing sentiment, a more comprehensive range of macroeconomic, market, and sustainability dimensions should be included in the computational formula for the CRE market yields.

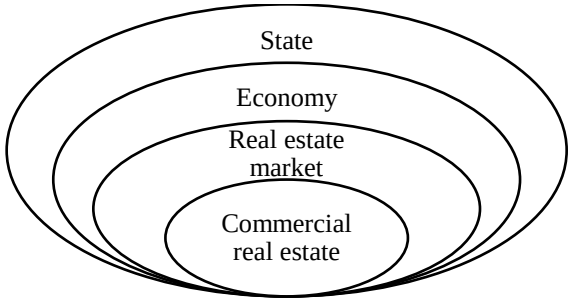
1.4.1. Macroeconomic Indicators

According to Kvedaraviciene (2010), the CRE market is a sub-system of a broader economy. Hence, national or regional economic, political, and demographic changes matter (Figure 2). Interest rates are deemed to be one of the most explanatory variables for CRE yields. It is estimated that a 1% change in the long-term interest rates may lead to a 25-80 basis points (bps) shift in yields (Sivitanides et al., 2001; Tsolacos et al., 2009). When interest rates rise by 100 bps, it implies a ca. 25 bps rise in the RE capitalization rate. Another variable, almost unanimously confirmed by the examined literature, is a 10-year governmental bond yield that is usually used as a proxy for the risk-free rate, shifting yields upwards (Chervachidze & Wheaton, 2013; Duca & Ling, 2020; Heinig & Nanda, 2018; Kim et al., 2019; McGrath, 2013). As CRE investment is relatively riskier, it is reasonable for RE investors to aim for a higher return when the risk-free rate rises (Clayton et al., 2009; Kim et al., 2019). In fact, Kim et al. (2019) claim that a standard yield

model considers risk-free rate, rental growth, and the risk premium as the classical independent variables for yield estimations, while Tsolacos et al. (2009) claim that the real rental change together with interest rates can explain even 78% of variations in yields. While there seems to be unanimous agreement that interest rates and risk-free rates are vital, other scholars consider that there is a broader panel of economic variables that can help explain CRE pricing sentiment.

Figure 2

Vizualization of interrelation between CRE market and macroeconomy



Source: compiled by the author based on Kvedaraviciene, 2010

According to Akinsomi et al. (2018), gross domestic product (GDP), unemployment, and interest rates (called in the paper a "proxy for economic growth" (p. 18)) are worth accounting for when looking at CRE yields in developing markets. When forming the sentiment, Heinig & Nanda (2018) also consider the general economic factors, including GDP, interest rates, logged consumer price index (CPI), logged consumer spending, unemployment rate, and industrial production. Others also agree that consumption, interest rates (including their term structure), and inflation systematically affect the returns (Morri & Benedetto, 2019). Considerable research in the field of CRE investment characteristics was done by Morri & Benedetto (2019), who stated that overall macroeconomic trends matter to offices, spending capacity of the population to retail, while demographic dynamics – to residential sectors.

Among other things, Chervachidze & Wheaton (2013) say that the amount of debt relative to GDP matters since CRE price changes "are driving the entire debt structure of the economy" (p. 12). Furthermore, some say that the RE market activity could result from the country's foreign direct investment (FDI) activity. Evidence from Dubai says that successful FDI attraction could translate to RE investors' decision-making (Joghee et al., 2020). In addition, the market risk premium is important. Researchers agree that risk premium affects yield values positively,

suggesting that RE yields are a valid cross-country comparison indicator (Chervachidze & Wheaton, 2013; Clayton et al., 2009; Duca & Ling, 2020; Heinig et al., 2020).

The effect of the harmonized index of consumer prices (HICP) on property returns tends to be ambiguous and transmitted through the lease agreement negotiations (Taderera & Akinsomi, 2020). It is expected to come across in the market both fixed annual inflation adjustments, as well as variable escalations, usually based on the local or regional CPI index. The goal of the rent adjustment is to hand over rising operating expenses to occupiers (Taderera & Akinsomi, 2020). Nevertheless, it is vital to distinguish expected and unexpected inflation and its' impact on CRE pricing (Clayton et al., 2009; Morri & Benedetto, 2019; Taderera & Akinsomi, 2020). Investment volumes and CRE pricing respond to fundamental macroeconomic variables and risk factors, including unexpected inflation, together with changes in real interest rates and risk premiums (Clayton et al., 2009). While in the short run, neither expected nor unexpected inflation has a statistically significant relationship with returns, investors were found to hedge against inflation in the long run, meaning that investment yields may take time to adjust to the inflation effect (Taderera & Akinsomi, 2020). On the other hand, Sivitanides et al. (2001) establish that inflation negatively affects yields, as expectations of higher inflation and, consequently, higher rent growth leads to a lower income return when acquiring an asset (a 1% increase in inflation lowers yields by 46 basis points). Blake et al. (2021) argue that when it comes to inflation, the roots of inflation matter: when inflation arises from strong economic growth, it increases CRE returns, but if it results from the higher cost of goods, it downgrades the returns.

To complement the above, macroprudential measures infer that "regulatory limits on leverage" could also help mitigate CRE assets from extreme variations (Duca & Ling, 2020, p. 28). Also, the research suggests that effective macroprudential policy can help mitigate, though not eliminate, the influence of fluctuations in risk premiums demanded by investors and their subsequent effects on the broader economy and financial stability (Duca & Ling, 2020). However, the immediate effects of regulations are found to be negative, turning to positive in the longer term. Morri & Benedetto (2019) also expand on regulatory controls by stating that the unpredictability of change in the regulations, the number of entities responsible for issuing authorizations, the interpretation of regulations, and the duration of authorization processes matter considerably to CRE returns.

Besides, force-majeures in the short-to-medium term might shift the yields. Crises may impact RE values and, consequently, yields. Based on Kaklauskas et al. (2021), recessions tend to lead to reduced space needs for companies, with the observed trend of companies downsizing by 35-40%. The impact of reduced space needs during recessions can result in a decrease in NOI for CRE properties. Hoesli & Malle (2022) looked beyond the generic results and concluded that retail, hospitality, and office RE are more exposed to crises than residential or industrial properties. Not only the fact of a recession but also its root causes may help explain CRE dynamics. During GFC, the source of financial instruments (Crotty, 2009) and the amount of leverage (Crowe et al., 2013) mostly mattered. Back then, defaulting CRE owners, highly leveraged investments, reduced lending, and a liquidity crisis led to significant shifts in yields and a high number of distressed assets (Sornette & Woodard, 2010). One business cycle later, after the worldwide Covid-19 pandemic, monetary easing quickly changed to tightening, yet again causing CRE yields to change. But this time, researchers argue that guided by uncertainty, the post-pandemic markets were facing systemic shifts in use (such as the emergence of the peripherical shopping centers, secondary offices, and the like) (Levy, 2023). The exhausted list of macroeconomic indicators is in Table 2.

Table 2

Expected effect on CRE yields, considering one unit increase (improvement) in macroeconomic indicators

Macroeconomic indicator	Academic literature	Expected effect on CRE yields
Interest rates	Akinsomi et al. (2018), Kim et al. (2019), Mokas & Nijskens (2019), Sivitanides et al. (2001), Tsolacos et al. (2009)	Increased (+)
10-year governmental bond yields (i.e., risk free rate)	Chervachidze & Wheaton (2013), Clayton et al. (2009), Duca & Ling (2020), Kim et al. (2019)	Increased (+)
Risk premium	Chervachidze & Wheaton (2013), Clayton et al. (2009), Duca & Ling (2020), Heinig et al. (2020)	Increased (+)
(Forecasted) GDP	Akinsomi et al. (2018), Heinig & Nanda (2018), Mokas & Nijskens (2019)	Decreased (-)
Debt to GDP	Chervachidze & Wheaton (2013), Heinig et al. (2020)	Decreased (-)
Unemployment	Akinsomi et al. (2018)	Increased (+)

Inflation	Akinsomi et al. (2018), Blake et al. (2021), Morri & Benedetto (2019), Sivitanides et al. (2001), Taderera & Akinsomi (2020)	Ambiguous
Regulations	Duca & Ling (2020)	Ambiguous
FDI	Joghee et al. (2020)	Decreased (-)
Force-majeures	Hoesli & Malle (2022), Kaklauskas et al. (2021)	Increased (+)

Source: compiled by the author based on research

1.4.2. Market Indicators

While economy-wide drivers are material, the supply and demand interplays also weigh on the transaction sentiment formation. As established above, with interest and risk-free rates, the rental growth rate is among the primary CRE characteristics most cited in literature when analyzing yields. Real rental growth explains demand fundamentals (Kim et al., 2019). The changes in the reported market rent are important to understand the factors that cause total returns to change (Jackson & White, 2005; Kim et al., 2019).

As an independent variable, rents' effect on yields is found to be negative in most cases. Some say that rents should bear a significant adverse effect on yields, reasoning that historically, during high rental growth phases, yields are lower, given investors' expectations of prolonged robust income growth in the future (Chambers et al., 2019; Heinig et al., 2020). Others argue that higher rents attract more profit-seeking developers to the market in the long run, which increases supply relative to demand and pushes yields down (Duca & Ling, 2020). Yet, there are opposing views, claiming that rental growth is a proxy for the CRE income growth which may push the yields up, especially in the short-term, and lead to lower office absorption going further (McCartney, 2012). In addition, when the transaction prices remain sticky, the increase in rent translates to the increase in yields. However, the literature discusses that when determining the rent fluctuations' impact on yields, investors must be cautious as market rents do not necessarily move the same way during different phases of the economic cycles (or are commonly lagged) and tend to differ across different market types (Jackson & White, 2005).

In addition, reported vacancy rates and operating expenses also matter. CRE returns have a direct relationship with vacancy rates, as higher vacancies lead to declining property values (Akinsomi et al., 2018; Hoesli & Malle, 2022). The relationship with operating expenses is also found to be negative (Akinsomi et al., 2018). Moreover, the overall supply or total existing stock

in the market may impact the transaction sentiment, as robust supply deteriorates perceived risk and lowers yields (Heinig et al., 2020; Hoesli & Malle, 2022). Furthermore, the overall investment volumes may matter in the pricing sentiment formation (Clayton et al., 2009).

Moreover, the risk is by far one of the most considered factors, even though it is hard to monetize. The bid-ask spread is one way to measure it (Clayton et al., 2009; Kim et al., 2019). Classical portfolio theories claim that financial instruments are picked depending on the variances and covariances of the returns among investment assets. However, since CRE returns depend on the risk-free rate (usually cited outside the local markets), the risk profile is also affected not only by the portfolio but also by international market performance (Clayton et al., 2009). In general, Morri & Benedetto (2019) define CRE investment risk as the likelihood that future income would differ from the expected value. The authors claim that the cost of capital required by investors is usually a function of the non-diversifiable risk in a CRE portfolio (Morri & Benedetto, 2019). Hence, if the risk of investing in a commercial property is perceived to be high, this would typically result in a higher required yield to attract investors.

Risks are usually classified into unsystematic (asset) and systematic (market) pieces, considering that the benefits of diversification are finite, and some risks may not be avoided across different asset types (Sagi, 2021). Another way to look at risks is by classifying the market, credit, liquidity, legal, and operational risks. Risks depend on each other and tend not to disappear entirely but rather interrelate and transform from one to another. There are usually several types of risks involved in CRE transactions. CRE portfolios are mainly exposed to the market (due to interest rate fluctuations) and liquidity forces. Pre-lease agreements could reduce market risk, especially given higher occupiers' creditworthiness and fundamental contract clauses (i.e., duration, break options) (Morri & Benedetto, 2019).

When it comes to liquidity, evidence suggests that CRE market liquidity is pro-cyclical with CRE pricing dynamics and NOI, as yield rate spreads tend to co-move (Van Dijk & Francke, 2021). Analysis of liquidity on property pricing suggests "common implications in explaining changes in yields" (Kim et al., 2019, p. 5). Liquidity increases CRE values, which means that higher liquidity results in a decrease in yields (Kim et al., 2019; Van Dijk & Francke, 2021). However, in extreme cases, the illiquidity of CRE assets might transform into credit risk, with the owner defaulting on its debt (Mokas & Nijskens, 2019). This finding implies that idiosyncratic

risks combined with higher credit risk explain tight financing covenants, as banks usually manage these risks through LTV ratios and interest rates (Mokas & Nijskens, 2019). Table 3 summarizes discussed relevant market-specific characteristics for the yield analysis.

Table 3

Expected effect on CRE yields, considering one unit increase (improvement) in market indicators

Market indicator	Academic literature	Expected effect on CRE yields
(Expected) rent	Chambers et al. (2019), Chervachidze & Wheaton (2013), Duca & Ling (2020), Heinig et al. (2020), Kim et al. (2019), Sivitanides et al. (2001), Tsolacos et al. (2009)	Ambiguous
Vacancy rates	Akinsomi et al. (2018), Hoesli & Malle (2022)	Increased (+)
Supply	Heinig et al. (2020), Hoesli & Malle (2022)	Decreased (-)
Idiosyncratic risk	Morri & Benedetto (2019)	Increased (+)
Investment volumes	Clayton et al. (2009), Kim et al. (2019), Van Dijk & Francke (2021)	Decreased (-)

Source: compiled by the author based on research

1.4.3. Sustainability Indicators

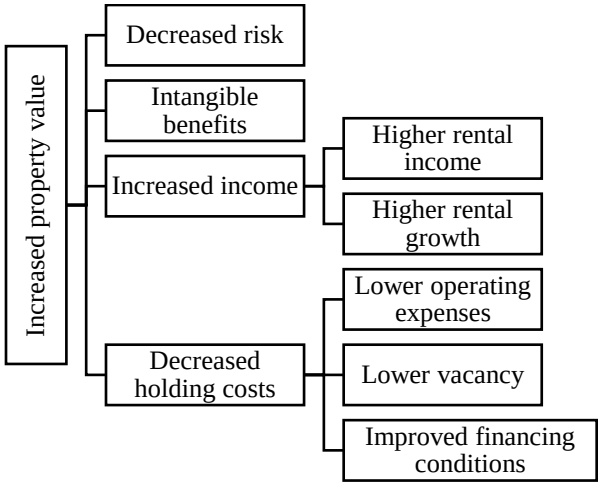
Sustainability has become one of the key components affecting CRE sector returns in recent years. Especially among the European markets, the EU green deal, setting the path for the EU to become carbon neutral by 2050, has shaken the whole operating RE environment, considering that buildings consume nearly 40% of the EU's energy and emit around 36% of greenhouse gas emissions (Deloitte, 2021). The EU Taxonomy regulation is also entering the picture, with a set of rules defining what green investment is. To be considered green, investment should significantly contribute to one of the following categories without harming others: climate change mitigation, climate change adaptation, use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, as well as protection and restoration of biodiversity and ecosystems (European Commission, n.d.). Hoepner et al. (2023) researched how the non-climate environmental indicators in the EU Taxonomy impact the structure of corporate credit risk. The study highlights that when considering the impact of sustainability legislation, it is vital to focus on real assets because they are designed to operate in

the long term. The effect is transmitted not only to the owners but also to the occupiers of the assets (Hoepner et al., 2023).

Clayton et al. (2021) claim that climate change has an impact on CRE values. Such acute events as flooding or hurricanes may decrease liquidity and have immediate price effects (diminishing over the long term if climate events do not repeat regularly). However, CRE owners and investors increasingly consider climate-related risks, requesting a higher risk premium on assets affected by climate events, "regardless of whether their individual properties have been directly affected" or not (Clayton et al., 2021, p. 16). In addition, Holtermans & Kok (2019) established that environmentally certified buildings display "significantly higher" rental, occupancy, and pricing levels than non-certified buildings (p. 20). Since certification databases are publicly disclosed, this reduces the information asymmetry for occupiers and incentivizes owners to improve the efficiency of buildings, especially those intending to sell in the longer horizon. Leskinen et al. (2020) also established green certifications' impact on property cash flows and values, claiming that certifications lead to increased property value, cascading effects on the rest of property-level KPIs (Figure 3).

Figure 3

Property level drivers for sustainable buildings adoption



Source: compiled by the author based on Leskinen et al. (2020)

A recent study on the so-called green premium was done by Fidler et al. (2023), which concludes that sustainability certifications provide a 6% rental premium in the offices' sector, a

25-bps five-year median valuation premium over the market prime net yield in the logistics sector. The study also cautiously highlights that with the increasing supply of sustainable buildings, premiums are likely to shrink over time. Mangialardo et al. (2018) also examined that the leasing of certified buildings is four times faster, displays half lower vacancy rates after 30 months, and increases the market value of the building by 7-11%. While CBRE (2023) provides evidence that around one-third of European investors intend to pay even a 20% premium for green assets, Fidler et al. (2023) estimate sustainability certificates to bring 14-16% capital values premium. Leskinen et al. (2020) describes that the sales premium could even reach up to 43% due to brand value of certifications, better operating returns, and signaling power.

In a 2022 survey conducted by Royal Institution of Chartered Surveyors, occupiers and investors were asked about the impact of green buildings on market values (Carson, 2023). Nearly 60% of European respondents suggest that buildings lacking sustainability certification may face reduced market values, referred to as a *brown discount*, while ca. 30% believe in a rent premium for certified properties (Carson, 2023). Most respondents reckon that this brown discount could be up to 10% of the property's value,f with some outlining an even larger impact. Synthesizing available literature, as per Table 4, the authors summarize that green certifications decrease CRE investment risk and, thus, yields by 0.36-0.55% (Miller et al., 2008; McGrath, 2013).

Table 4

Expected effect on CRE yields, considering one unit increase (improvement) in sustainability indicator

Sustainability indicator	Academic literature	Expected effect on CRE yields
Green certifications	Clayton et al. (2021), Holtermans & Kok (2019), Mangialardo et al. (2018), Leskinen et al. (2020)	Decreased (-)

Source: compiled by the author based on research

1.4.4. Transaction Indicators

Studies suggest that economic and market-related fundamentals alone may fail to fully explain asset returns (Cheung & Lee, 2021). Thus, another no less important dimension is the inclusion of particular transaction evidence, which refers to the property traits and investors'

preferences. This class of variables tends to be highly individualized, as per specific parameters of individual CRE transactions and unique preferences of buyers/sellers.

The expected NOI of the property is one of the core determinants of CRE yields (Heinig et al., 2020). While the prior-discussed market rents are important, the actual operating income of the particular property paints a more vivid picture of the transaction yield. However, the literature notes that not the level of NOI but rather the projected growth or change in NOI matters to investors (Clayton et al., 2009). Assuming no NOI growth, the rising property prices imply lower rental yields going forward (Chambers et al., 2019). On the contrary, given the absence of yield changes, "capital gains will equal real income growth rates" (Chambers et al., 2019, p. 7). And especially since yields would never increase or decrease indefinitely, the long-run growth rates of NOI can be a good proxy for the long-run average capital gains (Chambers et al., 2019).

Location is another core dimension that matters to the transaction-specific yield since the value of CRE properties may differ even "within a few meters", depending on the surroundings and catchment area (Morri & Benedetto, 2019, p. 15). The city may also translate to pricing due to the so-called "superstar city bias" (Chambers et al., 2019, p. 8). Jackson & White (2005) claim that geographical location is a traditional dimension in classification models. CRE returns are believed to be fundamentally reflected through the location variation, which determines the rental growth rate and investors' discount rate (Tsolacos et al., 2009). However, location is not a straightforward variable because each type of CRE property bears its preferred surroundings. When it comes to offices, connectivity, and ease of access matter. For retail properties – the number of potential customers in the micro-location is considered, while the residential sector considers the availability of services, quietness, and security (Morri & Benedetto, 2019).

Furthermore, the weighted average unexpired lease term (WAULT) is relevant in determining the attractiveness of CRE properties (Kołodziejczyk et al., 2019). WAULT is an internal characteristic that explains the lease's quality and duration, determining the overall project's financial rationality (Kołodziejczyk et al., 2019). This metric helps to ensure future cash flows for investors from tenants' lease continuation. Among other variables, some authors also consider financing terms and conditions, quality, the year of construction, or similar dimensions for CRE yield determination.

Sentiment in RE markets refers to a set of beliefs about expectations that are not grounded by attainable information, leading to mispricing, overreaction, or over-confidence (Cheung & Lee, 2021). Sentiment could be measured through either direct (investors' expectations surveys) or indirect methods (Heinig et al., 2020). Heinig & Nanda (2018) argue that improved sentiment should negatively influence property yields. Sivitanides et al. (2001) also documented behavioral investors' patterns, considering that yields exhibit consistent differences across markets based on investors' sentiment. It is essential to mention that yield models are found to be more explanatory and improved when sentiment measures are explicitly included (Heinig et al., 2020).

Information asymmetry and related inefficiencies also matter as markets exist under imperfect conditions, contrary to neo-classical assumptions. The efficient market hypothesis states that investors act rationally based on all available information (Fama, 1970). However, this hypothesis fails to explain the investors' behavior and psychological biases (Waweru et al., 2014), and markets may experience "frequent investor overreaction" when information is scarce (Heinig et al., 2020, p. 501). Kołodziejczyk et al. (2019) summarize that the RE market may display high information variance due to existing inefficiencies. The existence of "pricing anomalies and general market disequilibrium" could lead to sentiment formation and related yield shifts (Kołodziejczyk et al., 2019, p. 303). The direction of yield movement is also likely to be positively related to individual investors' desired rates of return (or else referred to as a discount rate derived from the risk-free rate and investor's risk premium) (Clayton et al., 2009; Duca & Ling, 2020). A summary of the relevant transactional indicators to property yield analysis is in Table 5.

Table 5

Expected effect on CRE yields, considering one unit increase (improvement) in transaction indicators

Transaction indicator	Academic literature	Expected effect on CRE yields
(Expected) NOI	Chambers et al. (2019), Heinig et al. (2020)	Increased (+)
Location	Morri & Benedetto (2019)	Decreased (-)
Operating expenses	Akinsomi et al. (2018), Chambers et al. (2019)	Decreased (-)
Investors' required rates of return (discount rate)	Duca & Ling (2020)	Increased (+)

Source: compiled by the author based on research

Overall, the first part of the study establishes that CRE is an illiquid financial instrument, as deals are infrequent and irregular, usually involving a private buyer and seller in off-market deals, making it challenging to access the pricing data timely. Classification of CRE has conventionally been based on their functional categories. The major segments that are usually distinguished are office, retail, and industrial. Investment yields have become the benchmark to determine investment attractiveness and compare returns across different asset types. When calculating CRE yields, three factors are widely considered, namely risk-free, risk premium, and rental rates. However, scholars argue that in order to provide a more thorough explanation of CRE yield sentiment, the computational formula should encompass a broader range of macroeconomic, market, and sustainability dimensions. As per raised research problem, it is especially unclear which of the many explanatory indicators matter to the Baltic CRE market, as transactions are infrequent, and no related studies have been performed for this geography. Leveraging the findings in part one, parts two and three follow related scientific literature and explore methodology and research to determine indicators relevant to CRE yield movements in the Baltics.

2. METHODOLOGICAL PART FOR BALTIC COMMERCIAL REAL ESTATE YIELDS DETERMINATION

The second part of the study uncovers the methodological approach for conducting research to determine relevant indicators influencing changes in the Baltic CRE yields. It provides the rationale for choosing the linear OLS time-series approach, details the composition of the dependent variable, and elaborates on the independent variables, interrelating the findings from the part one of the study. After describing the employed methodology, this section tips the reliability and certain limitations to which this study might be exposed.

2.1. Research Methodology and Utilized Approach

This paper aims to discover factors that historically have significantly affected CRE yields in the Baltic States and perform yield modelling based on the future forecasts of the market. To accommodate similar academic problems, researchers employed mainly quantitative methods. Since heterogeneous datasets were used, econometric analyses relied on different data processing methods, such as OLS regression, error correction models, linear and logarithmic regression models, or statistical analysis. Research models used in comparable studies are summarized in Tables A1 and A2.

This study applies the OLS time-series econometric techniques due to the quantitative and time-based nature of the dataset and following similar techniques used by Akinsomi et al. (2018), Duca & Ling (2020), Heinig & Nanda (2018), Kim et al. (2019). Such research mode is also considered reliable, given the continuous nature of the dependent variable (Ozgur et al., 2016). Classical OLS assumptions, related to the linear regression model, error term distribution and variance, correlation, and others are performed in the third part of the study. All statistical and regression analysis is done in the Gretl software package for econometric analysis. All regressions in this study rely on a 10% significance level when interpreting the results and testing the statistical hypotheses for OLS regression assumptions. As a rule of thumb, time-series regression requires at least 50 observations for robust models. This study consists of 93 observations, dated from January 2016 to September 2023. Hence, the models, constructed in the third part of the paper are considered reliable.

In this study, the CRE data is supplied by CBRE Baltics, an affiliate of the largest globally (based on 2022 revenue) CRE advisory and investment firm – CBRE. CBRE Baltics collects regular information on the Baltic CRE KPIs and yields based on transactional evidence and ongoing deal negotiations. If no transactions occur over the period in question, the yield is derived following the observed investors' sentiment in the market and directional evidence from the counterpart reference economies (i.e., Poland and the Nordics) and educated guesses by the market experts.

Following the academic literature findings in sections from 1.4.1 to 1.4.4 of the study, this paper intends to test the following hypotheses:

H1: The more economy expands[1], the lower the prime Baltic office, retail, and industrial yields in OLS time-series regression;

H2: The more robust performance in the CRE market[2], the lower the prime Baltic office, retail, and industrial yields in OLS time-series regression;

H3: A higher share of sustainable CRE stock leads to lower prime Baltic office, retail, and industrial yields in OLS time-series regression.

Transaction characteristics (i.e., NOI, location, investors' desired rate of return) could not be generalized for the market since they are purely determined in each individual transaction. Thus, no hypothesis is raised in relation to this group of variables.

Christensen (2017) supports the assumption that it is essential to understand CRE pricing, particularly in the post-GFC environment, as the markets were no longer featured by heightened market volatility and reduced investor confidence, as argued by Crotty (2009) and Crowe et al. (2013). Upon the assumption that distinct market forces affected CRE in the post-GFC period and given the data availability, this study examines monthly data in the Baltic CRE investment market

[1] Based on the literature review in section 1.4.1 of the study and the author's judgment, an expanding economy is associated with an increase in FDI, GDP, absence of force majeure, or a decrease in inflation, ECB interest rates, government bond yields, unemployment, and country risk premium. The hypothesis is considered to hold if at least one of the examined macroeconomic indicators follows the predicted direction.

[2] Based on the literature review in section 1.4.2 of the study and the author's judgment, a robust performance in CRE markets is associated with an increase in rents, supply, investment volumes, sustainable buildings, and a decrease in vacancy rates. The hypothesis is considered to hold if at least one of the examined market indicators follows the predicted direction.

over 2016-2023. Due to data availability, as a reference period, data from January 2016 until the latest available data, which is September 2023, are used in further analysis.

2.2. Dependent Variable of Prime Commercial Real Estate Yields

Prime yields, analyzed as dependent variables in this paper, refer to the most desirable, highest-quality properties that usually stand as a benchmark for the asset class (CBRE, 2021). More particularly, prime yield refers to the return on investment that an investor would gain from purchasing a top-tier property situated in a highly desirable location. The prime yield is intended to reflect the prevailing transaction levels in the market at that time, considering that the property is leased out at the market rates. This metric reflects the level at which relevant transactions are closed. Still, it should not be precisely matched to any of them, particularly if the number of deals is limited or made up of unusual one-off transactions. A hypothetical market yield is considered if no relevant transactions are recorded during the examined period. Although such theoretical yield is not derived from specific transactions, it represents an expert opinion based on prevailing market conditions. Evidence-based or judged, the referenced prime yield level for the market follows the same criteria regarding the property's location and specifications.

Based on CBRE (2015) guidelines, investment transactions include income-producing RE and forward purchases of properties closed by a binding agreement. The data does not consider pure land deals, owner-occupier transactions, derelict buildings, residential transactions (if not concluded by an institutional investor) or repurchases that place the property in the same conditions as at the initial transaction time. CBRE Baltics investment database considers asset or share deals, where CRE properties are transferred at a market price. In an asset deal, the buyer acquires only the property itself, including equipment, fixtures, leases, and other tangible and intangible assets. The property buyer is not concerned with the seller's liabilities, so any existing debts or obligations related to the property remain with the seller. In the meantime, a share deal transacts the shares of the legal entity that owns the commercial property.

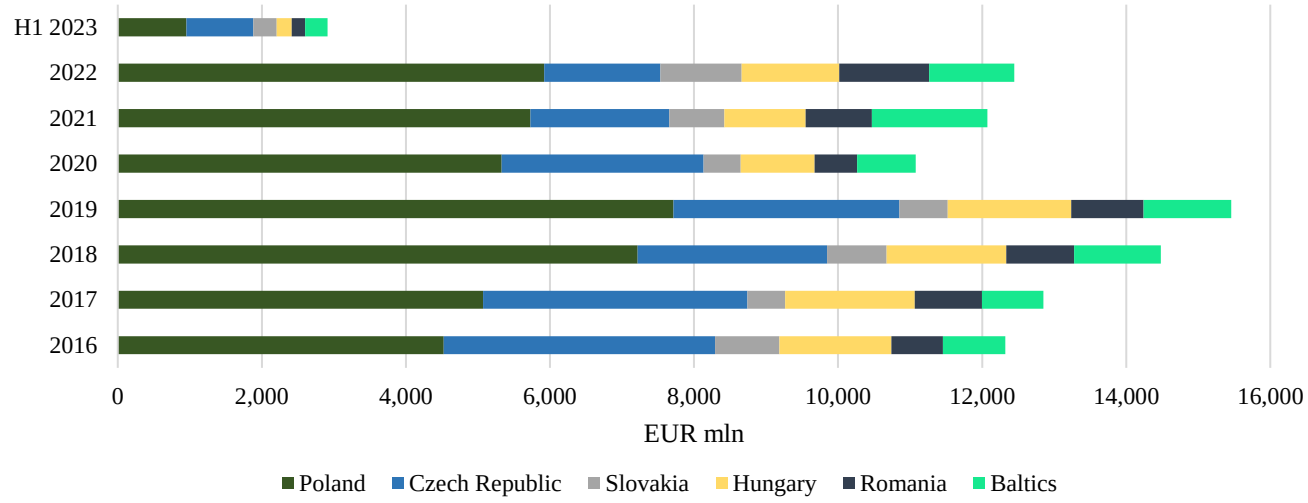
Since the Baltic capital cities (i.e., Vilnius, Riga, and Tallinn) are the most developed and liquid markets in the context of the Baltic states, this study further considers prime yields in those cities as the benchmark for the countries. Looking at CRE markets, office, retail, and industrial segments are considered the key ones (Ghent et al., 2019; Lamas & Romaniega, 2022; Sanderson et al., 2019), historically displaying the highest liquidity in the Baltics. Based on the CBRE Baltics

(2023b), the vast majority of transactions in the Baltics over 2016-2023 were also observed, particularly in these segments, with 35%, 31%, and 16% of investment deals recorded in office, retail, and industrial markets. Therefore, the yields for these properties in the Baltics should be considered the most representative ones. Models will further be titled Office, Retail, and Industrial, examining investment yields for each segment, respectively (variables carrying suffixes *_O*, *_R*, and *_I* further on in the analysis refer to each segment, accordingly).

According to CBRE (2015) guidelines, an office concerns a building whose area or value is over 75% used as an office. Shopping centers are schemes managed by a single entity, with 5,000 sqm or more gross leasable area, usually having at least 20 shop or service tenants and shared spaces. The industrial segmentation considers industrial, warehouse, distribution, and logistics facilities consisting of 5,000 sqm or more, high clear ceiling height, and a high ratio of loading bays to overall floor area.

Figure 4

Investment volumes in EUR mln, CEE Region, 2016 – H1 2023



Source: compiled by the author based on Pieksma (2023)

Due to the small market sizes of Estonia, Latvia, and Lithuania, the prime yield levels across the core markets of Tallinn, Riga, and Vilnius are almost identical, with spread varying between 0.25-0.5 bps. Moreover, Baltic markets are highly illiquid, and transactions happen irregularly. It is well-reflected in the CEE (Central Eastern Europe) context. In total, 7.8 bn EUR

were transacted across the Baltics compared to its counterpart economies of 42.5 bn EUR in Poland, 20.5 bn EUR in the Czech Republic, 10.5 bn EUR in Hungary, 6.5 bn EUR in Romania, and 5.6 bn EUR in Slovakia, from Q1 2016 to Q2 2023, according to Pieksma (2023) (displayed in Figure 4). Due to relatively low transaction volumes, a significant investment deal or portfolio transaction anywhere in the Baltics may set the tone for yield movements across all Baltic economies. In addition, foreign investors tend to perceive the Baltics as a single investment ecosystem and most commonly pursue investment opportunities in the context of the Baltic States (Muchová & Šuláková, 2022). Therefore, this analysis considers the prime yield for the Baltics as an average of Tallinn, Riga, and Vilnius prime yield levels.

2.3. Independent Variables of Macroeconomic, Market, and Sustainability Indicators

Most of the macroeconomic variables used in this analysis were obtained from Eurostat (2023acd) and Oxford Economics (2023). However, the interest rates were taken from the European Central Bank (2023) and the country risk premium variable was extracted from Damodaran (2023) online data platform. Each of the chosen control variables for this analysis has academic grounds, following Table A2, and linkages with the prime yields. Since the dependent variable is analyzed monthly, while specific macroeconomic indicators are announced on different frequencies, the available values were equally split in a monthly manner. For example, it was assumed that the quarterly level values were applicable throughout each month of a quarter.

The *HICP* variable refers to the harmonized consumer price index, which measures consumers' average price change for goods and services. *FDI* represents the foreign direct investment variable, showing the inward and outward investments when acquiring part of or the entire company, or establishing new operations. A variable named *GDP* is the annual percentage growth rate of the real GDP. As for the interest rates, the variable *ECB* considers the rate set by the European Central Bank, which is used to implement or signal the monetary policy stance, considering that Estonia joined the Eurozone in 2011, Latvia in 2014, and Lithuania in 2015. The abbreviation of *GovBonds* is used to consider the long-term interest rates of each Baltic government bond maturing in ten years. Long-term interest rates are perceived as risk-free rates for a given economy. Moreover, the *Unemployment* variable considers the percentage of the unemployed labor force over the specified period. The country risk premium variable (*CRP*) is derived from the volatility of the local equity markets, later added to the mature market equity risk

premium (i.e., the S&P 500 index). This metric shows how much premium investors need to compensate for additional risk related to investments in a particular country.

The independent variables concerning the CRE market were taken from numerous CBRE Baltics (2023abcd) databases. Again, in the same manner, as with macroeconomic indicators, some CRE market indicators were historically measured only quarterly. Hence, in such cases, the quarterly results were split equally in three months, as obtaining the actual monthly values was impossible. In the case of percentage indicators, the quarterly values were assumed to be applicable for each month of the quarter.

For the office yield analysis, the study considered office markets in Baltic capital cities, examining 338 existing office buildings in Tallinn (115), Riga (101), and Vilnius (122) (CBRE Baltics, 2023c). Regarding retail market data, due to the limited supply of quality modern stock in capital cities alone (with existing 65 qualifying retail assets), which corresponds to the prime yield levels, this study considers the CRE data for 128 retail assets, sub-used as shopping centers and retail parks, in five largest cities of each Baltic country (i.e., Tallinn, Tartu, Narva, Parnu, Kohtla-Jarve in Estonia; Riga, Daugavpils, Liepaja, Jelgava, Jurmala in Latvia; Vilnius, Kaunas, Klaipeda, Siauliai, Panevezys in Lithuania) (CBRE Baltics, 2023d). As for the industrial yields analysis, in the Baltics, the leading industrial cities, having modern distribution, logistics, stock-office, and warehouse stock, are considered Tallinn, Riga, Vilnius, Kaunas, Klaipeda, and the surroundings of these cities (CBRE Baltics, 2023a). Thus, when considering the prime industrial yield level, all these cities were taken into consideration to analyze the data (the sample of 381 buildings in total).

For all three CRE markets, namely office, retail, and industrial, the following independent variables were considered from January 2016 to September 2023. The variable *Rent* corresponds to the highest achievable rent for a standard-sized unit in sync with local demand, emphasizing top quality and location (CBRE, 2021). Prime rent aligns with market transactions but may differ from actually concluded lease agreements, especially if they are limited or unique. If no transactions occur over the analyzed period, the figure is hypothetical, based on market expert opinion, maintaining criteria on size and specifications. The prime rent for offices denotes the open-market rent that a blue-chip occupier would pay for a standard-sized unit (ca. 1,000 sqm) in a prime location within the local market. The prime rent for retail signifies the expected open market rent for a ground floor retail unit, not exceeding 200 sqm, of top quality and specifications, located in

the best market location, and usually paid by an international retail chain. For industrial assets, prime rent also refers to the top-tier asset lease in a prime location, usually paid by a reputable international occupier.

The independent variable for vacancy rate (abbreviated as *Vacancy* further in the study) denotes the entire net rentable floor area within the analyzed sample that is physically unoccupied and actively promoted as of the survey date. Total stock (*Supply*) signifies the aggregate existing space (occupied and vacant) in private and public sectors, recorded as the net rentable area. Total stock encompasses all modern buildings within the segment, irrespective of quality, age, and ownership (leased or owner-occupied). The variable *Certified* denotes the share of the total existing supply at the survey period, which has voluntarily obtained one of the benchmark green certifications, proving sustainable strategies for development, water consumption, energy efficiency, materials selection, etc. In the Baltic CRE environment, such certificates are predominantly classified under BREEAM or LEED standards. The variable, abbreviated as *InvVol*, refers to the overall value of completed investment transactions, priced one mln Eur and above, during the reported period. Property is considered sold when contracts are signed or a binding agreement is in place.

The study introduces two variables to measure force majeure, which is explicitly considered impactful on the Baltic CRE markets. One of them is *Covid*, where 1 refers to pandemic restrictions being in force in any of the Baltic states (including closed facilities, open with restrictions, or open with digital Covid certificate, according to CBRE Baltics (2022)), 0 – otherwise. Another introduced variable – *War*, where 1 denotes the ongoing geopolitical tensions in Ukraine, which started in February 2022 and is ongoing until the latest date of the analysis, 0 – otherwise.

All the above-listed CRE market variables are employed in all three regression analyses for office, retail, and industrial yields, with the only exception for offices, where one additional variable was added to have a more comprehensive selection of sustainability variables, as such data was available to use. Under the definition of *AClass*, the variable considers the entire net rentable area classified as Grade A according to local market standards.

As some variables are recorded per country level, while the study focuses on the Baltic region, the averages were calculated as either simple means or, where variables depend on related

absolute values, as weighted averages. Table 6 summarizes methods that were employed to derive the single Baltic value per each independent variable. For others, such as *Supply* or *InvVol*, sums of each country monthly results were calculated. Table A3 summarizes the abbreviations, measurement scale and, source of each variable.

Table 6

Independent variables for the Baltics

<table>
<tr><th>Variable</th><th>Weighting factor</th><th>Formula</th></tr>
<tr><td>CPI, FDI, ECB, CRP, Unemployment, Rent (office, retail, industrial)</td><td>N/A</td><td>Simple average = $\frac{\text{sum of variables}}{\text{total number of observations}}$</td></tr>
<tr><td>GDP</td><td>GDP, real, LCU, chained 2015 prices</td><td rowspan="6">Weighted average = $\frac{\text{sum of (variable} * \text{weighting factor)}}{\text{sum of all the weights}}$</td></tr>
<tr><td>GovBonds</td><td>Government debt (debt securities)</td></tr>
<tr><td>Vacancy (office, retail, industrial)</td><td rowspan="3">Total stock (office, retail, industrial)</td></tr>
<tr><td>Certified (office, retail, industrial)</td></tr>
<tr><td>AClass (office)</td></tr>
</table>

Source: compiled by the author

Besides all the above, as the study relies on the OLS time-series model, the time trend variable was added to all three models. This variable indicates the passage of time and represents not the actual dates but categories, giving order to observations.

2.4. Reliability and Limitations

This research entails certain limitations. First, some explanatory variables (e.g., tax or statutory qualifications, ease of entry to the market for international companies, political power, trust in the economy, level of bureaucracy) are not available. Also, the sample may not cover specific transactions or properties if they do not correspond to the CBRE Baltics methodology, though they may impact the explanations for yields. In addition, while prime yields refer to the prime CRE in capital cities, retail and industrial segments account for corresponding assets in some other sizeable towns in the Baltic region, since the capitals' sample alone is too narrow.

Simultaneously, the RE market's specificity, information flow imperfections, and the prevalence of non-specialized investors can impose limitations. As noted by Ghent et al. (2019), CRE deals mostly happen between private parties in off-market negotiations, and some of them may not be reflected within the analyzed data or be analyzed with a lag. Another limitation is related to data frequencies. Since the analysis is done monthly, while certain independent variables were available only quarterly, the analysis assumes that such variables are evenly distributed across the three months within a quarter. However, this approach may need to be more balanced if there is seasonality or variability within the quarter. In addition, if tested, the model might rely on an alternative form of a relationship (i.e., non-linear, logarithmic), and a different model specification may produce more robust results.

Overall, OLS time-series regression analysis in Gretl software is selected as a method to test determinants that influence CRE yield changes in the Baltics, given the quantitative and time-based nature of the dataset and following similar techniques used by scholars. Following the rule of thumb, the current sample of 93 observations, dated from January 2016 to September 2023, should be considered reliable. The study tests three hypotheses related to the impact of the expanding economy, robust performance in the CRE market, and green certifications on the prime Baltic office, retail, and industrial yields. Since the Baltic capital cities (i.e., Vilnius, Riga, and Tallinn) are the most developed and liquid markets in the Baltics, this study further considers prime yields in those cities as the benchmark for the countries. However, in retail and industrial datasets, shopping centers and prime industrial projects consider properties in regional hubs (not only capitals) due to the limited supply of quality modern stock in capital cities alone. Simple or weighted averages are used to derive values for the Baltic region. Although considered reliable, the study has several limitations, such as information imperfection and data frequencies.

3. RESEARCH PART DETERMINING INDICATORS FOR YIELDS IN THE BALTIC COMMERCIAL REAL ESTATE MARKET

This part of the study details the statistical and econometric approaches that help reach the study's raised objective. First, to give a general overview of the data, descriptive statistics are performed to outline the general understanding of the dataset used, its statistical values, and variations. Then, the study visualizes the high-level assessment of the relationship between yields and selective explanatory indicators. Further on, after testing the classical OLS assumptions, this part extensively presents the findings for the Office, Retail, and Industrial segments, considering statistically significant factors that have affected the recent shifts in yields across the segments. Once the relevant equations are obtained, this part discusses why specific indicators matter within the Baltic CRE market. Lastly, on the available forecast data, the anticipated movement of yields is modeled to see how the markets in the Baltics are expected to perform further.

3.1. Descriptive Statistics

Descriptive statistics provide information about the dataset's central tendencies and key values. Table B1 presents the main characteristics for the Office model. The dependent variable *Yield_O* has its mean and median metrics relatively close, with values 6.19 and 6.12, respectively. It indicates that data is expected to be relatively normally distributed. The minimum and maximum values are also fairly close, at values 5.33 and 7.00, which may infer that the time trend does not influence a wide range of variation for this variable. Tables C1 and D1 confirm the same findings for the dependent variables of the Retail and Industrial models.

Considering macroeconomic independent variables, *HICP*, *GDP*, *ECB*, and *GovBonds* are likely positively skewed and have high positive outliers since the mean values are significantly larger than the median metrics. The variable *FDI* is supposedly vastly fluctuating, with a standard deviation of 118 mln EUR, varying from as low as -302 mln EUR to as high as 426 mln EUR. In the meantime, *Unemployment* and *CRP* variables are more normally distributed, with means and medians being relatively close. Analyzing CRE market metrics across all three sectors, *Rent*, *Vacancy*, *Supply*, and *Certified* variables display relatively consistent values, with mean and median values being relatively close and standard deviation comparably mild. What tends to vary, in the office segment specifically, is the value of *InvVol*, as investments in the Baltics are majorly driven by several more significant transactions and do not entail a consistent pattern.

X-Y scatterplots are commonly used to initially assess and test visually the relationship between the dependent and selective control variables. In this study, the first hypothesis claims that the more the economy expands, the lower the expected prime office, retail, and industrial yields. Although the study uses numerous economic variables to justify this hypothesis, for initial illustrative assessment, *GDP* was selectively taken as one of the driving indicators for economic growth. The scatterplot implies the negative relationship between the change in GDP and changes in yields for offices (marked as *d_Yield_O*), retail (*d_Yield_R*), and industrial (*d_Yield_I*) segments (Figures B1, C1, D1), signaling that *H1* may have conclusive directional ties across all sectors. However, such a high-level assessment is only preliminary, does not guarantee that this relationship is statistically significant, and does not account for other variables that might significantly affect the relationship. This will be further investigated in sub-sections 3.3-3.5. As for the *H2*, the first difference in rents was taken as a selective CRE market variable to initially review the directional relationship (following McGrath, 2013) between CRE market robustness and prime yields. Figure B2 concludes that across the office sector, a positive relationship exists between prime rents (in this context, used as a proxy for the CRE market) and prime yields, while Figure C2 shows a negative relationship for the Retail segment. No clear relationship is found in the context of the industrial market (Figure D2). Regarding *H3*, initial visualizations are also inconclusive across the segments for the effect of green certifications, as *Yield_O* and *Yield_I* (Figures B3 and D3) seem to be related negatively to certified stock (as *H3* predicts), while *Yield_R* (Figure C3) – positively, when not accounting for other control variables.

Factorized boxplots prove the importance of adding two circumstantial dimensions into the analysis, which are believed to have recently shaped CRE yield movements over 2016-2023. Given two different conditions, factorized boxplots can provide quick insights into the extent to which categorical independent variables affect the dependent yield variable. *Covid* and *War* dummies were added to the equation, following Hoesli & Malle (2022) and Kaklauskas et al. (2021). However, what remains unknown is the significance of the effect of these dummies in terms of the yield analysis. Factorized boxplots offer a graphical representation of these effects under different circumstances: the presence (1) or absence (0) of the Covid-19 pandemic and the presence (1) or absence (0) of the Russo-Ukrainian war.

Initially, it is deemed that both *Covid* and *War* have noticeable effects across all three CRE segments. Months with pandemic restrictions have mainly brought the compression in yields (apart from the retail segment where yields increased), with observed difference of means between non-pandemic and pandemic states being 60, 10, and 40 bps in office, retail, and industrial sectors, respectively (Figures B4, C4, D4). The change in the *War* variable has resulted in a 50-90 bps spread, depending on the sector (Figures B4, C4, D4). Nevertheless, it is worth pointing out that data for both *Covid* and *War* variables is relatively unbalanced, where values indicating the existence of Covid-presence and War-presence account for 19 and 20 observations out of 93, respectively. In both cases, that represents roughly 20% of all observations, which may lead to dispersed existing tales when the circumstance is absent (i.e., the dummy is 0). More balanced data is likely to bring more robust statistical conclusions.

Overall, descriptive statistics give solid grounds to investigate the raised hypotheses further in the regression analysis. While statistical values for the dependent variable in each model tend to predict a relatively normal distribution of data, X-Y scatterplots show that the hypothesized direction between yields and control variables may be inconclusive, relying on the analyzed sector. Factorized boxplots also validate the introduction of the dummy variables, representing two force majeure circumstances. They validate that force-majeure situations have an impact on the mean and median values of the dependent variables – yields.

3.2. Specification of Models

Classical Assumptions. The selected methodology of OLS time-series regression relies on numerous assumptions. Each time series model is an aggregate of trends, seasonal, and irregular components (Franzini & Harvey, 1983). As Rahman (2018) specifies, along the lines of time-series data, OLS needs to be analyzed keeping in mind six relevant assumptions: (1) the assumed relationship of variables is linear, the model is correctly specified (all included variables have logical grounds), and there is an added error term; (2) there is no perfect collinearity among explanatory variables; (3) the error term has a zero population mean since all the unexplained part of the model is aggregated in the constant term; (4) homoscedasticity ensures that the error term has a constant variance; (5) there is no serial correlation or autocorrelation, ensuring observations of the error term and any explanatory variables are uncorrelated; (6) residuals follow normal distribution. It is also essential to ensure that the time series model is stationary, meaning that it

has a constant trend throughout time, constant variance, and autocorrelation is the same across the whole sample.

Correlation. Firstly, the study observes the correlation among the explanatory variables in each regression model, examining whether either of them is the perfect function of the other. A correlation is deemed to be high when variables are correlated by 0.75 or more (in both positive and negative directions) (Vasile et al., 2018). Applying logical reasoning, correlations were considered only among the same category of variables (macroeconomic with macroeconomic, market with market).

Among macroeconomic variables (Figures B5, C5, D5), the highest positive correlation with a value of 0.87 is observed between *ECB* and *GovBonds*. Such an outcome was likely since the yield of government bonds results from the borrowing costs derived from the central bank interest rates (Alexopoulou et al., 2010). Classical models consider the risk-free rate, expected rental income, and risk premium (Heinig & Nanda, 2018; Heinig et al., 2020; Kim et al., 2019) when estimating the yields. Thus, variable *GovBonds*, qualifying as a risk-free rate for the Baltics, is left in further analysis, while *ECB* was eliminated due to multicollinearity. Variables *GovBonds* and *War* also display a high multicollinearity of 0.88. Thus, following the same reasoning of the importance of the *GovBonds* variable, *War* will not be further considered in the regression analysis across all three models.

Among the CRE market variables in the Office model, Figure B5 displays that most of them are positively correlated. Due to the high multicollinearity of the *Supply_O* variable with *Rent_O* (0.85), *Vacancy_O* (0.76), *Certified_O* (0.95), and *AClass_O* (0.96), this metric will be eliminated and not further considered in regression analysis. Variables *Certified_O* and *AClass_O* (0.94), as well as *Certified_O* and *Vacancy_O* (0.75) also were almost perfectly positively correlated. Thus, only *Certified_O* is left for further examination due to its importance in investigating the sustainable stock impact on CRE yields.

In the Retail model (Figure C5), the variable *Supply_R* was also not further considered due to the high positive correlation with *Certified_R* (0.81). In the Industrial model (Figure D5), *Supply_I* was also forced to be eliminated, following similar reasoning and its significant correlation with *Certified_I* (0.95) and *Vacancy_I* (0.76).

Normality of Dependent Variable. One of the assumptions in the OLS regression is the normality of a dependent variable. Three methods were employed to test whether the yield data distribution is normal, namely histogram and Q-Q plots for quick visual observations, together with statistical Doornik-Hansen and Jarque-Bera normality tests. For the *Yield_O* variable, histogram and Q-Q plot allow us to graphically observe that the *Yield_O* variable is likely to be normally distributed. In Figure B6, observations for *Yield_O* plotted against the black bell-shaped normal distribution are normally distributed, with the P-value for the null hypothesis (stating that data is normally distributed) being beyond the threshold of 0.01. A confirmation could also be obtained from the graphical representation in Figure B7, where a straight line in the Q-Q plot represents the normal distribution, while marked quantiles are the observations sorted in an ascending order, which visually match the theoretical normal distribution.

Normality tests can more accurately test normality outcomes than visual graphs, as they use hypothesis testing. The null hypothesis in these tests states that there is no difference between the distribution of the analyzed data and a normal distribution. A general rule for these tests is that the distribution is not normal if the P-value is less than 0.1. In this analysis, Doornik-Hansen and Jarque-Bera tests (Table B2) display the P-value of 0.15 and 0.21, respectively, confirming the findings from the histogram and Q-Q plot that *Yield_O* is normally distributed.

As for the *Yield_R* variable, the histogram and Q-Q plot do not provide complete certainty regarding the normality of distribution. Observations do not fall under bell-shaped normal distribution in the histogram (Figure C6) and may seem somewhat dispersed around the straight line, representing normal distribution, in the Q-Q plot (Figure C7). However, the normality tests infer that *Yield_R* follows the normal distribution pattern and does not require any additional variable transformations, as the Jarque-Bera test is beyond the 0.1 threshold, having a value of 0.16 (Table C2). In the Industrial model, the dependent variable *Yield_I* nicely follows the normal distribution patterns, as per Figures D6 and D7. Such a finding is also confirmed by conducted normality tests, which display P-values of over 0.2 (Table D2).

Nevertheless, although the normality assumption is validated and does not call for any transformations in the dependent variables, the subsequent paragraphs reveal and elaborate on the existing stationarity condition. Given the stationary data, the dependent variables had to be transformed to the first-order difference for the robust regression analysis. Consequently, the first-

order differences in *Yield_O*, *Yield_R,* and *Yield_I* impose changes and make the data fall out of the normal distribution pattern, as per Figures B6, B7, C6, C7, D6, D7, and Tables B2, C2, and D2. Stationarity in time-series regression is a critical dimension to produce a reliable model. The inability to render a time series to the stationary form can lead to spurious results (Van Greunen et al., 2014). Hence, this study puts a preference to making the data stationary rather than normally distributed and uses first-order differenced dependent variables from now on.

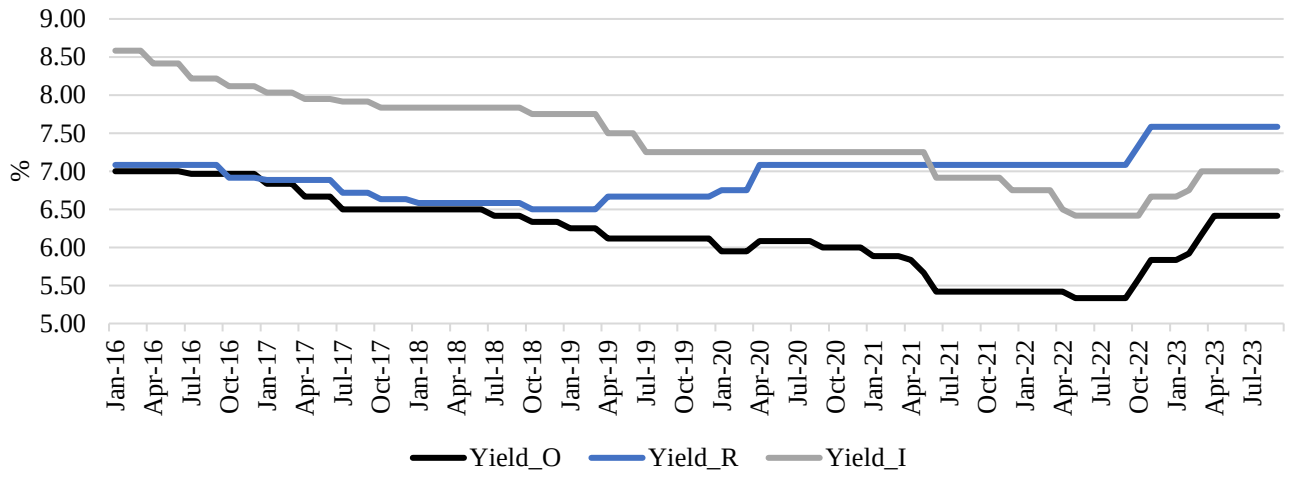
Although the normality of residuals is assumed in classical linear regression, the Central Limit Theorem suggests that with a sufficiently large sample size, the distribution mean in the sample tends to be normal regardless of the underlying population distribution, which makes the normality assumption somewhat less critical (Kwak & Kim, 2017). In addition, linear regression models have been proven to produce valid results even when deviating from normal distributions (Schmidt & Finan, 2018). Where the number of observations per variable is approximately 10, violations of the normality assumption do not significantly affect results (Schmidt & Finan, 2018). In this case, Office, Retail, and Industrial models use 10 or 11 independent variables each, requiring over 100 observations. The current dataset has a similar, though slightly lower, number of observations, 93. Other scholars argue that, as a rule of thumb, all samples with over 50 observations could already be deemed sizeable (Geweke & Porter-Hudak, 1983). Thus, this study prefers stationarity over normality, primarily because, in many cases, deviations from normality are proven not to impact the validity of the regression analysis severely. The regression models will further use the first order differenced dependent variables marked as *d_Yield_O*, *d_Yield_R,* and *d_Yield_I*.

Stationarity. When analyzing trends between multiple variables, it is crucial to determine whether the observed relationship is due to an existing relationship or simply the passage of time. Stationary data is characterized by a constant trend over time, where the mean and variance remain unchanged, and autocorrelation is consistent throughout the sample. In contrast, non-stationary data generally exhibits a positive or negative trend that could be due to time or other factors. If the data is non-stationary, the model might produce results heavily biased by external factors or time trends. Non-stationary data can lead to spurious correlations in regression analysis, deteriorating the model's reliability, which can result in an incorrect specification of the results (Van Greunen et al., 2014).

A time series plot provides a visual representation of trends and patterns in the data that can be useful for analyzing and understanding changes in the variables over time. The time series chart infers that the data on yields in all three sectors is likely to be non-stationary (Figure 5). The mean, variance, and other statistical properties of data seem to change over time. As OLS assumes stationary data, initial analysis reveals that data adjustments may be necessary moving further.

Figure 5

Time-series plot for dependent variables in Office, Retail, and Industrial models



Source: compiled by the author, in accordance with CBRE Baltics (2023e)

To validate the stationarity of all variables, Augmented Dickey-Fuller and KPSS tests were done for each model. The study also displays a correlogram for a graphical representation of the stationarity for each dependent variable. The correlogram in Figure B8 displays a clear non-stationarity in *Yield_O* data. The slowly decreasing bars in Figure B8 indicate that the variable could be predicted using its lags. Therefore, it is necessary to calculate the first-order difference and then start modeling the regression to account for the non-stationarity.

The Augmented Dickey-Fuller test was done to validate the findings from correlograms, which examines how well the dependent variable can be predicted with its lagged values. The null hypothesis in this test is that data is non-stationary. The results indicate that the *Yield_O* variable is non-stationary, with a P-value of 0.45 with constant and even 0.99 with constant and trend (Table B3). The non-stationarity was also validated with the KPSS test, whose null hypothesis, as opposed to the Augmented Dickey-Fuller test, states that the data is stationary. With a P-value of less than

0.01, the hypothesis of stationarity was rejected (Table B3). In order to fix the issue, the first-order difference was taken to bring data to the stationary pattern. The variable with the first-order difference is referred to as *d_Yield_O* in the analysis. Figure B8 indicates a high probability of existing stationarity in the *d_Yield_O* variable since the bars are zigzagging around zero and do not signal autocorrelation issues, which is a desirable outcome for this analysis. Stationarity for the *d_Yield_O* variable is also confirmed in Augmented Dickey-Fuller and KPSS tests (Table B3).

The stationarity tests were performed not only for the dependent variables but also for all independent variables used further on in the Office regression model. Table B3 concludes that variables *FDI*, *GovBonds*, *CRP*, *Rent_O*, and *Certified_O* were non-stationary. Thus, their first-order difference will be used in the subsequent regression analysis (abbreviated as *d_Variable*). As for the variables *HICP*, *GDP*, *Unemployment*, and *InvVol_O*, Augmented Dickey-Fuller and/or KPSS tests confirmed their stationarity, and their initial values are left for further model analysis.

When considering the specifications for the Retail and Industrial models, similar outcomes were observed as per Office model. Correlograms in Figures C8 and D8 confirm the non-stationary pattern for *Yield_R* and *Yield_I* variables, respectively, and the fix of the issue when taking the first difference and analyzing *d_Yield_R* and *d_Yield_I* variables. The conducted Augmented Dickey-Fuller and KPSS tests, summarized in Tables C3 and D3, confirm the findings from correlograms for the dependent variables and present independent variables stationarity assessment. As per the Office model, the same results apply to explanatory macroeconomic and CRE market variables. While *HICP*, *GDP*, *Unemployment*, *InvVol_R*, and *InvVol_I* variables were found to be stationary and required no transformations, all the rest of the independent variables were transformed using the first-order differences to bring the data to the stationarity condition.

Other time-series OLS assumptions, including collinearity, heteroscedasticity of residuals, normality of residuals, autocorrelation, and causality, are further specified in the sub-sections 3.3-3.5 when building the regression model for each analyzed sector, namely Office, Retail, and Industrial.

3.3. Office Model Determination with OLS Time-Series Regression

A regression with logically tied independent variables is this study's key component, which helps empirically test the relationship between the prime office yield and exogenous variables.

Applying all the above specified OLS time-series assumptions and metrics, the Office model, run in Gretl software, establishes which variables are statistically significant when assessing changes in the office market yield rate. OLS is one of the most adequate regression models whose purpose is to minimize the sum of squared residual values for all sample data points. The rationale for choosing the linear form of the relationship was detailed in section 2.1.

Some variables enter the model with lagged values. The model recognizes that not all variables may have an immediate effect on the changes in the office yields, as some data is measured and published after a certain period of time, affecting investors' sentiment with a delay. From the bulk of the macroeconomic variables, based on logical reasoning, one period lag is applied to *HICP* and *Unemployment*, as these are monthly variables whose announcement usually takes up to a month to be published. What is more, *d_FDI* and *GDP* are lagged from 1 to 3 periods back, as these variables are produced by national statistics, which announcements to the public are commonly delayed to monthly or even quarterly results. As for the market variables, two variables are lagged, namely *d_Rent_O* and *InvVol_O* from 1 to 3 periods, as these metrics are comprehensively surveyed across all landlords and investors monthly or quarterly, and it may take some time for investors to comprehend the latest values.

Before interpreting the OLS regression findings, the model's quality is assessed. Firstly, the collinearity is evaluated to ensure that no variable is a replica of another indicator. Gretl software suggests that the variance inflation factors above 10 indicate a collinearity issue that must be fixed by removing problematic variables from the regression equation. Results seen in Table B4 validate that no such issue exists in the current Office model, suggesting that the model is correctly specified in this regard.

Other important assumptions to test are related to normality and heteroscedasticity of residuals, and autocorrelation (Table B5). The normality of residuals assumption implies that the model captures the main patterns, meaning that the errors are random and independent. The test of residuals' normality displays the P-value of 0.03, which infers that residuals may be non-normally distributed and some trends may still be left in the error terms. Following the academic literature assessment in section 1.4 of the study, the regression already incorporates all imperatively important variables which are available for the models' geographic and time coverage. If other variables were to be included, they may help to tackle the normality of residuals.

Heteroscedasticity shows whenever the residuals do not display uniform variance. White's test is carried out to examine the heteroscedasticity assumption. The P-value in White's test is 0.35 (Table B5). As this study relies on the significance level of 0.1, it could be concluded that the current model has no heteroscedasticity issue, and that the variance of the residuals is constant. Another assumption that requires validation is autocorrelation. To control the autocorrelation, the LM test is carried out, whose null hypothesis states that there is no autocorrelation. The P-value for this test is 0.02, which is below the 0.1 critical value used in this analysis, indicating that this regression model has an autocorrelation problem (Table B5). To solve the autocorrelation issue, the Office model regression equation was adjusted to *robust standard errors* (heteroscedasticity and autocorrelation consistent error) to have reliable results.

With the improved model, the regression equation results are interpreted to test which variables have a material effect on the office prime yields. Table 7 presents the regression outcome. The goodness of fit in the OLS regressions commonly relies on the R-squared metric, which for this model is 0.47. It means that such a model can explain around half of the variation in the office yields. It is an acceptable reliability indicator for the study with the real-life dataset, when some or most explanatory variables are statistically significant, as Ozili (2023) suggested. Too low or too high R-squared metrics tend to be problematic. While too low R-squared (below 0.1) may indicate shortage of the explanatory dimensions, a too high metric (over 0.51) may signal an overfitted model, displaying spurious causation or multi-collinearity among independent variables. Although the current model is treated reliable, it is likely that other unconsidered variables, if added, may improve the model, as in reality, CRE yield is moved by various intangible indicators such as investors' sentiment, the presence of international solid corporate investment funds, and others. After running the OLS time-series regression and aligning the model to the assumptions, Equation 2 was obtained, with a P-value less or equal to 0.1:

$$d\_Yield\_O_t = -0.034 * GDP_{t-1} - 0.023 * GDP_{t-2} + 0.046 * Covid_t + 0.181 * d\_Rent\_O_{t-3} - 0.064 * d\_Certified\_O_t + \varepsilon_t, \quad (2)$$

where t – analyzed time period, ε_t – error term. Other abbreviations are summarized in Table A3.

Table 7

OLS regression results for Office model with d_Yield_O dependent variable

Independent Variable	Coefficient	P-value
const.	0.127	0.2428
HICP_1	0.002	0.1949
d_FDI_1	0.000	0.1755
d_FDI_2	0.000	0.5777
d_FDI_3	0.000	0.2924
GDP_1	-0.034	0.0020***
GDP_2	-0.023	0.0260**
GDP_3	0.024	0.2453
d_GovBonds	-0.014	0.7523
Unemployment_1	-0.014	0.2262
d_CRP	-0.008	0.9570
Covid	0.046	0.0951*
d_Rent_O_1	0.042	0.3855
d_Rent_O_2	0.072	0.4052
d_Rent_O_3	0.181	0.0181**
InvVol_O_1	0.00	0.5722
InvVol_O_2	0.00	0.7735
InvVol_O_3	0.00	0.4316
d_Certified_O	-0.064	0.0190***
time	-0.001	0.1854

Source: created by the author

Note: * refers to the 90% confidence level, ** - 95%, *** - 99%.

Table 7 shows that with 99% confidence, one unit increase in the previous month's GDP leads to 3 bps suppression in office yields, keeping other variables constant. Moreover, the one-unit change in the two-month lagged GDP signals a 2 bps contraction in the office yield variable, ceteris paribus. The significance of one- and two-period lagged GDP variables infer that economic growth is a vital indicator that may have a domino effect on the office sector's performance, as the growing economy commonly explains the increased business activity, which translates to office demand. However, as GDP indicator in the Baltics is accessible via statistical bureaus, which make this data available with a delay, it may take a few periods for investors to grasp the changes and

adjust their expectations towards the business centers' pricing. In general, with growing GDP, the contraction in the office yields signals lower riskiness for the investment. As explained by the evidence of South Africa, documented by Akinsomi et al. (2018), economies that have been actively converging towards mature markets over the past 10-20 years usually bear a significant negative relationship between GDP and CRE returns due to the recent robust sector growth. This is precisely the case in the Baltics, which have expanded their economies since the countries acceded to the EU (Randveer & Staehr, 2021).

As anticipated in the 1.4.1 section of this study, certain short-term force majeures can help explain investment return changes. The existing pandemic restrictions (shifting the binary variable from 0 to 1) translated into a 5 bps monthly increase in the office yield, with other variables fixed. Such a change could have been tied to increased uncertainty (Kaklauskas et al., 2021). The remote or hybrid working policies applied by many corporations during quarantines within the Baltics raised concerns for the future of office space. Evidence from France and Italy dictates that work-from-home policies decrease prices and increase office yields, reflecting higher risk for the asset class (Hoesli & Malle, 2022).

Moreover, a one EUR per sqm change in the earlier 3 months' rental levels generally leads to an 18 bps increase in the Baltic office yields, ceteris paribus. Academic literature did not predict uniform findings within this topic, although most scholars agree that expected or future rent matters the most. While some scholars argue that within the office market, higher rents lead to lower perceived investment risk and accelerated cashflow (Kim et al., 2019), others suggest that an increase in the market rent translates to higher NOI upon new rental agreements or renewing terms with the existing ones (Chambers et al., 2019). The latter explanation is considered to hold within the Baltics. Within the realms of this study, the office returns are calculated for the prime market (using prime yields and prime rent levels). Thus, an increase in the prime rent may lead to larger NOI in the short-term and slower absorption in the more extended period, increasing the prime yield levels, as per McCartney's (2012) evidence from the Dublin office market. Interestingly, the scholar employed lagged rental evidence, as in this model.

Sustainability was found to be significant and affect the office market yield levels. 1 pp increase in the certified office stock leads to a 6 bps decrease in yields, ceteris paribus. Such an outcome is in line with the previous literature studies, as green stock is found to provide a

considerable sales premium, affecting the denominator of the yield formula. Within the office market, Fidler et al. (2023) estimate that green certifications provide a sales premium and lease faster, pushing yields downward. Furthermore, based on Leskinen et al. (2020), the "capitalized value of the enhanced cash flow parameters" together with the certificates' brand value eventually leads to lower capitalization rates and lower investment risk (p. 12).

Overall, the modeled regression for the office segments reveals that lagged GDP, presence of the pandemic, lagged prime rents, and green certifications determined the fluctuations in the office prime yield, considering monthly data over 2016-2023. The office model confirms hypotheses one and three and rejects the *H2*. As per *H1*, the expanding economy, pictured via lagged GDP growth and absence of the pandemic, predicts the negative relationship with the office yields. The expanding GDP and absence of force majeure situations lower prime office yield, reflecting lower uncertainty and investment risk to the segment. The second hypothesis is not confirmed, as increasing rents cause the growth in the prime office yield. The study hypothesized the opposite relationship to hold since higher rents tend to be associated with a growing and more robust office market. The third hypothesis aligns with the expectations as the more sustainable office stock leads to lower prime office yields in the OLS time-series regression.

3.4. Retail Model Determination with OLS Time-Series Regression

The retail model also employs the OLS time-series regression technique to test the relationship between retail investment yield and macroeconomic, market, and sustainability indicators. Mirroring the Office model, some variables also enter the Retail model with lagged values. From the macroeconomic indicators, applying a one-period lag to *HICP* and *Unemployment* is common since these are monthly variables usually published up to a month after the end of the period they refer to. In addition, *d_FDI* and *GDP* use 1 to 3 months' lags, as these variables are produced by national statistics bureaus, typically released monthly or quarterly. Regarding the market dimension, three variables are included with 1 to 3 periods lags, namely *d_Rent_R*, *d_Vacancy_R*, and *InvVol_R*. Following the reasoning explained in the Office model, this is because they are comprehensively surveyed across all landlords and investors by some agencies monthly by others – quarterly, and it may take some time for investors to comprehend the changes.

Before delving into the findings of the factors affecting retail market yields, the classical OLS assumptions are tested to ensure robust findings. The collinearity assumption passed the examination, as no explanatory variables were facing the collinearity issue, with values below the threshold of 10 (Table C4). Following that, the assumptions of normality and heteroscedasticity of residuals and the autocorrelation assumption were tested (Table C5). In this model, the model is exposed to the non-normally distributed error term. It means that the current specification of the model may still not capture some trends driving the investment pricing performance within the frames of the retail market. Moving further, White's test for heteroscedasticity allows us to observe that heteroscedasticity is present, as the P-value is under the 10% threshold. Such a finding dictates that heteroscedastic residuals do not have a constant variability across all levels of the independent variables, violating one of the classical assumptions of linear regression. To solve the issue of heteroscedasticity, the Retail model is adjusted to *robust standard errors*, which does not fundamentally solve the heteroscedasticity issue but accounts for such conditions so that the model produces non-biased results. In addition, when testing for the autocorrelation, the P-value landed over the 10% threshold, implying no autocorrelation issue with the Retail model.

With the required adjustments, the model, run in the Gretl software, provides that the R-squared for the model is 0.29. As confirmed by recent Ozili (2023) research, a relatively lower metric of an R-squared of at least 0.10 is acceptable in empirical modeling, given that "some or most of the explanatory variables are statistically significant" (p. 8). As per Table 8, the constructed OLS time-series regression resulted in obtaining Retail model, as per Equation 3:

$$d\_Yield\_R_t = 0.211 - 0.013 * GDP_{t-1} - 0.023 * Unemployment_{t-1} + 0.072 * Covid_t - 0.0003 * InvVol\_R_{t-1} - 0.0003 * InvVol\_R_{t-2} - 0.0002 * InvVol\_R_{t-3} + \varepsilon_t, \quad (3)$$

where t – analyzed time period, ε_t – error term. Other abbreviations are summarized in Table A3.

Table 8

OLS regression results for Retail model with d_Yield_R dependent variable

Independent Variable	Coefficient	P-value
const.	0.211	0.0110**
HICP_1	0.003	0.1152
d_FDI_1	0.000	0.4831

d_FDI_2	0.000	0.4038
d_FDI_3	0.000	0.4706
GDP_1	-0.013	0.0360**
GDP_2	0.002	0.7636
GDP_3	-0.015	0.2103
d_GovBonds	0.039	0.2619
Unemployment_1	-0.023	0.0085***
d_CRP	-0.103	0.1759
Covid	0.072	0.0135**
d_Rent_R_1	-0.007	0.2052
d_Rent_R_2	-0.006	0.1788
d_Rent_R_3	0.004	0.5917
d_Vacancy_R_1	0.001	0.9752
d_Vacancy_R_2	0.015	0.3893
d_Vacancy_R_3	-0.061	0.3876
InvVol_R_1	−0.0003	0.0175**
InvVol_R_2	−0.0003	0.0411**
InvVol_R_3	−0.0002	0.0854*
d_Certified_R	0.018	0.6625
time	-0.001	0.1170

Source: created by the author

Note: * refers to the 90% confidence level, ** - 95%, *** - 99%.

The first thing that stands out from the created equation is that the retail yield formula has a statistically significant positive constant of 0.2, ceteris paribus. It means that the yield curve passes the y-axis not at zero, but at 0.2. It implies that the retail segment generally bears an inherited higher-risk profile in the Baltics. It could be related to the redefined traditional shopping centers concept, with the emergence of e-commerce, fundamental changes in post-pandemic retail sales (the retail volumes are still behind the 2019 figures in the Baltics), and financial concerns of retailers within the Baltics market. Considerably, traditional shopping center schemes are trying to redefine themselves into multifunctional projects, where not only shops and entertainment areas but also experience components become fundamental for shopping centers. Currently, traditional shopping centers and multifunctional schemes are considered as a single asset class and fall under the same prime retail yield definition. Hence, since traditional physical retail is reshaping (and the

examined retail yield blends both traditional and multifunctional retail), it could explain why the constant term bears a positive and significant effect.

Furthermore, one-unit change in a one-period lagged GDP translates to a 1 bps decrease in the prime retail yield, keeping other variables fixed. Considering the expenditure approach, the GDP formula is a sum of consumption, investment, government spending, and net exports, where consumption and investment tend to be closely tied to the spending capacity of both households and corporations. Based on the evidence from Malaysia, demand for shopping center space results from a more robust macroeconomic performance (Zakaria et al., 2021). The lag goes only one period back because the effect of economic welfare is transmitted through savings and consumption almost immediately. Providing an example of the Taiwanese economy, Soós and Kozák (2022) argue that rising GDP leads to rising purchasing power, while higher retail sales increase investment attractiveness for retail properties, pushing yields down.

Furthermore, unemployment was among the most essential dimensions for the Retail model, with the P-value below 1%. A 1 pp increase in the unemployment rate causes a 2 bps decrease in the retail yield, ceteris paribus. This finding is consistent with Akinsomi et al. (2018), which established the negative relationship between unemployment and CRE returns “across the office, retail and industrial sectors in South Africa” (p. 18). As argued by Anagboso and McLaren (2009), increasing unemployment is commonly associated with a fall in discretionary expenditure, which may result in lower shopping center sales and decrease investment attractiveness, especially where rents are tied to the turnover (Gerbich, 1998).

Across the CRE market, pandemic restrictions have arguably impacted the retail sector the most. Due to lockdowns and limited allowances to shopping centers in the Baltics upon the introduction of vaccine certification, e-commerce has expanded at an unprecedented rate. As in-store retailing has been stopped or limited, the negative price abruptions have been the most evident in the retail market, “reflecting the structural changes occurring in the sector” (Hoesli & Malle, 2022, p. 10). This was directly tied to investors requiring higher risk premiums, which is well reflected by Equation 3. Within the sample of this study, the presence of the Covid-19 pandemic results in 7 bps monthly increase in the retail yield, ceteris paribus.

All three lags of investment volume variables explain that this is an essential dimension in prime retail yield determination. An increase in the retail properties investment by one mln euro

explains 0.3 bps (considering one and two period lags) and 0.2 bps (considering three periods lag), keeping other variables constant. Historically, on average, 27 mln EUR per month are transacted throughout the Baltic retail market. Depending on the volumes of retail transactions (or the absence of such), the transaction pricing gives solid evidence for the retail yield movements. The transactions might matter specifically to this asset class due to liquidity matters, as any retail property transacted over one mln EUR (considered within the frames of this study) can set investment sentiment across the whole Baltic region.

All in all, the Retail model reveals that the lagged GDP, lagged value of the unemployment rate, force majeure (i.e., *Covid*), and lagged results of the monthly investment volumes have a statistically significant effect on the prime retail yield. Within the frames of the Retail model, *H1* is partially confirmed, *H2* is fully confirmed, and *H3* is found to be invalid. Only partial confirmation of *H1* comes from the results of the *Unemployment_1* variable. Usually, the expanding economy is associated with a decrease in unemployment, which is hypothesized to affect the yields negatively. Nevertheless, in this model, findings reveal that a unit increase in unemployment leads to a decreased retail yield, ceteris paribus. It infers that the riskiness of investments in this segment grows together with the expanding economy. As explained, such an outcome is derived from the realms of the retail market, where rents are commonly tied to turnover (Gerbich, 1998). As unemployment is expected to lower retail sales, it, in turn, leads to lower rental income and yields, especially in the short term. However, *GDP_1* and *Covid* variables display the relationship with the prime retail yields, as *H1* predicts. The *H2* is confirmed, considering the negative co-integration between investment volumes and retail yield. However, it is worth noting that if the investment volumes are low, their effects on retail yields are nearly nonexistent. Only sizeable retail transactions (i.e., large-scale shopping centers or similar) may cause a material effect on the retail yield movements. In the meantime, the *H3* could not be validated since green certifications were not found to display statistically significant ties with the dependent variable.

3.5. Industrial Model Determination with OLS Time-Series Regression

The industrial sector is also modeled, considering the linear relationship between the industrial prime yield and associated explanatory variables, as set in 2.1 section. As per Office and Retail models, certain variables were lagged to have a logically specified study. Following the before-mentioned reasoning, the one-period lag is applied to *HICP* and *Unemployment* variables,

while period 1 to 3 lags are used for the *d_FDI*, *GDP*, *d_Rent_I*, *d_Vacancy_I*, and *InvVol_I* variables.

The model identified no collinearity issues, inferring that explanatory variables are independent of each other (Table D4). The tested assumptions showed that the error terms are non-normally distributed, the heteroscedasticity issue is present, while the autocorrelation issue does not exist (Table D5). To account for the heteroscedastic errors, the model accounted for the *robust standard errors* when analyzing the model results.

In general, the Industrial model displayed a 0.44 R-squared metric, which is considered a reliable outcome in the study with the real-world data (Ozili, 2023). After running the OLS model in Gretl, Equation 4 was obtained, as detailed further in Table 9:

$$d\_Yield\_I_t = -0.005 * HICP_{t-1} - 0.0001 * d\_FDI_{t-3} - 0.041 * GDP_{t-2} + 0.643 * d\_Rent\_I_{t-1} + 0.502 * d\_Rent\_I_{t-2} + 0.189 * d\_Rent\_I_{t-3} - 0.0008 * InvVol\_I_{t-2} - 0.0009 * InvVol\_I_{t-3} - 0.057 * d\_Certified\_I_t + \varepsilon_t, \quad (4)$$

where t – analyzed time period, ε_t – error term. Other abbreviations are summarized in Table A3.

Table 9

OLS regression results for Industrial model with d_Yield_I dependent variable

Independent Variable	Coefficient	P-value
const.	0.067	0.3432
HICP_1	-0.005	0.0249**
d_FDI_1	0.000	0.7394
d_FDI_2	0.000	0.2566
d_FDI_3	−0.0001	0.0382**
GDP_1	-0.005	0.4763
GDP_2	-0.041	0.0698*
GDP_3	0.033	0.1459
d_GovBonds	0.091	0.2083
Unemployment_1	-0.008	0.3306
d_CRP	0.053	0.2423
Covid	0.022	0.3527
d_Rent_I_1	0.643	0.0011***

d_Rent_I_2	0.502	0.0119**
d_Rent_I_3	0.189	0.0545*
d_Vacancy_I_1	0.002	0.9287
d_Vacancy_I_2	0.028	0.2058
d_Vacancy_I_3	0.036	0.2482
InvVol_I_1	-0.0002	0.5292
InvVol_I_2	-0.0008	0.0664*
InvVol_I_3	-0.0009	0.0686*
d_Certified_I	-0.057	0.0454**
time	0.000	0.6921

Source: created by the author

Note: * refers to the 90% confidence level, ** - 95%, *** - 99%.

Within the Industrial model, a 1 pp increase in the *HICP_1* leads to a 1 bps decrease in the prime industrial yield, ceteris paribus. Such a nature of relationships is well-explained by Sivitanides et al. (2001). The scholars argued that the lagged inflation is a proxy for the expected inflation. The inflation metric, in general, should negatively affect capitalization rates, as higher inflation expectations, tied with the higher nominal rent growth, "would motivate investors to accept a lower income return when acquiring a property" (Sivitanides et al., 2001, p. 10). Investors were found to hedge against inflation in the long run, meaning that investment yields may take time to adjust to the inflation effect (Taderera & Akinsomi, 2020).

Another critical dimension is *d_FDI_3*, reflecting the three-month lagged FDI changes. Evidence from Dubai indicates that when FDI is successfully attracted, RE investors tend to make investment decisions within that market (Joghee et al., 2020). Especially within the industrial market, an FDI, working within production, logistics, manufacturing, or similar fields, enters the market by acquiring land and developing production plants on-site or investing in existing facilities. In any case, a sizeable new international manufacturer sets the scene for establishing higher trust for the region, which in turn decreases risk and industrial prime yield.

The lagged GDP also has a statistically significant impact on the industrial market development. A one-unit increase in the *GDP_2* variable results in a 4 bps contraction in the prime industrial yield, ceteris paribus. Indirectly, production is included in the GDP formula within the net exports piece. Driven by the vitality of exports and imports, the segment may place higher or

lower attractiveness from the point of view of investors, who evaluate the pricing expectations, taking a broader economy into account. A convincing reasoning is also provided by Mokas and Nijskens (2019), who argue that positive GDP deviations translate to lower lending risk and fewer subsequent defaults, providing higher confidence in CRE investments. The scholars also consider that the relationship is likely to be lagged, as per the findings of this study (across all three examined segments).

Built-to-suit developments are the preferred choice for many local and international players in the Baltics region, while speculative projects are rather rarer. Due to the stickiness of rents, changes in prime rent have a significant effect on the attractiveness of industrial investments. A change of one EUR/sqm/month in prime rent can shift the industrial yield up by 64 basis points, all other things being equal. The effect is less pronounced but still considerable for changes that occurred two or three months earlier. The yield can increase by 50 bps with a two-month lag (other variables fixed) and by 19 bps with a three-month lag (other variables constant). Despite the opposite relationship between rents and yields is predicted by *H2*, some scholars suggest that changes in the asking rent reflect investor expectations about income, which can shift yields upwards (Clayton et al., 2009; Heinig et al., 2020). The sticky nature of prime rents in the industrial segment in the Baltics is the reason for this effect. Historical data shows that prime rents have remained unchanged, at times, for several consecutive years in a row due to the limited demand for the speculative industrial projects in the region. Therefore, even a slight increase in rents can make investors reassess their expected NOI and impulse an upward yield movement.

As per the Retail model, the investment volumes in the industrial segment have a significant impact on the Baltic region for several periods in a row. On average, around 14 million EUR are invested each month into industrial and logistics properties. However, the data is highly dispersed, with some periods accounting for no investment, while others have seen up to 70 mln EUR invested in the sector. Based on the findings of the OLS model, an investment of one mln euro in the industrial segment two months ago could explain the 0.8 basis point drop in industrial yield, keeping all other variables constant. For the three-month lag, the effect is -0.9 bps, keeping all other variables constant. This provides the basis to believe that small transactions would not significantly impact the yield sentiment, while major ones can shape the overall Baltic region yield sentiment.

Green certifications have also proved to be an essential indicator within the realms of the industrial market. A 1 pp increase in the certified Baltic industrial and logistics stock implies 6 bps lower yields, keeping other variables constant. Fidler et al. (2023) present evidence that BREEAM certification helped to achieve "a 25bps five-year median valuation premium" over the prime yield in the analyzed logistics companies (p. 10). Although the certified logistics assets databases are relatively thinner compared to offices, the researchers also elaborate that within the industrial and logistics segment, green certifications provide the benefit of "lower void periods, higher liquidity and easier (re)letting" (Fidler et al., 2023, p. 10).

In conclusion, the industrial yield explanatory model relies upon lagged HICP, FDI, and GDP variables from the macroeconomic perspective, together with lagged rents and investment volumes from the market realm, and certified stock from the sustainability perspective. Based on this model, hypotheses one and three are confirmed fully, while hypothesis two is only partially confirmed. The model shows that a more robust economy (illustrated by growing inflation, FDI, and GDP), more robust CRE markets (reflected by increased investment volumes), and more sustainable property markets lead to lower prime industrial yield levels in the OLS regression. However, *H2* could not be fully validated since the lagged rent variables offer a positive relationship with industrial yields, while a negative one was expected.

3.6. Discussion of Findings

This study aims to test three generic hypotheses to see how macroeconomic, market, and sustainability indicators help to explain the movements in the CRE yields. Based on the constructed model, Table 10 generalizes the outcomes of the three studied models. Markets may experience investor overreaction when information is scarce (Heinig et al., 2020). Therefore, as information for some Baltic macroeconomic and market indicators is not available straight away and is announced on different than monthly frequencies, some variables dictate that lagged output is significant for the yield metric forecasting.

Table 10

Validation of hypotheses in Office, Retail, and Industrial models with 90% confidence level

Hypothesis	Statistically significant independent variable	Discovered effect on dependent variable	Expected effect on dependent variable	Validation of hypothesis
Office Model				
H1	GDP_1	-	-	Confirmed
	GDP_2	-	-	
	Covid	+	+	
H2	d_Rent_O_3	+	-	Rejected
H3	d_Certified_O	-	-	Confirmed
Retail Model				
H1	GDP_1	-	-	Partially confirmed
	Unemployment_1	-	+	
	Covid	+	+	
H2	InvVol_R_1	-	-	Confirmed
	InvVol_R_2	-	-	
	InvVol_R_3	-	-	
H3	N/A	N/A	-	Not valid
Industrial Model				
H1	HICP_1	-	-	Confirmed
	d_FDI_3	-	-	
	GDP_2	-	-	
H2	d_Rent_I_1	+	-	Partially confirmed
	d_Rent_I_2	+	-	
	d_Rent_I_3	+	-	
	InvVol_I_2	-	-	
	InvVol_I_3	-	-	
H3	d_Certified_I	-	-	Confirmed

Source: created by the author

What stands out from the performed regressions is that the lagged GDP variable turned out to be statistically significant for all three examined models. The negative relationship between GDP and yields within the Baltic markets is well-comprehended. The Baltic economies are actively converging towards the other EU countries, which attracts more confidence to the market. Galstyan et al. (2021) present that GDP per capita grew over 170% in all three Baltic countries

five years after joining the EU. When analyzing the contributors to the Baltic GDP growth in 2022, it stands out that industry and trade fueled the economic growth in all three countries (Eurostat, 2023b), giving the grounds on why GDP is important for industrial and retail CRE investment yields. Moreover, according to the EBRD (2022), Baltic economies are export-oriented (40% of the Baltic value added is exported) and have significantly increased their production and manufacturing capacities, contributing to the discovered close ties with the industrial sector yields. Regarding the office sector, the ease of doing business in the Baltics is well above the OECD average, which explains the recent robust investment attractiveness to business centers in Vilnius, Riga, and Tallinn (EBRD, 2022).

In addition, Mokas & Nijskens (2019) initiate the discussion that more robust GDP growth, which is commonly estimated through the lagged output as in this study, decreases the riskiness of firms and gives higher confidence in CRE investments. However, scholars warn that GDP growth should not be taken for granted and that CRE investments should be evaluated based on the economic cycle's stage. During high-growth phases, banks may be tempted to provide loans for higher-yield (risker) properties, which can be problematic. In downturns, risks increase due to worsening macroeconomic conditions, which can put pressure on CRE cash flows (Mokas & Nijskens, 2019). Hence, risks resulting from the economic cycle might affect yields differently than expected.

Based on the works of previous scholars, it is concluded that yields are essentially the proxies to the investors' sentiment, reflecting the aggregate of the economy and market. However, if shifts in yields occur more dramatically and over a shorter period, it is important to consider short-term events that may cause turbulence in the CRE market (e.g., as discovered, *Covid* was essential in explaining yield shifts in the Office and Retail models). Although the pandemic, added as an explanatory variable to CRE models in this study, may not be a significant driving force in future yield movements, it can be used as a proxy for other force majeure events that cause tangible changes in investment sentiment in the short term.

It is important to note that for the retail model, the constant term was found to bear a statistically significant positive effect, ceteris paribus. It means that if no further changes occur in the market, the yield does not remain flat but is positively inclining, which shows continually increasing risk to the segment. This study considers that such a finding is related to the redefined

retail concept in the post-pandemic market, where not only transactions but also customer experience matter. The traditional shopping center schemes incorporate only shops or combine shops with leisure zones. However, the currently evolving mixed-use developments are beyond that, and such developments are currently settling within all CEE markets. The main differentiator of the mixed-use projects is synergies rather than a stand-alone concept. Usually, multifunctional developments follow the so-called *live-work-play* concept, successfully integrating residential, administrative, or even public services, such as city hall, hospital, and kindergarten, into the scheme (Property Forum, 2023a). For future retail market analysis, it could be advised to separate traditional retail from multifunctional schemes. It is expected that while traditional retail in the Baltics may still be exposed to the high-risk profile, multifunctional projects are expected to be based on different fundamentals and bear lower investment risk. However, the Baltic sample, consisting of multifunctional schemes alone, is too narrow for robust findings. If examined, the study advises considering a more comprehensive geographical range, for example, within the CEE region.

In some cases, the models reveal that not only the specific period value matters but also the trend over time. This is particularly evident in the Retail and Industrial models, where investment volumes in the segment matter for several consecutive periods. The same applies to the Office model, where changes in GDP, and the Industrial model, where changes in rent are significant for several months in a row. This suggests that for certain variables, investors tend to look for trends rather than a single value change. A one-time metric may not necessarily reflect the underlying tendency accurately.

Sustainability was a novel feature introduced to the prime yield formula, and it is statistically significant within the Office and Industrial models. This is consistent with the findings by Fidler et al. (2023), who documented that the so-called *green premium* adds financial value to the buildings by tackling the building's response to climate change, energy efficiency, lower carbon footprint, water usage, and similar. Although the authors mention that all these features add value to the rental premium, the sales premium is much more pronounced, leading to the contraction of the CRE yields. In summary, the average gross premium from sustainability certificates is 6-8% for rents and 14-16% for capital values (Fidler et al., 2023). Leskinen et al.

(2020) documents the evidence that the sales premium could even reach up to 43% due to brand value of certifications, better operating returns, and signaling power.

Two variables turned out to bear the opposite effect on the yield changes than hypothesized. In the Retail model, rising unemployment decreases the yields, while in the Office and Industrial models, rising rents increase the yields (opposite to what was expected as per raised hypotheses in section 2.1 and Table 10). The deviations for the sign in the unemployment variables are understood considering the retail market because in the short-term, unemployment reflects the fall in discretionary expenditure, resulting in lower shopping center return, especially where rents are tied to turnover (Gerbich, 1998). Moreover, Office and Industrial models have lagged rent as a statistically significant outcome in yield determinations. Although some researchers provided evidence for the relationship to be negative (Heinig et al., 2020; Kim et al., 2019; Sivitanides et al., 2001; Tsolacos et al., 2009), the opposite relationship turned out to matter within the Baltic office and industrial markets. A plausible explanation for such a result is related to the matter that in the Baltics, prime rents tend to be relatively sticky and do not change each period. Therefore, when the changes happen, investors adjust their expectations about short-term income, increasing yields (Clayton et al., 2009; Heinig et al., 2020). It is important to note that within this study, prime rents and prime yields were investigated, which do not reflect market averages that tend to adjust each period but rather reflect the higher end of the range for the best-quality assets.

It is important to note that some authors suggest that in certain cases, the relationship between variables can be reversed. This means that the yields could actually influence the development of some variables rather than the other way around. For instance, Kong et al. (2016) have pointed out that investments in CRE are significant and can act as a catalyst for economic growth. Similarly, Plazzi et al. (2010) have argued that yield rates are a marginal predictor of rent growth in industrial and retail sectors.

Some scholars argue that, in general, the market-level KPIs tend to bear their flaws. According to Chambers et al. (2019), market-wide rent may not be the most desired metric when considering the capitalization rates, as authors find considerable “cross-sectional variation in yields across individual properties” (p. 3) for any type of CRE. Thus, the market-level yields may only serve as a benchmark for the transaction. Nevertheless, asset-level parameters remain crucial when evaluating the specific CRE property (Cheung & Lee, 2021) (as described in section 1.4.4).

All the findings from the examined Office, Retail, and Industrial models relate to the monthly changes in the yields, meaning that the discovered variables help to predict short-term fluctuations. However, if the yield performance was to be forecasted for a longer period, it is advised to perform annual rather than monthly analysis with a more extensive geographical data sample. It is expected that indicators that matter in the short-term may not necessarily play out to be significant in the medium-to-long-term.

An essential finding is that the classical yield calculation formula, as presented in Equation 1, appears invalid when considering a wider range of explanatory variables in the Baltics. Surprisingly, neither the government bond yield nor the country risk premium proved to be statistically significant indicators in any analyzed sectors. It is argued that CRE pricing has long been based on a yield gap for 10-year government bonds, but this is now changing as RE is no longer seen as an alternative to bonds (Property Forum, 2023b). While REITs could still be referenced against the governmental debt securities, as the trading methods and liquidities are comparably similar, actual commercial properties should instead have an alternative benchmark, as investors engaged in these transactions are primarily high-net-worth individuals or institutional profile investors. They engage not only in investing but also in developing, managing, and financing the properties. Some considerations exist that if risk-free was used in the yield determination, it should be included not only in conjunction with the country risk premium, as traditionally considered, but also with liquidity risk. Annaert et al. (2019) provide argumentation that since CRE investments are highly illiquid, investors' compensation is a sum of risk-free, country risk premium, and liquidity risk premium.

Furthermore, in smaller markets, such as Estonia, Latvia, or Lithuania, it could be argued whether the local 10-year government bonds, referenced as risk-free rates, are essentially pure risk-free measures, even considering the dedicated country risk premiums. Some market experts claim that risk-free rates are fairly articulated in the global treasury markets, considering a wider pool of investors comprehending risk (Clayton et al., 2009). For smaller Eurozone economies, the core countries' (German or French) 10-year governmental bond yield could serve as a more suitable reference rate, especially after the historical evidence of the Greek sovereign crisis (Bratis et al., 2020). It is also considered that, if available, the EU bond rate could be a purer risk-free rate to benchmark Eurozone investments. As of December 2023, the EU has announced intentions to

issue EU-wide bonds worth up to 75 bln EUR in 2024 as a part of the latest EU funding plan (European Commission, 2023). Reiterating back to the local government bonds, it is also important to point out that, for example, Estonia's public debt structure is based primarily on long-term amortizing loans rather than debt securities, meaning that in specific periods, the 10-year governmental bond yield could be derived via estimate, not the market (ECB Data Portal, 2023). In any case, despite the origin of governmental bonds, nowadays, CRE investors rarely base their required rate of return on governmental debt securities since such investors rarely view CRE markets through the lenses of government bond substitutes. Therefore, it is unsurprising that local government bonds did not play out as statistically significant variables in the derived models.

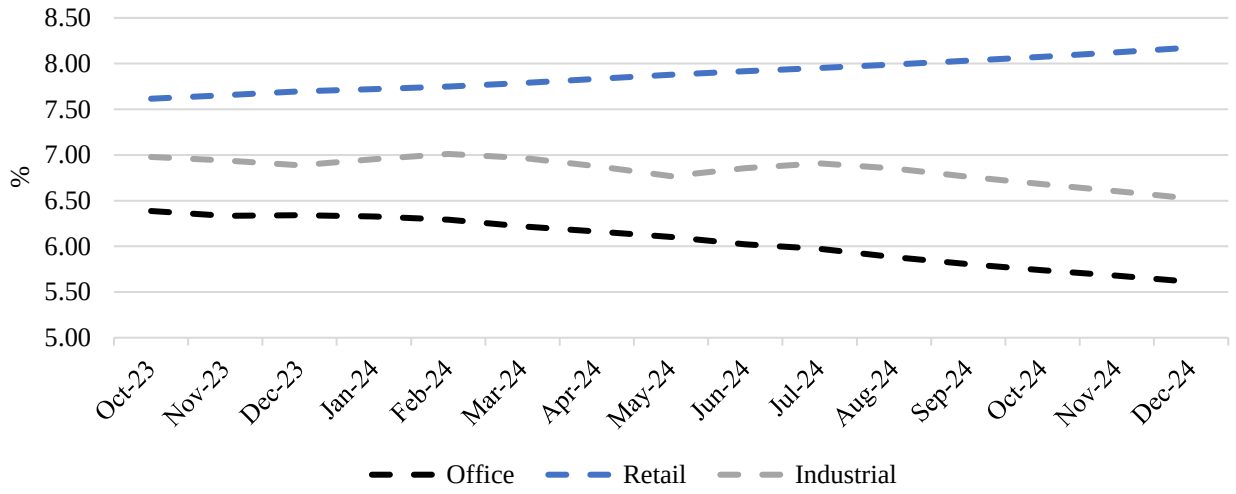
When considering investing in CRE in the Baltic region, CRE funds and investors are advised to view Lithuania, Latvia, and Estonia as a single investment market. Although these countries are not a single territorial or economic market when evaluated separately, they share similar financial and CRE market performances. Due to the small market sizes of Estonia, Latvia, and Lithuania, the prime yield levels across the core markets of Tallinn, Riga, and Vilnius are almost identical, with spread varying between 0.25-0.5 bps. Moreover, as transactions happen irregularly in all three countries, a single sizeable transaction in any of the countries could set the tone for the regional yield movement. In addition, the region has higher competitiveness when looking at these economies in the context of the Baltics. Therefore, it is recommended for investors to evaluate the performance of all three countries holistically.

3.7. Short-Term Baltic Commercial Real Estate Yield Modelling

This study aimed not only to identify factors that have historically had a significant impact on CRE yields in the Baltic States, but also to model short-term anticipated yield movements based on available market forecasts. To consider future values, the same data sources were used. Oxford Economics (2023) projections were taken for the periods from October 2023 to December 2024 for macroeconomic forecasting. The projected values of CRE market data, including market and sustainability dimensions, were taken from CBRE Baltics (2023abcd). The interpolation is done in the Excel software, using the findings presented in Equations 2, 3, and 4. The results are graphically presented in Figure 6.

Figure 6

Forecasted short-term yields development in the Baltics based on regression findings



Source: created by the author

One important thing to note is that investment volumes are difficult to predict and largely depend on executed transactions during the period. Therefore, historical data is used to interpolate the monthly transactions by the end of 2024 for the retail and industrial segments (where this variable turned out to be statistically significant). It is important to emphasize that if these or other future values vary significantly from the used forecasts, the modeled yields must be revised. The modeling, presented in Figure 6, is solely for illustrative purposes to demonstrate how the discovered equations for yield calculation work with forecasted market data. It is worth reiterating that the residuals' normality tests (in Tables B5, C5, and D5) displayed the P-value below the 0.1 thresholds in all three models, meaning that residuals are non-normally distributed, and some trends are still left in the error term. If unconsidered variables were to be included, they may tackle the trends currently left within the error term.

The office yield development is expected to point downwards by the end of 2024. This is due to the fact that the GDP is projected to enter a growth phase next year for all three Baltic economies, and the Covid pandemic is no longer expected to cause significant turbulence. Also, although prime rents should face little to no growth, the certified stock as a share of total stock will modestly continue to grow, as most pipeline projects target or have achieved BREEAM or LEED standards. The demand for sustainable assets also remains strong, as many corporations are

currently working on their corporate sustainability strategies, which should translate throughout all operational fields, including RE. Therefore, it is expected that next year, the region will face a contraction in the prime office yields. This contraction is expected for the Baltics and other CEE countries, as recessionary sentiment is abandoning the region and demand for quality office space remains robust. However, it is crucial to take into account intangible factors like the presence of multinational corporations, political influence, confidence in the economy's long-term growth, and other similar factors while making decisions about investing in office buildings.

Within the retail model, the anticipated further direction of yields faces an upward pattern. Mathematically, such an outcome is mainly determined by the positive constant and relatively decent interpolated retail investment volumes. As discussed, the positive constant reflects the inherited risk of the traditional shopping center concept, which, after the pandemic, does not correspond to the market demand. However, if more significant transactions occur, it may give a more vital impulse and reverse the direction of yields to point downwards (since the model accounts for even three consecutive periods of lagged investment volumes). However, there are some grounds to believe that the retail segment within the Baltics may actually be exposed to a higher risk profile moving further, and the growing yield sentiment is a likely outcome. The stock of Baltic shopping centers is relatively older, and the pipeline developments are not significant. In fact, according to CBRE Baltics (2023d), Baltic capitals have one of the highest densities of retail space per existing population, but 62% of the shopping center stock is 15 years old or older. The foundations of such an outcome date back to the regained independence of the Baltic states when moving from the planned to the market economy. Back then, the retail segment expanded at an unprecedented pace. Currently, as there are serious concerns about the declining population in all three countries, lagging retail sales, the limited pipeline of new projects, and expanding e-commerce trade, traditional shopping schemes may be exposed to relatively higher riskiness compared to office or industrial developments in the Baltics.

In the short term, industrial yields may still increase slightly due to closing ongoing transactions. However, it is predicted that the industrial yield in the Baltic region will decrease by about 50 basis points, reaching a level of 6.5 by the end of 2024. Such an outcome could be explained not only mathematically but also considering the anticipated trend of nearshoring across the CEE region. Many companies are relocating from Asia to the CEE region to take advantage of

land availability and cost efficiency, increasing manufacturing companies across Eastern Europe. Although this trend has yet to reach the Baltics, it is anticipated to do so later due to less efficient infrastructure in the Baltic region than in its CEE counterparts. Moreover, the industrial segment generally bears strong market fundamentals, with long lease terms and firm tenant profiles. Within the frames of this study, the industrial, logistics, and manufacturing segments in the Baltic region are expected to offer a lower-risk environment, considering factors such as the growing GDP, less pronounced inflation, forecasted FDIs, sticky rents, investment volumes, and expanding certified stock. This is especially true if the nearshoring trend becomes important for the Baltic industrial landscape.

In conclusion, developing a single formula to determine the yield fluctuation in all CRE segments is challenging since each asset class has a unique risk-return profile. The research discovers that the traditional yield formula, considering the risk-free rate, expected rental income, and a risk premium (Heinig & Nanda, 2018; Heinig et al., 2020; Kim et al., 2019) does not help to estimate CRE yields in the Baltic market. Different macroeconomic and market forces affect investment cash flows and pricing expectations across each examined asset class. In general, it has been found that GDP is a critical factor to monitor across all primary market segments, namely office, retail, and industrial properties. Force majeure, unemployment, inflation, and FDI also play a role, subject to the analyzed sector. Rents and investment volumes are fundamental indicators from the CRE market perspective when modeling the yields, while the novel introduction of sustainability matters for the office and industrial segments. Nevertheless, scholars have differing views regarding the effect of some considered indicators. Therefore, it is advised that the findings of this study are only applied when examining the CRE landscape within the Baltic states.

CONCLUSIONS AND RECOMMENDATIONS

The below-listed conclusions and recommendations summarize the main outcomes of this study, in accordance with the raised objectives and tasks.

1. Analysis of the existing academic literature shows that CRE refers to a financial instrument that requires long-term commitment and is illiquid. Such properties are usually transacted through private off-market deals, making access to pricing and trading data challenging. Investors and developers should work with local consultancy companies to understand market data and fundamentals.
2. Asset classes are the most widely used CRE classification method, with office, retail, and industrial considered the core segments. Classification by the functional categories helps to collect data, measure performance, and analyze portfolios.
3. Risk-free, risk premium, and rental rates are traditionally considered when identifying relevant indicators affecting CRE investment yields across global markets. However, there are contradictory views about which factors beyond that tackle the impact of CRE yield changes to benchmark relative investment returns. It is advised to consider that nowadays, the yield computational formula incorporates more extensive macroeconomic, CRE market, and sustainability indicators to enable investors to make informed decisions.
4. Prime yields in the capital cities of Vilnius, Riga, and Tallinn should be considered benchmarks for the Baltic states, as these are the most developed and liquid markets. Simple or weighted averages are used to derive values to cover the Baltic region from the single countries' data. After reviewing research models employed in similar academic studies and given the quantitative time-based nature of the dataset, this study utilizes OLS time-series econometric techniques.
5. The study tests three hypotheses related to the impact of the expanding economy, robust performance in the CRE market, and green certifications on the prime office, retail, and industrial yields in OLS time-series regression. The hypotheses and performed analysis relate to the short-term (monthly) changes in the prime yields and do not help to forecast long-term movements. If future studies were done on a similar topic, it is advised to consider different data frequencies to examine a medium-to-long-term effect on the yield movement for comparative reasons.

6. Considering the OLS time-series regression, the office prime yield is determined by lagged GDP, pandemic presence, lagged prime rents, and green certifications. The expanding economy and lack of force majeure situations lead to lower prime office yields while increasing rents cause growth in prime office yield. Sustainable office stock leads to lower prime office yields.
7. Considering the OLS time-series regression, the retail model suggests that factors, including lagged GDP, lagged unemployment rate, pandemic presence, and lagged investment volumes, significantly impact prime retail yield. Unemployment affects yields negatively, contrary to expectations. Expanding GDP and absence of force majeure relate to decreasing prime retail yields, as predicted. Investment deals also matter for prime retail yields, but only large-scale transactions have a significant effect. However, no relationship has been discovered between sustainability and changes in retail yields.
8. The retail model's constant term has a statistically significant positive effect, indicating a continuously increasing risk to the segment. It is related to the diminished importance of traditional shopping schemes in the post-pandemic environment. For future market analysis, it is advised to separate traditional shopping centers from multifunctional schemes. However, the Baltic sample of multifunctional retail projects is too narrow to derive robust findings. If examined, the study advises considering a more comprehensive geographical range, for example, within the CEE region.
9. Considering the OLS time-series regression in the industrial segment, lagged HICP, FDI, lagged GDP, lagged rents, investment volumes, and certified stock variables help predict the yields. The model suggests that a more robust economy (featured by increasing HICP, FDI, and GDP) and sustainable property markets lead to lower prime industrial yield. However, an opposite to the expected, a positive relationship was observed between lagged rent variables and industrial yields.
10. If it is noticed that shifts in yields occur more dramatically and over a shorter period, it is advised to consider short-term force majeure events that cause turbulence in the CRE market. The recent Covid-19 pandemic was significant in explaining office and retail yields.
11. Sustainability is a novel feature introduced to the prime yield formula, and it is statistically significant within the office and industrial segments. The discovered sales premium is

associated with the brand value of certifications, better operating returns, and signaling power, pressing yields downwards. When developing new commercial schemes, developers should consider the projects' alignment with BREEAM, LEED, or any other building sustainable development standards to increase asset liquidity and strengthen market fundamentals.

12. The classic yield calculation formula is invalid when considering a more comprehensive range of explanatory variables. Government bond yield and country risk premium are not statistically significant indicators in analyzed sectors. It is advised to account for the liquidity premium for similar future studies. It is also recommended to reckon alternative risk-free measures to the local government's 10-year governmental bond yield, when assessing the CRE pricing.
13. When engaging in CRE transactions in the Baltics, the developers and funds should take into account the lagged effect of some indicators, as timely data is not accessible via published sources. It is also essential to consider that specific intangible forces are likely to be left in the models' error terms and can play an important role in CRE investment decisions, which are not necessarily fully reflected via macroeconomic or market variables.
14. Based on the interpolated short-term yield modeling, it has been identified that while the office and industrial yields are expected to decrease, the retail yields are expected to see an upward trend in the Baltics. If traditional and multifunctional properties had separate yields, the study predicts that multifunctional retail, incorporating synergies with other sectors and experience-based operating models, would likely face contracting yields.

In conclusion, as yields allow comparing the returns across different property types in various geographies, it is essential to have a more sophisticated yield determination technique, apart from following transactional evidence or educated market guesses. Although it is tricky to quantify behavioral finance, yields are commonly used as a proxy for discussing the investment climate in the country. Investors are generally advised to pay more attention to the Baltic real estate environment instead of separately following Estonian, Latvian, or Lithuanian indicators, as the Baltic RE markets are closely interrelated, and the harmonization of data makes the region more competitive. In order to encourage further growth in the Baltic CRE markets, the primary focus should be placed on creating a welcoming ecosystem for businesses to have a higher value-add for economic growth, investing in the workforce skills to generate interest from sizeable international

players, and creating effective urban planning to ensure that developers can provide sufficient supply of modern and sustainable CRE stock. It is also important to envisage that CRE pricing has long been based on a yield gap for 10-year government bonds, but this is likely to change as RE is not considered a pure alternative to bonds.

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APPENDIX A – INDEPENDENT VARIABLES ANALYSIS

Table A1

Summary of similar research studies across different geographies

Academic literature	Country	Research question	Research method
Akinsomi et al. (2018)	South Africa	To examine how macro-economic indicators contribute to the explanation of direct CRE returns in an emerging economy.	OLS regression
Clayton et al. (2009)	USA	To explore how the CRE pricing is affected by both market fundamentals and the sentiment of investors.	Error correction models
Heinig & Nanda (2018)	UK	To determine how capturing investors' sentiment improves the yield modeling.	Regression models
Hromada & Krulický (2021)	Czech Republic	To examine dependencies between technical and economic parameters in RE.	Regression analysis (linear & logarithmic)
Kim et al. (2019)	Six Asian countries	To examine the effects of normal and excess liquidity in the RE market.	Ln (natural log) M2 model
Waweru et al. (2014)	Kenya	To determine behavioral factors that influence RE investment decisions.	Statistical analysis (percentages, modes, mean and dispersion scores)

Source: compiled by the author based on research

Table A2

Research-based list of explanatory variables and their expected effect on CRE yields after one-unit increase (improvement)

Variable	Academic literature	Conclusion	Research method	Expected effect on CRE yields
Macroeconomic indicators				
Interest rates	Akinsomi et al. (2018)	The positive relationship exists between changing interest rates and CRE returns across all property types, (13.10 with 1% significance level).	OLS regression	Increased (+)

Variable	Academic literature	Conclusion	Research method	Expected effect on CRE yields
	Kim et al. (2019)	A one-unit increase in long-term interest rates increases office yields.	Regression models (fixed- and random-effect)	
	Mokas & Nijskens (2019)	An increase in interest rates impact the credit quality of CRE portfolios (increasing risk and, thus, yields).	Standard logistic Probability of Default model	
	Sivitanides et al. (2001)	When interest rate rises by 100 basis points, it implies a 25 basis-point rise in the RE capitalization rate.	Time-Series Cross-Section (TSCS) model	
	Tsolacos et al. (2009)	1% change in long-term interest rates shifts retail yields 80 basis points up.	Panel model	
10-year governmental bond yields (i.e., risk free rate)	Chervachidze & Wheaton (2013)	T-bond yield has a positive and statistically significant sign across office, industrial, multifamily, and retail sectors.	Multiple regression	Increased (+)
	Clayton et al. (2009)	Cap rate changes are positively related to the Treasury yields.	Error correction models (ECM)	
	Duca & Ling (2020)	1 pp increase in the real Treasury rate, pushes yield up by >50 bps (after 2 quarters) and >60 bps (after 3 quarters).	Regression	
	Kim et al. (2019)	The increase in the risk-free rate pressures yields upward.	Regression models (fixed- and random-effect)	
Risk premium	Chervachidze & Wheaton (2013)	Risk premium causes strong positive effect on the RE pricing.	Multiple regression	Increased (+)
	Clayton et al. (2009)	Cap rate changes are positively related to changing equity risk premiums.	Error correction models (ECM)	
	Duca & Ling (2020)	1 pp increase in the risk premium pushes yield up.	Regression	

Variable	Academic literature	Conclusion	Research method	Expected effect on CRE yields
	Heinig et al. (2020)	Risk premium is mostly found to have significant positive effect on CRE yields (depending on the analyzed sector).	Cap rate modeling framework	
GDP	Akinsomi et al. (2018)	There is a negative relationship between change in GDP and CRE returns for all property types (-0.83 at 5% significance level).	OLS regression	Decreased (-)
	Heinig & Nanda (2018)	GDP (together with other macroeconomic sentiment indicators) has an adverse effect on yields.	Regression models	
	Mokas & Nijskens (2019)	GDP growth, measured by the lagged output gap, decreases riskiness (and, thus, yields).	Standard logistic Probability of Default model	
Debt to GDP	Chervachidze & Wheaton (2013)	Debt to GDP has a positive effect on asset values and a negative effect on cap rates.	Multiple regression	Decreased (-)
	Heinig et al. (2020)	The growth rate of debt to GDP significantly influences the cap rate.	Cap rate modeling framework	
Unemployment	Akinsomi et al. (2018)	There is a negative relationship between change in unemployment rate and CRE returns for all property types (-56.77 at 1% significance level).	OLS regression	Increased (+)
Inflation	Akinsomi et al. (2018)	There is a positive relationship between change in inflation and CRE returns for retail properties (0.64% at 10% significance level).	OLS regression	Ambiguous
	Blake et al. (2021)	There is no clear relationship between inflation and returns.	Regression	
	Morri & Benedetto (2019)	Unexpected inflation systematically affects the returns on CRE.	N/A	

Variable	Academic literature	Conclusion	Research method	Expected effect on CRE yields
	Sivitanides et al. (2001)	1% increase in expected inflation lowers the yield by 46 bp.	Time-Series Cross-Section (TSCS) model	
Regulations	Duca & Ling (2020)	Positive effect in the long run but negative effect for the short period considering liberalized capital regulation.	Regression	Ambiguous
FDI	Joghee et al. (2020)	FDI investor biases have a significant impact on the Dubai RE.	Bivariate regression	Decreased (-)
Force-majeures	Hoesli & Malle (2022)	COVID-19 has hit hospitality, retail, and office sectors the hardest. Other sectors have seen more price resilience.	Simple direct capitalization valuation method	Increased (+)
	Kaklauskas et al. (2021)	Recessions tend to lead to reduced space needs for companies, resulting in lower NOI.	CIRED model	
Market indicators				
(Expected) rent	Chambers et al. (2019)	During high rental growth phases, yields are lower, given investors' expectations of prolonged robust income growth in the future.	Regression	Ambiguous
	Chervachidze & Wheaton (2013)	Rent has a statistically significant negative effect on cap rates.	Multiple regression	
	Duca & Ling (2020)	Expected rent growth has a significant negative relationship with cap rates.	Regression	
	Heinig et al. (2020)	Expected rent (office) bear a negative impact on logarithm of office yields.	Cap rate modeling framework	
	Kim et al. (2019)	The real rent growth has a significant negative effect on office yields.	Regression models (fixed- and random-effect)	

Variable	Academic literature	Conclusion	Research method	Expected effect on CRE yields
	Sivitanides et al. (2001)	10% increase in real rent leads to a 56 bp drop in yields.	Time-Series Cross-Section (TSCS) model	
	Tsolacos et al. (2009)	Real rental growth has a significant negative impact on yields.	Panel model	
Vacancy rates	Akinsomi et al. (2018)	Vacancy rates have a negative relationship with capital growth for all property types (-0.32% at 5% significance level).	OLS regression	Increased (+)
	Hoesli & Malle (2022)	Values decline given higher vacancy rates.	Simple direct capitalization valuation method	
Supply	Heinig et al. (2020)	Markets with more stringent supply have lower yield levels.	Cap rate modeling framework	Decreased (-)
	Hoesli & Malle (2022)	The limited availability of completed or under construction properties worsened the impact on pricing.	Simple direct capitalization valuation method	
Idiosyncratic risk	Morri & Benedetto (2019)	Investors typically require a cost of capital that is determined by the non-diversifiable risk.	N/A	Increased (+)
Investment volumes	Clayton et al. (2009)	Capital flows, or trading activity, influence CRE returns.	Error correction models (ECM)	Decreased (-)
	Kim et al. (2019)	A lower yield level in CRE is impacted by higher liquidity.	Regression models (fixed- and random-effect)	
	Van Dijk & Francke (2021)	Liquidity is pro-cyclical to changes in asset prices.	Repeat sales model framework	

Variable	Academic literature	Conclusion	Research method	Expected effect on CRE yields
Sustainability indicator				
Green certifications	Clayton et al. (2021)	Climate change has an impact on CRE values.	N/A	Decreased (-)
	Holtermans & Kok (2019)	Certified buildings have significantly higher rental, occupancy, and pricing levels.	Repeated measure regression method	
	Mangialardo et al. (2018)	With a Gold certification, the market value increases by 7%, with the Platinum – 11%.	Linear and non-linear regression models	
	Leskinen et al. (2020)	Green certifications decrease CRE yields, indicating the sales price premium between 0-43%.	Statistical analysis	
Transaction indicators				
(Expected) NOI	Chambers et al. (2019)	Long-run growth rates of NOI translate to the long-run capital gains.	Regression	Increased (+)
	Heinig et al. (2020)	Expected NOI from RE determines yields.	Cap rate modeling framework	
Location	Morri & Benedetto (2019)	The catchment area has a significant impact on the value of CRE, varying even within a few meters.	N/A	Decreased (-)
Operating expenses	Akinsomi et al. (2018)	Operating expenses are significantly negatively related to total returns for all property types (-11.90% at 1% significance level).	OLS regression	Decreased (-)
	Chambers et al. (2019)	Operating costs lower gross yields by 20-30%.	Regression	
Investors' required rates of return (discount rate)	Duca & Ling (2020)	Investors' required rates of return are directly proportional to yields.	Regression	Increased (+)

Source: compiled by the author based on research

Table A3

Dependent and independent variables considered in the Office, Retail, and Industrial regressions

Variable	Model	Type	Abbreviation	Measurement scale	Source
Prime office yield	Office	Dependent, numeric	Yield_O	Percentage (%) per annum	CBRE Baltics (2023e)
Prime retail yield	Retail	Dependent, numeric	Yield_R	Percentage (%) per annum	CBRE Baltics (2023e)
Prime industrial yield	Industrial	Dependent, numeric	Yield_I	Percentage (%) per annum	CBRE Baltics (2023e)
Harmonized index of consumer price	Office, retail, industrial	Independent, numeric	HICP	Percentage (%) per annum	Eurostat (2023a)
Foreign direct investment	Office, retail, industrial	Independent, numeric	FDI	Million USD	Oxford Economics (2023)
Real GDP annual growth	Office, retail, industrial	Independent, numeric	GDP	Percentage (%) per annum	Oxford Economics (2023)
Interest rate, central bank policy	Office, retail, industrial	Independent, numeric	ECB	Percentage (%) per annum	European Central Bank (2023)
Interest rate, long-term government bond yields	Office, retail, industrial	Independent, numeric	GovBonds	Percentage (%) per annum	Oxford Economics (2023)
Unemployment rate	Office, retail, industrial	Independent, numeric	Unemployment	Percentage (%) of population in the labor force	Eurostat (2023c)
Country risk premium	Office, retail, industrial	Independent, numeric	CRP	Percentage (%) per annum	Damodaran (2023)
Prime rent	Office, retail, industrial	Independent, numeric	Rent	Eur/sqm/month	CBRE Baltics (2023acd)
Vacancy rate	Office, retail, industrial	Independent, numeric	Vacancy	Percentage (%) of the total stock	CBRE Baltics (2023acd)
Total stock	Office, retail, industrial	Independent, numeric	Supply	Million sqm	CBRE Baltics (2023acd)
Investment volumes to the sector	Office, retail, industrial	Independent, numeric	InvVol	Million Eur	CBRE Baltics (2023b)
Share of certified stock	Office, retail, industrial	Independent, numeric	Certified	Percentage (%) of the total stock	CBRE Baltics (2023acd)

Variable	Model	Type	Abbreviation	Measurement scale	Source
Share of A-class stock	Office	Independent, numeric	AClass	Percentage (%) of the total stock	CBRE Baltics (2023c)
Covid-19 pandemic	Office, retail, industrial	Independent, categorical	Covid	Binary: 1 – restrictions, 0 – otherwise	CBRE Baltics (2022)
Geopolitical tensions in Ukraine	Office, retail, industrial	Independent, categorical	War	Binary: 1 – ongoing tensions, 0 – otherwise	N/A

Source: compiled by the author based on research

Note: the prefix of *d_* for certain variables in the study is used to signal that the variable has been transformed to the first-order difference. The suffixes of *_O*, *_R*, and *_I* refer to office, retail, and industrial sectors, accordingly. The suffixes of *_1*, *_2*, and *_3* refer to lagged variables by 1-3 periods, respectively.

APPENDIX B – SUPPORTING MATERIAL FOR OFFICE MODEL

Table B1

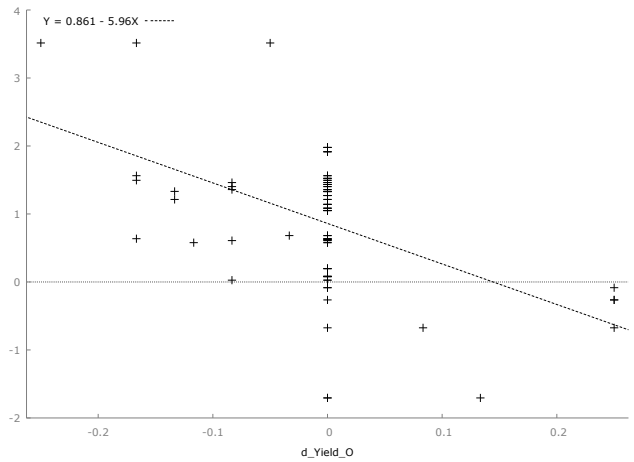
Summary statistics for Office model, using the observations January 2016-September 2023

Variable	Mean	Median	S.D.	Min	Max
Yield_O	6.19	6.12	0.504	5.33	7.00
HICP	5.24	2.83	6.47	-0.833	22.9
FDI	84.5	86.1	118.	-302.	426.
GDP	0.900	1.08	0.931	-1.71	3.52
ECB	0.448	0.000	1.16	0.000	4.75
GovBonds	1.20	0.845	1.17	0.134	4.00
Unemployment	6.86	6.67	0.905	5.50	8.63
CRP	1.25	1.19	0.251	0.910	1.63
Covid	0.204	0.000	0.405	0.000	1.00
War	0.215	0.000	0.413	0.000	1.00
Rent_O	17.1	16.9	0.953	15.8	19.7
Vacancy_O	6.75	5.61	2.34	3.96	11.2
Supply_O	2.23	2.23	0.403	1.55	2.91
InvVol_O	31.0	20.8	41.0	0.000	292.
Certified_O	40.8	41.4	2.44	36.0	44.3
Aclass_O	28.3	29.5	3.85	21.1	33.4

Source: created by the author

Figure B1

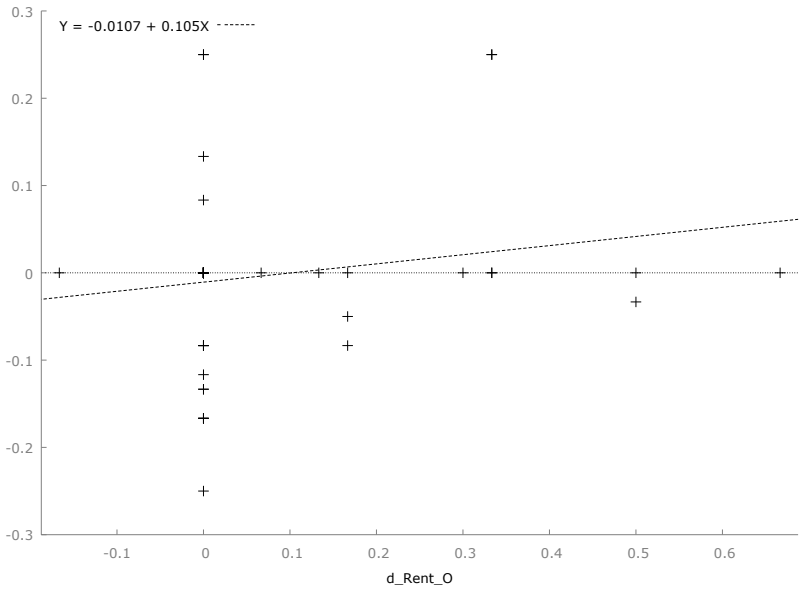
X-Y scatterplot of d_Yield_O versus GDP (with least squares fit)



Source: created by the author

Figure B2

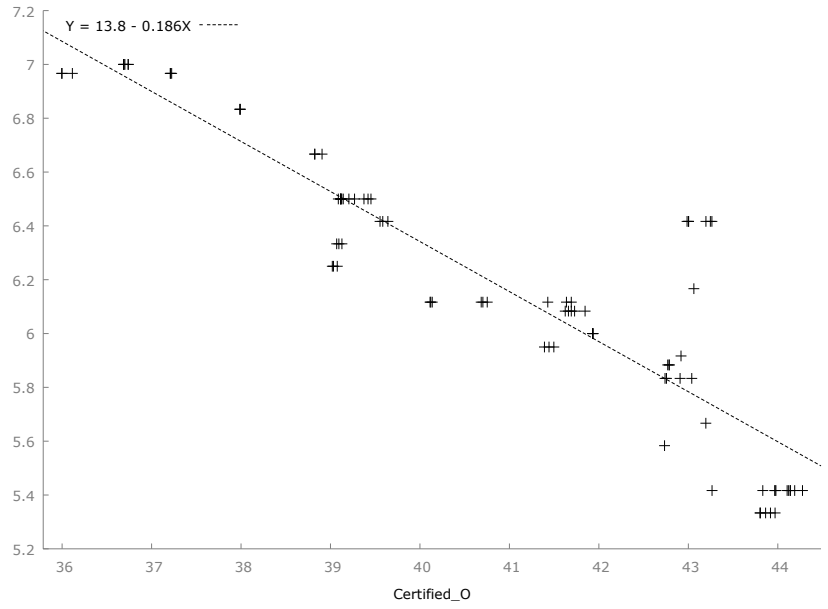
X-Y scatterplot of d_Yield_O versus d_Rent_O (with least squares fit)



Source: created by the author

Figure B3

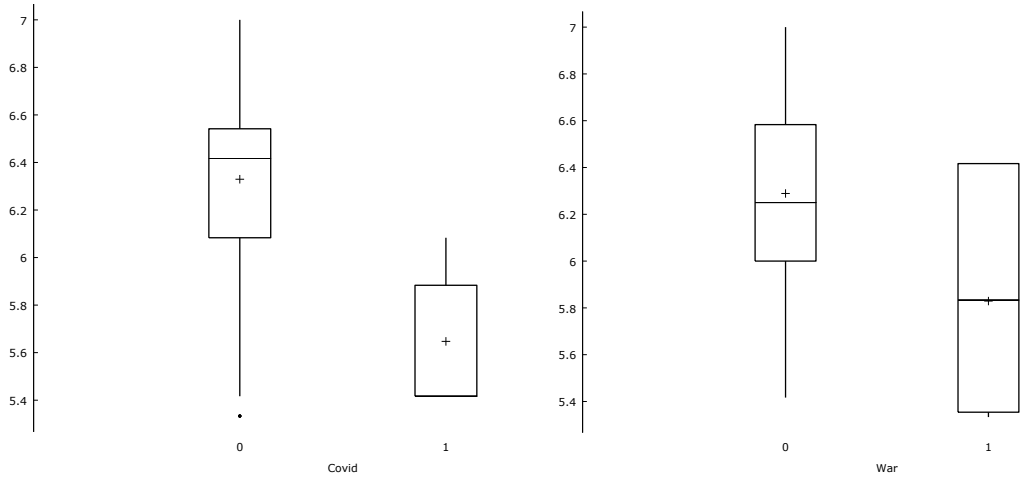
X-Y scatterplot of Yield_O versus Certified_O (with least squares fit)



Source: created by the author

Figure B4

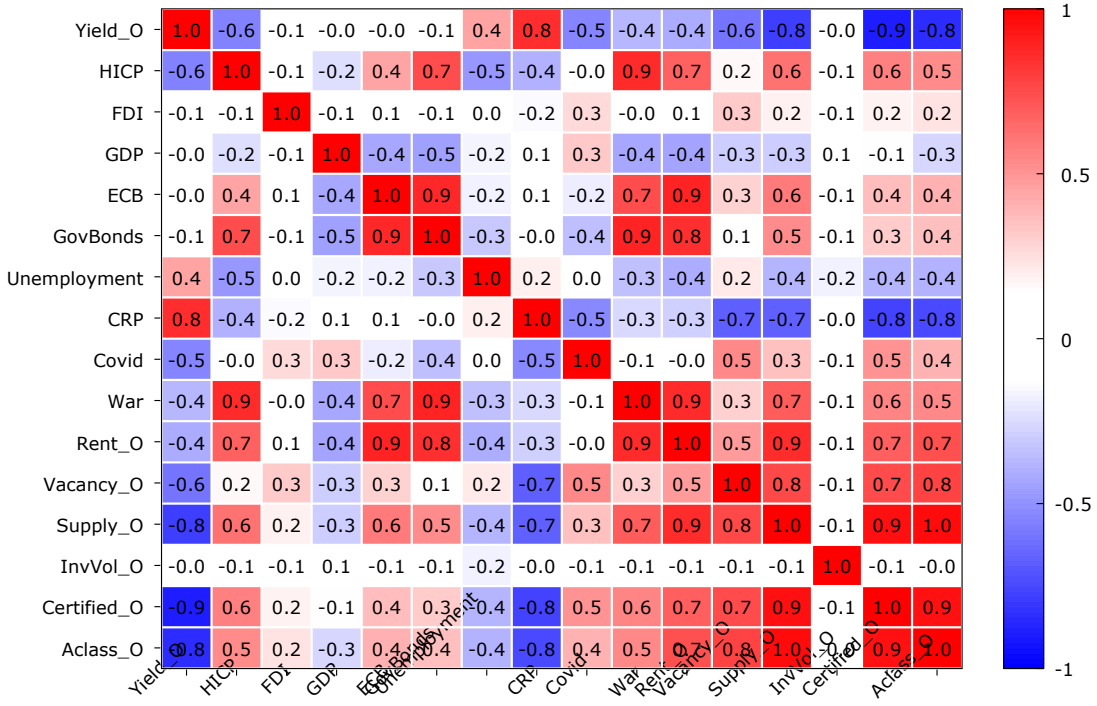
Distribution of Yield_O by Covid and War in factorized boxplots



Source: created by the author

Figure B5

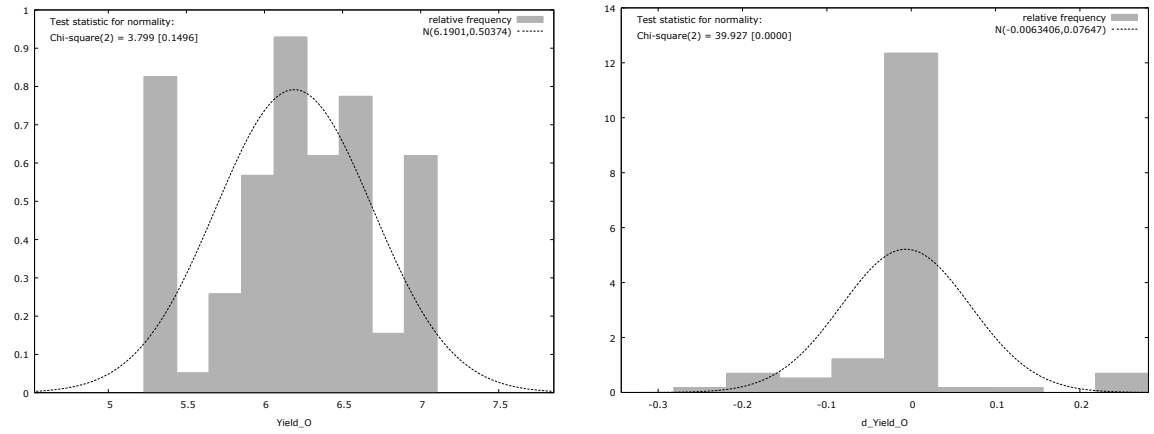
Correlation matrix for Office model



Source: created by the author

Figure B6

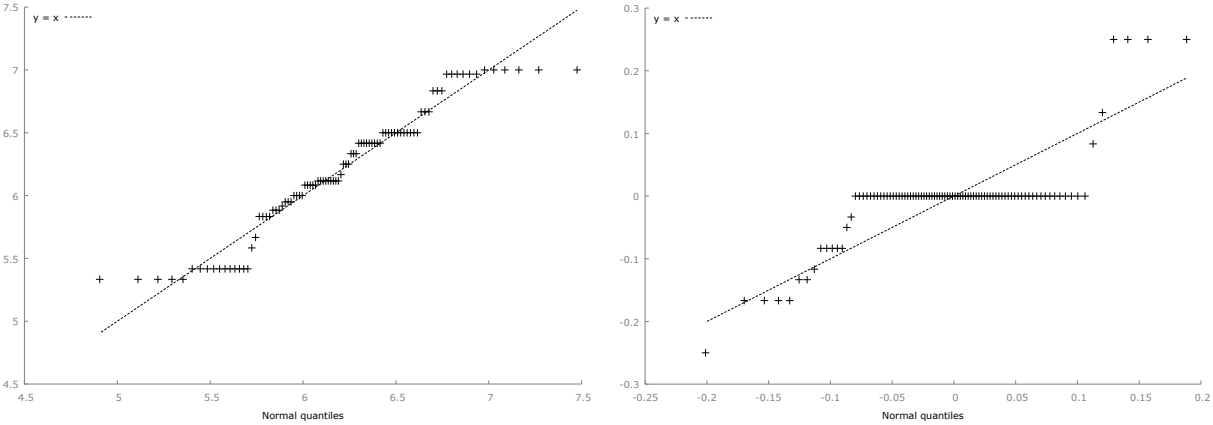
Histogram of Yield_O and d_Yield_O variables against normal distribution



Source: created by the author

Figure B7

Q-Q plot for Yield_O and d_Yield_O variables



Source: created by the author

Table B2

Normality tests for Yield_O and d_Yield_O variables

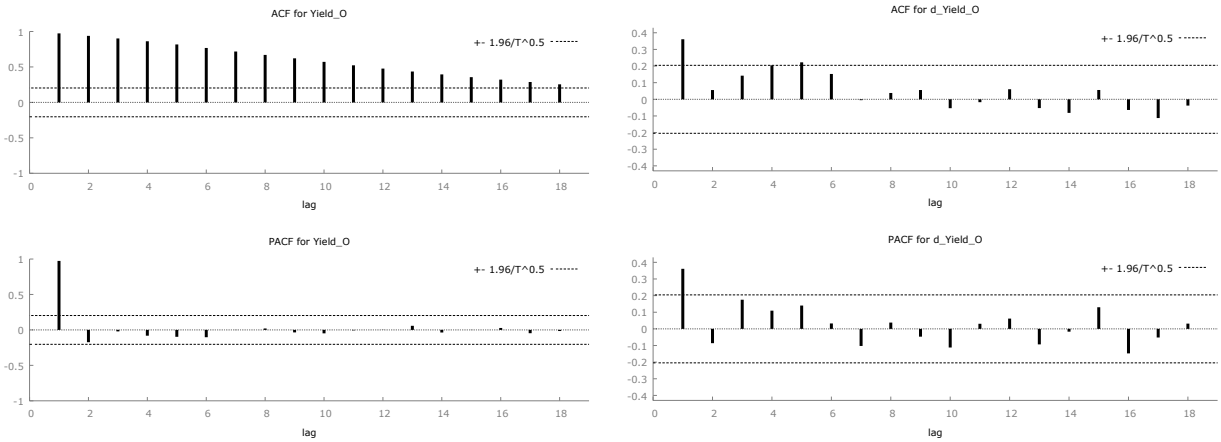
Variable	Test name	Test outcome	P-value
Yield_O	Doornik-Hansen test	3.79932	0.14962
	Jarque-Bera test	3.10364	0.211863
d_Yield_O	Doornik-Hansen test	39.9274	2.13735e-009

Jarque-Bera test	106.828	6.34747e-024

Source: created by the author

Figure B8

Correlograms for Yield_O and d_Yield_O variables



Source: created by the author

Table B3

Augmented Dickey-Fuller and KPSS tests for all variables in Office model before and after taking first differences

Variable	Augmented Dickey-Fuller test		KPSS test
	P-value with constant	P-value with constant and trends	P-value
Level values			
Yield_O	0.4545	0.9915	< .01
HICP	0.0471	0.006869	< .01
FDI	0.2162	0.5109	> .10
GDP	0.0001	0.0001	> .10
GovBonds	0.8329	0.9425	< .01
Unemployment	0.08344	0.2848	0.046
CRP	0.3445	0.8422	< .01
Rent_O	0.9889	0.7391	< .01
InvVol_O	1.513e-006	8.941e-013	> .10
Certified_O	0.5918	0.8017	< .01

Values after taking the first-order difference, where needed, to solve non-stationarity issue			
d_Yield_O	3.283e-007	4.864e-007	0.049
d_FDI	7.276e-009	8.577e-008	> .10
d_GovBonds	0.08186	0.1098	0.040
d_CRP	6.363e-008	1.23e-011	> .10
d_Rent_O	0.02049	0.7052	0.042
d_Certified_O	6.525e-007	1.704e-012	> .10

Source: created by the author

Table B4

Collinearity assessment for Office model

Independent Variable	**Variance Inflation Factors** *Minimum possible value = 1.0* *Values > 10.0 may indicate a collinearity problem*
HICP_1	4.532
d_FDI_1	1.064
d_FDI_2	1.048
d_FDI_3	1.215
GDP_1	4.265
GDP_2	7.110
GDP_3	4.585
d_GovBonds	1.825
Unemployment_1	2.755
d_CRP	1.246
Covid	2.759
d_Rent_O_1	1.639
d_Rent_O_2	1.661
d_Rent_O_3	1.831
InvVol_O_1	1.223
InvVol_O_2	1.359
InvVol_O_3	1.195
d_Certified_O	1.329
time	4.280

Source: created by the author

Table B5

Normality of residuals, heteroscedasticity of residuals, and autocorrelation for Office model

Test	**P-value**	**Null hypothesis**	**Outcome** *(considering $P \leq 0.1$)*
Test for normality of residual	0.0303297	Error is normally distributed	Reject null hypothesis
White's test for heteroskedasticity	0.350315	Heteroskedasticity is not present	Do not reject null hypothesis
LM test for autocorrelation up to order 12	0.0249481	There is no autocorrelation	Reject null hypothesis

Source: created by the author

APPENDIX C – SUPPORTING MATERIAL FOR RETAIL MODEL

Table C1

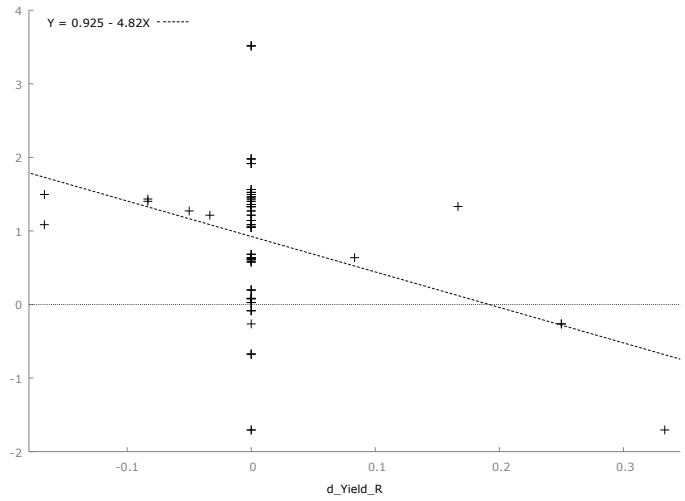
Summary statistics for Retail model, using the observations January 2016-September 2023

Variable	Mean	Median	S.D.	Min	Max
Yield_R	6.96	7.08	0.313	6.50	7.58
HICP	5.24	2.83	6.47	-0.833	22.9
FDI	84.5	86.1	118.	-302.	426.
GDP	0.900	1.08	0.931	-1.71	3.52
ECB	0.448	0.000	1.16	0.000	4.75
GovBonds	1.20	0.845	1.17	0.134	4.00
Unemployment	6.86	6.67	0.905	5.50	8.63
CRP	1.25	1.19	0.251	0.910	1.63
Covid	0.204	0.000	0.405	0.000	1.00
War	0.215	0.000	0.413	0.000	1.00
Rent_R	48.4	48.5	1.87	45.0	51.3
Vacancy_R	1.63	1.50	0.333	1.00	2.17
Supply_R	2.37	2.42	0.184	2.07	2.61
InvVol_R	27.1	13.3	38.8	0.000	213.
Certified_R	25.9	26.8	1.73	23.3	28.1

Source: created by the author

Figure C1

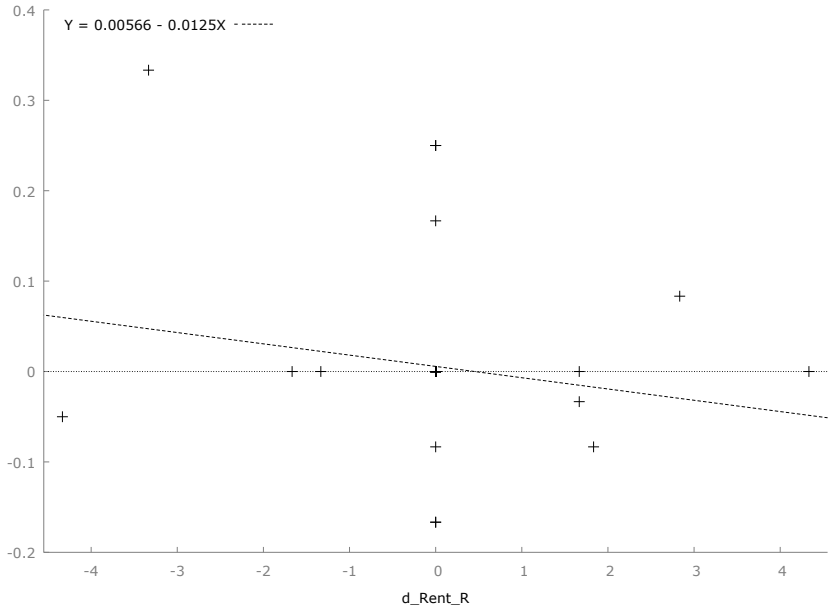
X-Y scatterplot of d_Yield_R versus GDP (with least squares fit)



Source: created by the author

Figure C2

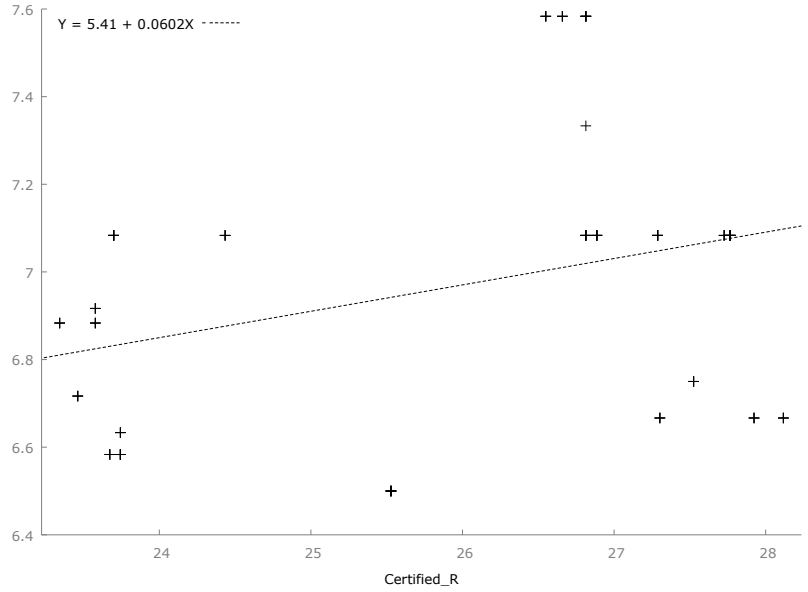
X-Y scatterplot of d_Yield_R versus d_Rent_R (with least squares fit)



Source: created by the author

Figure C3

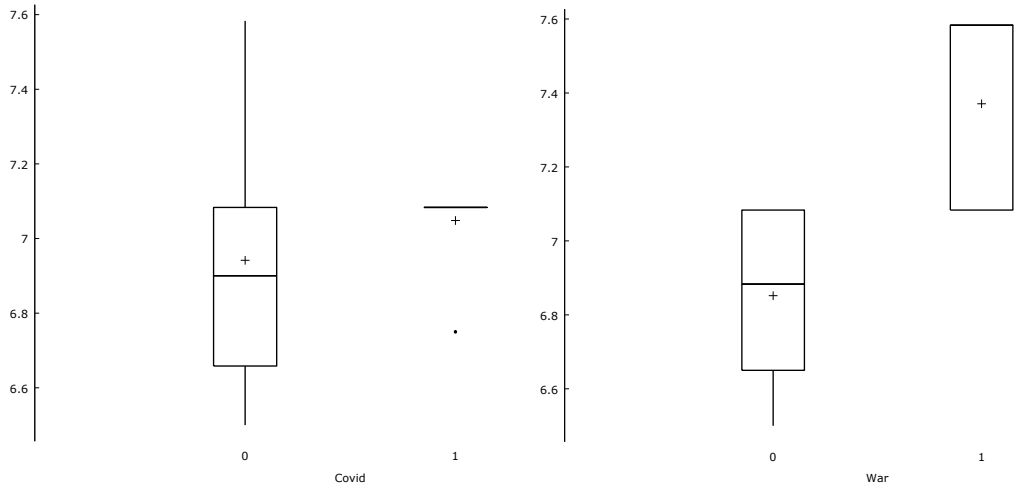
X-Y scatterplot of Yield_R versus Certified_R (with least squares fit)



Source: created by the author

Figure C4

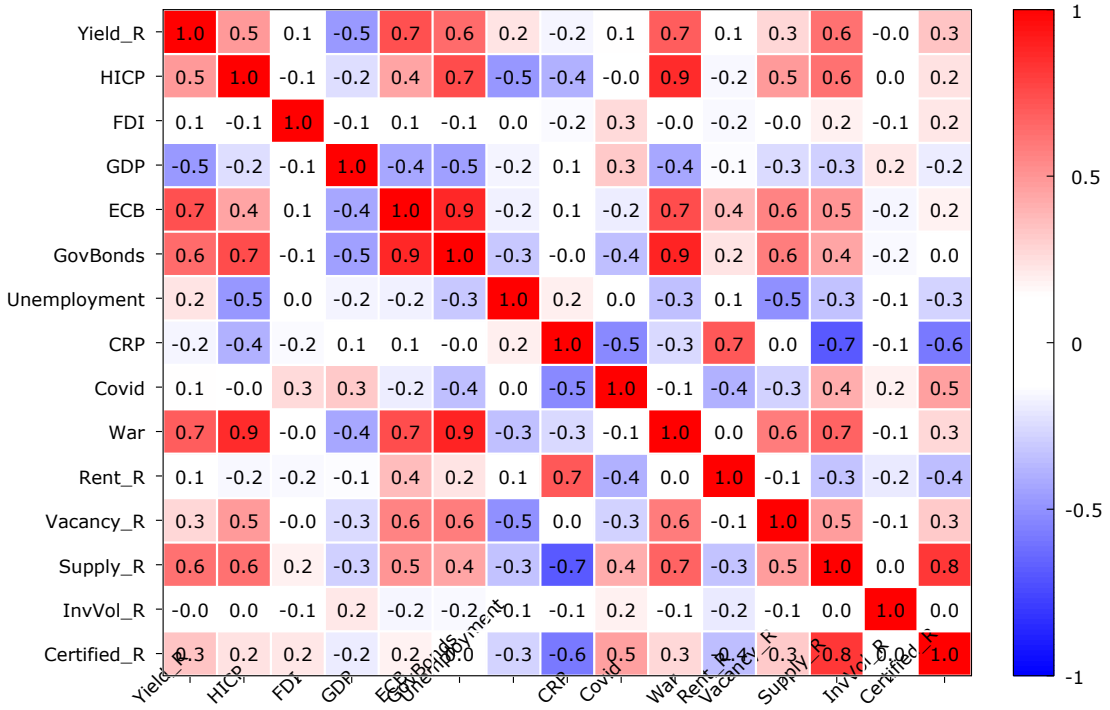
Distribution of Yield_R by Covid and War in factorized boxplots



Source: created by the author

Figure C5

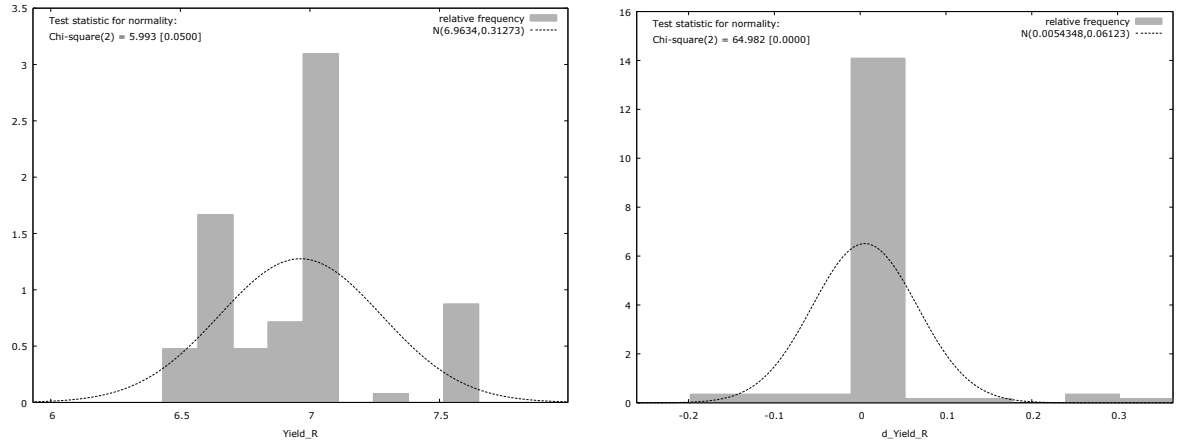
Correlation matrix for Retail model



Source: created by the author

Figure C6

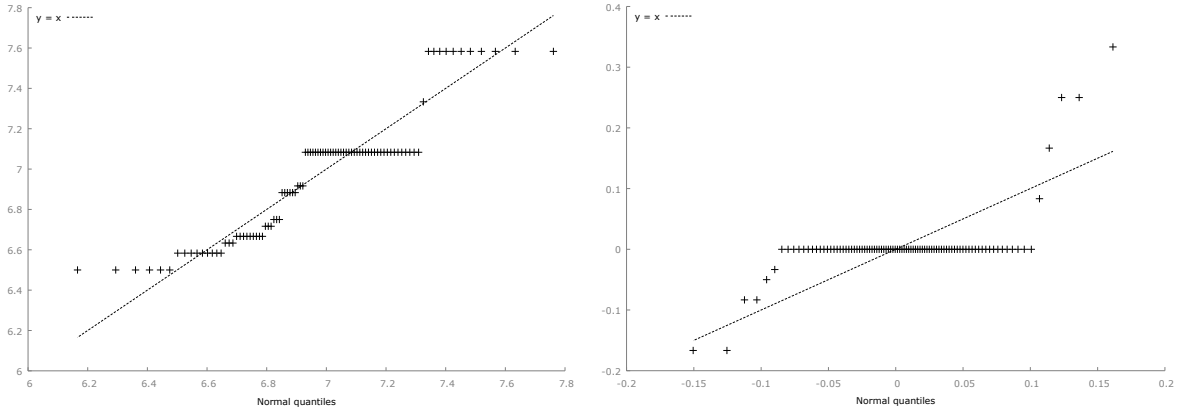
Histogram of Yield_R and d_Yield_R variables against normal distribution



Source: created by the author

Figure C7

Q-Q plot for Yield_R and d_Yield_R variables



Source: created by the author

Table C2

Normality tests for Yield_R and d_Yield_R variables

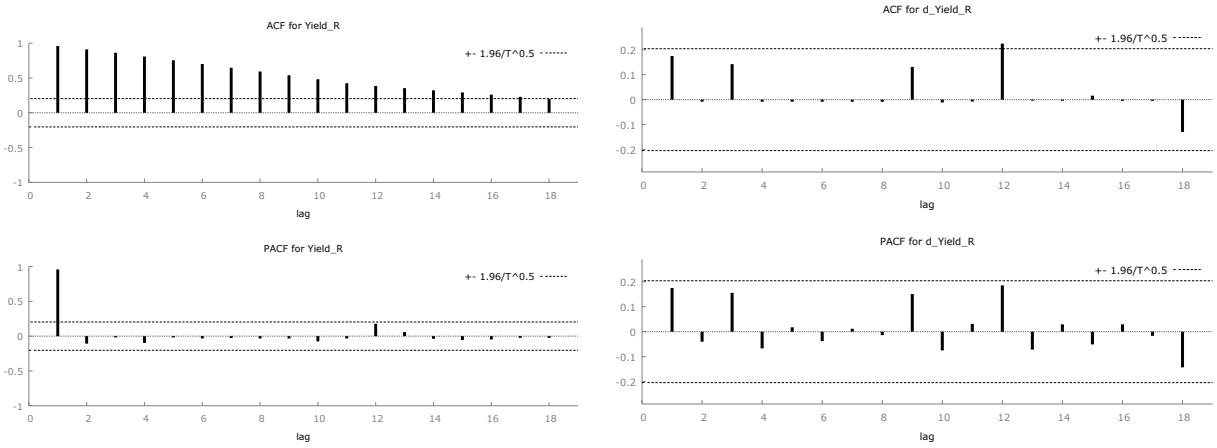
Variable	Test name	Test outcome	P-value
Yield_R	Doornik-Hansen test	5.993	0.0499616
	Jarque-Bera test	3.68372	0.158523
d_Yield_R	Doornik-Hansen test	64.9823	7.74949e-015

Jarque-Bera test	852.074	9.4289e-186

Source: created by the author

Figure C8

Correlograms for Yield_R and d_Yield_R variables



Source: created by the author

Table C3

Augmented Dickey-Fuller and KPSS tests for all variables in Retail model before and after taking first differences

Variable	Augmented Dickey-Fuller test		KPSS test
	P-value with constant	P-value with constant and trends	P-value
Level values			
Yield_R	0.9279	0.7062	< .01
HICP	0.0471	0.006869	< .01
FDI	0.2162	0.5109	> .10
GDP	0.0001	0.0001	> .10
GovBonds	0.8329	0.9425	< .01
Unemployment	0.08344	0.2848	0.046
CRP	0.3445	0.8422	< .01
Rent_R	0.2449	0.6167	0.046
Vacancy_R	0.2309	0.2427	< .01

InvVol_R	6.656e-007	1.782e-012	> .10
Certified_R	0.3348	0.7326	< .01
Values after taking the first-order difference, where needed, to solve non-stationarity issue			
d_Yield_R	1.452e-008	1.426e-009	0.058
d_FDI	7.276e-009	8.577e-008	> .10
d_GovBonds	0.08186	0.1098	0.040
d_CRP	6.363e-008	1.23e-011	> .10
d_Rent_R	6.252e-008	1.749e-011	> .10
d_Vacancy_R	4.257e-012	0.001013	> .10
d_Certified_R	0.1435	0.3098	> .10

Source: created by the author

Table C4

Collinearity assessment for Retail model

Independent Variable	**Variance Inflation Factors** *Minimum possible value = 1.0* *Values > 10.0 may indicate a collinearity problem*
HICP_1	3.584
d_FDI_1	1.357
d_FDI_2	1.328
d_FDI_3	1.318
GDP_1	4.308
GDP_2	7.286
GDP_3	5.156
d_GovBonds	1.421
Unemployment_1	2.624
d_CRP	1.177
Covid	3.774
d_Rent_R_1	1.564
d_Rent_R_2	1.522
d_Rent_R_3	1.449
d_Vacancy_R_1	1.509
d_Vacancy_R_2	1.531
d_Vacancy_R_3	1.604
InvVol_R_1	1.325
InvVol_R_2	1.435

InvVol_R_3	1.424
d_Certified_R	1.243
time	5.132

Source: created by the author

Table C5

Normality of residuals, heteroscedasticity of residuals, and autocorrelation for Retail model

Test	**P-value**	**Null hypothesis**	**Outcome** *(considering $P \leq 0.1$)*
Test for normality of residual	2.03565e-006	Error is normally distributed	Reject null hypothesis
White's test for heteroskedasticity	0.0310609	Heteroskedasticity is not present	Reject null hypothesis
LM test for autocorrelation up to order 12	0.143407	There is no autocorrelation	Do not reject null hypothesis

Source: created by the author

APPENDIX D – SUPPORTING MATERIAL FOR INDUSTRIAL MODEL

Table D1

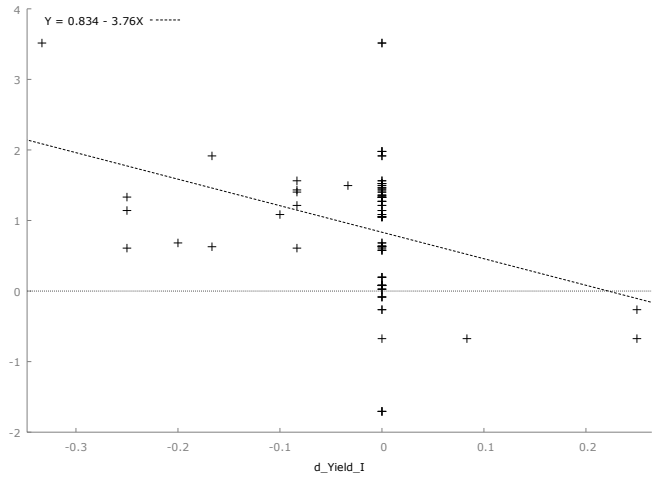
Summary statistics for Industrial model, using the observations January 2016-September 2023

Variable	Mean	Median	S.D.	Min	Max
Yield_I	7.43	7.25	0.572	6.42	8.58
HICP	5.24	2.83	6.47	-0.833	22.9
FDI	84.5	86.1	118.	-302.	426.
GDP	0.900	1.08	0.931	-1.71	3.52
ECB	0.448	0.000	1.16	0.000	4.75
GovBonds	1.20	0.845	1.17	0.134	4.00
Unemployment	6.86	6.67	0.905	5.50	8.63
CRP	1.25	1.19	0.251	0.910	1.63
Covid	0.204	0.000	0.405	0.000	1.00
War	0.215	0.000	0.413	0.000	1.00
Rent_I	5.01	4.87	0.356	4.83	5.97
Vacancy_I	2.89	2.90	0.880	1.30	4.53
Supply_I	3.99	3.95	0.630	2.92	5.14
InvVol_I	14.4	9.38	16.8	0.000	71.0
Certified_I	8.69	9.53	2.05	5.77	11.8

Source: created by the author

Figure D1

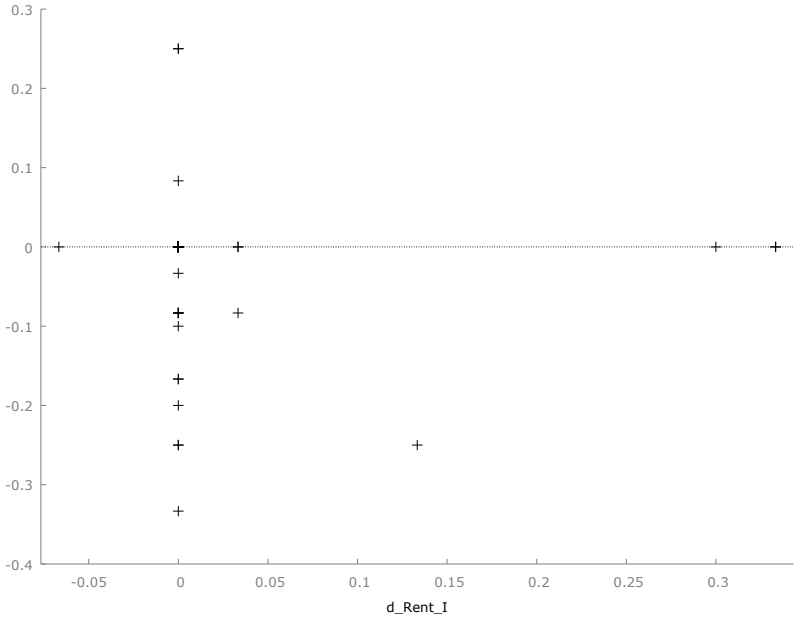
X-Y scatterplot of d_Yield_I versus GDP (with least squares fit)



Source: created by the author

Figure D2

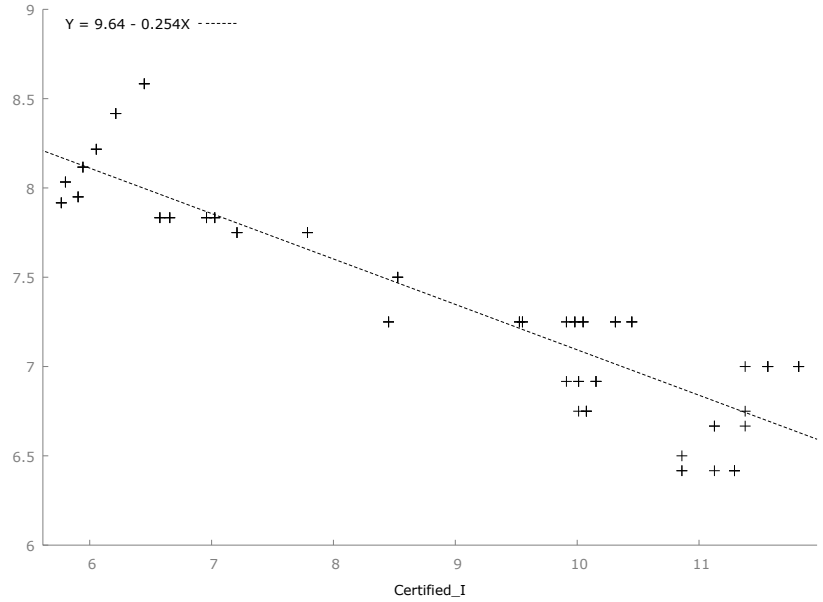
X-Y scatterplot of d_Yield_I versus d_Rent_I (with least squares fit)



Source: created by the author

Figure D3

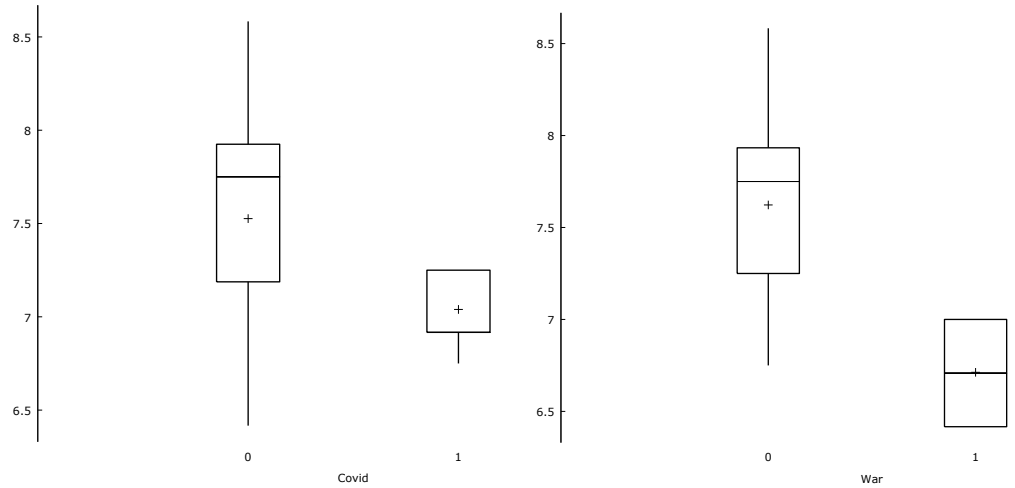
X-Y scatterplot of Yield_I versus Certified_I (with least squares fit)



Source: created by the author

Figure D4

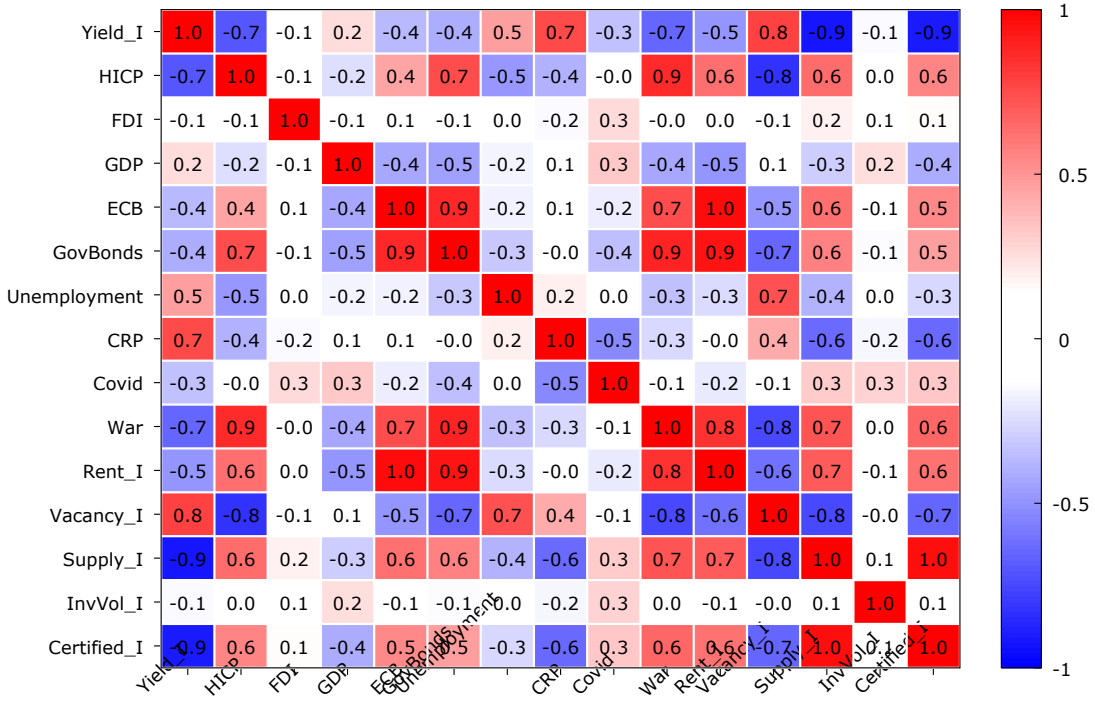
Distribution of Yield_I by Covid and War in factorized boxplots



Source: created by the author

Figure D5

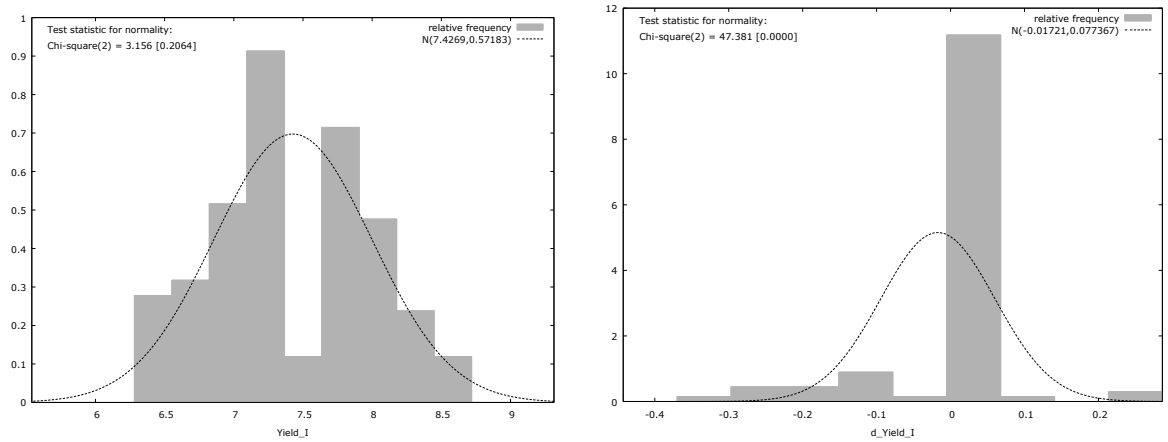
Correlation matrix for Retail model



Source: created by the author

Figure D6

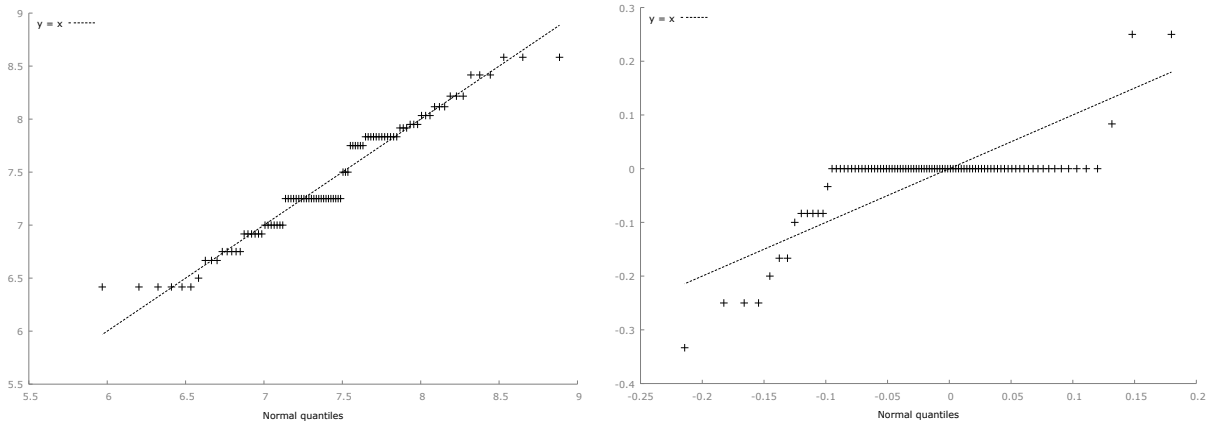
Histogram of Yield_I and d_Yield_I variables against normal distribution



Source: created by the author

Figure D7

Q-Q plot for Yield_I and d_Yield_I variables



Source: created by the author

Table D2

Normality tests for Yield_I and d_Yield_I variables

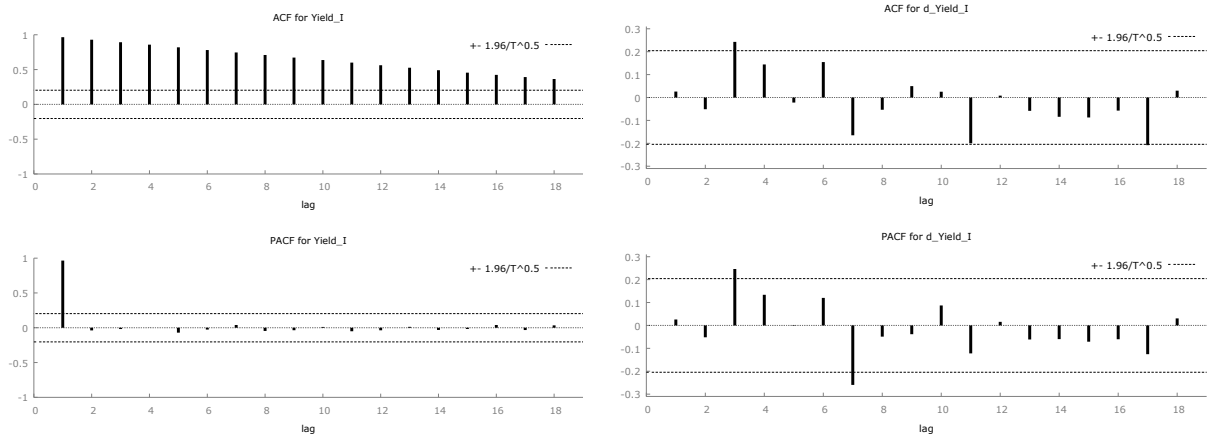
Variable	Test name	Test outcome	P-value
Yield_I	Doornik-Hansen test	3.15555	0.206434
	Jarque-Bera test	2.82534	0.243493
d_Yield_I	Doornik-Hansen test	47.3811	5.14438e-011

Jarque-Bera test	190.734	3.82439e-042

Source: created by the author

Figure D8

Correlograms for Yield_I and d_Yield_I variables



Source: created by the author

Table D3

Augmented Dickey-Fuller and KPSS tests for all variables in Industrial model before and after taking the first difference

Variable	Augmented Dickey-Fuller test		KPSS test
	P-value with constant	P-value with constant and trends	P-value
Level values			
Yield_I	0.2614	0.01198	< .01
HICP	0.0471	0.006869	< .01
FDI	0.2162	0.5109	> .10
GDP	0.0001	0.0001	> .10
GovBonds	0.8329	0.9425	< .01
Unemployment	0.08344	0.2848	0.046
CRP	0.3445	0.8422	< .01
Rent_I	0.9978	0.9989	< .01
Vacancy_I	0.4141	0.571	< .01
InvVol_I	1.587e-008	9.037e-011	> .10

Certified_I	0.9214	0.282	< .01
Values after taking the first-order difference, where needed, to solve non-stationarity issue			
d_Yield_I	0.01132	1.575e-011	> .10
d_FDI	7.276e-009	8.577e-008	> .10
d_GovBonds	0.08186	0.1098	0.040
d_CRP	6.363e-008	1.23e-011	> .10
d_Rent_I	0.01131	0.01159	0.033
d_Vacancy_I	8.054e-008	1.413e-011	> .10
d_Certified_I	2.817e-007	4.521e-012	> .10

Source: created by the author

Table D4

Collinearity assessment for Industrial model

Independent Variable	**Variance Inflation Factors** *Minimum possible value = 1.0* *Values > 10.0 may indicate a collinearity problem*
HICP_1	8.804
d_FDI_1	1.198
d_FDI_2	1.206
d_FDI_3	1.277
GDP_1	5.545
GDP_2	8.198
GDP_3	5.040
d_GovBonds	1.945
Unemployment_1	2.528
d_CRP	1.399
Covid	3.144
d_Rent_I_1	2.943
d_Rent_I_2	2.847
d_Rent_I_3	2.663
d_Vacancy_I_1	1.537
d_Vacancy_I_2	1.406
d_Vacancy_I_3	1.471
InvVol_I_1	1.446
InvVol_I_2	1.520
InvVol_I_3	1.469

d_Certified_I	1.224
time	5.035

Source: created by the author

Table D5

Normality of residuals, heteroscedasticity of residuals, and autocorrelation for Industrial model

Test	**P-value**	**Null hypothesis**	**Outcome (considering P ≤ 0.1)**
Test for normality of residual	0.0025249	Error is normally distributed	Reject null hypothesis
White's test for heteroskedasticity	0.0661774	Heteroskedasticity is not present	Reject null hypothesis
LM test for autocorrelation up to order 12	0.816329	There is no autocorrelation	Do not reject null hypothesis

Source: created by the author