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2023 **Thanh Huong Nguyen**

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The Commercial Real Estate Analysis for CEEs region

Bachelor's Thesis

Author of the Thesis: Thanh Huong Nguyen

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Supervisor: PhDr. Michal Hlaváček, Ph.D.

Year of the defence: 2023

Declaration

1. I hereby declare that I have compiled this thesis using the listed literature and resources only.
2. I hereby declare that my thesis has not been used to gain any other academic title.
3. I fully agree to my work being used for study and scientific purposes.

In Prague on 3 January 2023 Thanh Huong Nguyen

References

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Abstract

This research examines the evolution of the commercial office sector in Central and Eastern European countries, which have experienced long-term and substantial increases in real estate prices in recent years. A error correction model was constructed to examine the connection between property prices and macroeconomic variables. The model considers both demand and supply factors impacting the market. The study utilizes fixed effects models and an error correction model to analyze the prices of commercial properties in the CEE region.

Abstrakt

Tento výzkum zkoumá vývoj sektoru komerčních kanceláří v zemích střední a východní Evropy, které v posledních letech zaznamenaly dlouhodobý a výrazný růst cen nemovitostí. Pro zkoumání souvislosti mezi cenami nemovitostí a makroekonomickými proměnnými byl sestaven model korekce chyb. Model zohledňuje jak poptávkové, tak nabídkové faktory ovlivňující trh. Studie využívá modely fixních efektů a model korekce chyb k analýze cen komerčních nemovitostí v regionu střední a východní Evropy.

Keywords

Commercial Real Estate, CEE region, determinants of commercial property prices, financial stability,commercial property prices

Klíčová slova

Komerční nemovitosti, CEE regiony, determinanty cen komerčních nemovitostí, finanční stabilita, ceny komerčních nemovi tostí

Title

The Commercial Real Estate Analysis for CEE regions

Název práce

Analýza komerčních nemovitostí CEE regionů

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2. Introduction

The real estate market in Central and Eastern Europe (CEE) is diverse and has experienced significant growth in recent years. Many CEE countries have seen an increase in foreign investment. As a result, the commercial real estate market has reached its highest peak since 2008 in recent years.

Therefore, there is increased interest and research on commercial real estate in the Central and Eastern European (CEE) region. These studies or research are often conducted by real estate companies such as JLL, Colliers, Cushman & Wakefield, Knight Frank, and CBRE are used by non-bank financial institutions as a tool to assess loan defaults for small and medium-sized enterprises. The CNB also addresses commercial real estate market trends in its annual report on financial stability. However, data on commercial properties are often less readily available than on residential properties, and commercial properties can have more specific characteristics that make them challenging to analyse. Real estate agencies may only provide information on commercial property prices upon request or to their clients, and commercial properties may require more specialized analysis due to their unique features.

This thesis investigates the relationship between the office space market and financial stability. Despite the importance of the commercial real estate sector, there have been relatively few empirical analyses specifically examining the office space market. This dearth of research may be partially attributed to the historically low levels of transparency and credibility in data on commercial real estate, particularly in certain countries. However, recent improvements in transparency in countries like the Czech Republic and Poland have facilitated the examination of this topic. The primary objective of this study is to contribute to the existing literature by examining the determinants of the office space market and exploring the potential impact of market fluctuations on financial stability. In addition, the results of this research may serve as a helpful tool for financial institutions seeking to make informed predictions about future market trends.

It is important to note that this thesis focuses on the real estate market in the Central and Eastern European (CEE) region and is based on data collected prior to the outbreak of the Covid-19 pandemic. As such, the statistical analysis does not account for the impacts of the pandemic on the CEE real estate market, which has not yet to fully recover from these effects. This thesis aims to provide a snapshot of the CEE real estate market prior to the

pandemic and to identify key trends and factors that may have influenced the market at that time[1].

Certainly, it is worth considering the potential impacts of the Covid-19 pandemic on the CEE real estate market in future research. This could provide valuable insights and contribute a more comprehensive understanding of the market and its dynamics. The financial crisis of 2008 was the last major crisis to affect the global economy, and research on the real estate market in the aftermath of that crisis has been instrumental in advancing our understanding of the market. By including data on the Covid-19 pandemic and its effects on the CEE real estate market, future research could build on this foundation and provide additional insights into the market and its resilience in the face of global economic challenges.

This thesis begins with a review of the relevant literature on the real estate market in the Central and Eastern European (CEE) region. In the following chapter, we provide an overview of the real estate market in the CEE region, with a focus on commercial real estate. We then delve into the specific indicators and macroeconomic factors that impact the commercial real estate market in the CEE region. The second to last chapter outlines the methodology we have used in this research, and the final chapter presents the results of our analysis.

[1] Another reason why this study may not include data on the impacts of Covid-19 on the commercial real estate market is the complexity of the market itself. Moreover, during Covid-19, regulatory or structural issues, such as restrictions on real estate, can also influence market conditions. In order to gain a more comprehensive understanding of the market and its dynamics, it is important to consider the full range of factors that can influence the market. This can be a challenging task, as these factors may interact in complex ways and may not be easy to disentangle. Therefore, it is really worth addressing as a tremendous topic itself.

3. Literature review

There has been a relatively limited number of studies conducted on the commercial real estate market in the Czech Republic compared to foreign publications on the topic. This may be due to various factors, including the availability of data for analysis, the quality of the data, and the limited time series available for study. Despite this, several institutions, and companies, such as the Czech ARTN association, JLL, Colliners, Cushman & Wakefield, CBRE, Knight Frank, and regional companies, have been engaged in research on the commercial real estate market. These organizations often publish reports summarizing market analyses, including information on take-up, prime rents, yields, and vacancy rates. However, these reports may not be easily accessible to the public and may only be available for a specific time period or on request. In addition, the Czech National Bank (CNB) has been focusing on the real estate market in Central and Eastern Europe (CEE) since 2004 and publishes an overview of the market in its annual Financial Stability Report.

A few literature sources that address similar research questions or studies that have inspired this thesis are mentioned in this section.

One of the early studies to examine the relationship between commercial real estate prices and bank performance is Davis and Zhu (2004). Using data from a sample of banks in the United Kingdom, this paper investigates the relationship between commercial property prices and bank performance. The authors find a positive relationship between commercial property prices and bank performance, with higher commercial property prices being associated with better performance by banks. They also find that the relationship between commercial property prices and bank performance is stronger for banks with a higher degree of exposure to commercial real estate lending. These findings suggest that banks with a larger proportion of their loan portfolio invested in commercial real estate may be more sensitive to changes in commercial property prices. The authors of this study also discuss the implications of their findings for policymakers and banks. They argue that policymakers should be aware of the link between commercial property prices and bank performance, as changes in property prices can have important consequences for the banking sector's stability. They also suggest that banks consider

their exposure to commercial real estate when making lending decisions to manage their risk more effectively. In a subsequent study published in 2005, Davis and Zhu expanded on these findings and argued that their research has implications for monetary policy and financial stability. They suggest that movements in commercial property prices can affect the financial system's stability, and that in countries with more developed financial systems and more liquid property markets, the relationship between commercial property prices and bank performance tends to be stronger. Overall, these studies highlight the importance of considering the relationship between commercial real estate prices and bank performance to understand the impacts of changes in property prices on the financial system's stability.

Another study by Davis and Zhu (2004) examines the relationship between bank lending and commercial property cycles in various countries. The paper discusses the role of banks in financing commercial property markets and how changes in bank lending can affect commercial property prices. Using data from a sample of advanced and emerging economies, the authors provide empirical evidence on the relationship between bank lending and commercial property cycles and the impact of these cycles on bank performance and financial stability. The authors found that when bank lending increases, commercial property prices tend to rise, and when bank lending falls, commercial property prices tend to fall. However, the strength of this relationship varied across countries. They also found that the nature of the relationship between bank lending and commercial property cycles depended on the phase of the business cycle. The relationship was typically positive during expansions, with increased lending leading to higher property prices. However, the relationship was often negative during recessions, with reduced lending leading to lower property prices.

In a subsequent study published in 2009, Davis and Zhu built on their previous research using data from a sample of U.S. banks from the FDIC's Financial Institution Directory for the period from 1980 to 2004. They employed panel data models with fixed effects to control for unobserved heterogeneity among banks and conducted various robustness checks to ensure the reliability of their results. In addition, the authors used multiple measures to assess the performance of banks, including return on assets, return on equity, and net interest margin, and controlled for other factors that could affect bank performance, such as the level of non-performing loans and bank size. They also used

data on commercial property prices from the National Council of Real Estate Investment Fiduciaries (NCREIF) Property Index. The results of this study suggest that changes in commercial property prices can significantly impact the performance of banks, particularly for those with high exposures to commercial real estate loans. The authors also found that the impact of changes in property prices on bank performance is stronger during periods of economic downturns, such as recessions. During economic downturns, demand for commercial real estate tends to decline, leading to a decrease in property values and potentially causing losses for banks with large exposures to commercial real estate loans. Overall, these studies highlight the importance of considering the relationship between commercial real estate prices and bank performance in order to understand the impacts of changes in property prices on bank performance and financial stability.

In a study published by Gyourko (2009), the author discusses the characteristics of commercial real estate and how it differs from residential real estate. Gyourko argues that commercial real estate is typically more complex and less transparent than residential real estate, and as a result, it may be more difficult for investors to value accurately. He also notes that the demand for commercial real estate is typically more sensitive to economic conditions than the demand for residential real estate, as businesses are more likely to reduce their real estate investments during economic downturns. Gyourko's article provides insight into the differences between commercial and residential real estate and the factors that may influence the demand for each type of property. For example, in terms of economic sensitivity: The demand for commercial real estate is typically more sensitive to economic conditions than the demand for residential real estate. Businesses may be more likely to reduce their real estate investments during economic downturns, which can lead to a decline in commercial real estate prices. In his article, he also mentioned that commercial real estate is a crucial component of the economy and can play a significant role in the overall performance of financial markets.

Goetzmann et al. (1999) discuss the performance of global real estate markets and how they are influenced by economic and market cycles and fundamental factors such as supply and demand. In this article, the authors also examine the global real estate market and the factors influencing real estate prices. They use data on real estate prices,

macroeconomic variables, and real estate market fundamentals such as rental rates and occupancy rates from the 1970s to the 1990s to analyse the cross-country differences in the performance of real estate markets. The authors find that real estate markets tend to be cyclical, with periods of growth followed by periods of decline. They argue that various factors, including economic conditions, interest rates, and demographic trends, influence real estate market performance. The article provides insight into the global real estate market and the factors influencing real estate prices.

A study written by Quan and Titman (1999) examines the relationship between real estate prices and stock prices in a sample of six countries: the United States, Canada, Japan, the United Kingdom, Australia, and New Zealand. They use data on real estate prices, stock prices, and macroeconomic variables from the early 1970s to the mid-1990s to analyse the cross-country differences in the strength and nature of this relationship. The authors find that in most of the countries in their sample, there is a positive relationship between real estate prices and stock prices. In other words, when real estate prices rise, stock prices also tend to rise, and when real estate prices fall, stock prices tend to fall. However, the strength of this relationship varies across countries. The authors also find that the relationship between real estate prices and stock prices depends on the stage of the business cycle. The relationship is typically positive during expansions, as rising real estate prices lead to rising stock prices. However, the relationship is often negative during recessions, as falling real estate prices lead to falling stock prices. Overall, Quan and Titman's article provides insight into the relationship between real estate prices and stock prices in different countries and the factors that may influence this relationship.

Sanderson, Farrell, and Thoday (2006) describe in their research the dynamics of global office markets by analysing the relationship between rental growth and vacancy rates in a sample of major office markets around the world. The rental growth is described as a result of an adjustment process between the supply of and demand for rental properties. In their study authors used model the first difference of rental rates (the change in rental rates over time) using the lagged vacancy rate as a measure of the disequilibrium between supply and demand to identify the factors that drive rental growth in different office markets and to estimate natural vacancy rates at the city and regional level.

Laurin et al. (2010) The authors of the study sought to determine whether investors had accurately valued office property markets in CEE cities. They used regression analysis to estimate the predicted property prices and capitalization rates for each CEE city based on the cities' actual real estate and economic conditions, using data from Western European cities as a reference point. The study's results showed that investors' valuations of office properties in CEE cities were similar to the expected values calculated using real estate and economic fundamentals. The authors also found that macroeconomic factors had a larger impact on property prices in CEE cities compared to Western European cities. The authors conclude that these findings have implications for investors and developers looking to enter the CEE office market and for policy makers seeking to understand and address the drivers of property price fluctuations in the region.

Iacoviello (2002) finds a positive relationship between house prices and business cycles in most countries in his sample. In other words, house prices rise during expansions and fall during recessions. Iacoviello also finds that other macroeconomic variables, such as interest rates and inflation, affect the relationship between house prices and business cycles. He argues that these variables can influence house prices by affecting housing affordability and real estate attractiveness as an investment. Since Gyourko (2009) argues that there are common characteristics between residential and commercial real estate, the variables presented in the author's study are used in this thesis.

Hilbers, Lei, and Zacho (2001) explore in their study the relationship between real estate market fluctuations and the financial sector's stability. The authors analyse the significance of real estate in the economy and its potential impact on the financial sector. Additionally, they address the risks and challenges that may arise during times of instability in the real estate market and offer suggestions for mitigating these risks. Authors use a probit-logit model to analyse the potential contribution of property price movements in the real estate market to the observed financial sector. The paper concludes that imbalances in real estate prices frequently contribute to financial sector distress and recommends closely monitoring trends in real estate markets as part of financial sector assessments.

In terms of literature in the Czech, there is a few studies mainly published by Michal Hlaváček with his co-authors. For example, a study published by Hlaváček et al. (2016) conducted a study to understand the factors that influence the development of the office property market in five CEE countries and how these markets compared to that of Germany. They used an error correction model to examine the relationship between office property prices and various macroeconomic, demographic, and structural determinants. The analysis showed that both demand-side factors, such as GDP and inflation, and supply-side factors, such as the total stock of office space, impacted property prices. The study also found that the maturity of the credit market may play a role in property prices. In addition, the model suggested that office property prices may have been overvalued between 2006-2008 and that office space in the Czech Republic may be slightly undervalued. This research provides valuable insight into the factors that shape the office property market in CEE regions and the potential implications for financial stability. It should be noted that this thesis is based on this study.

3. Overview

3.1 Real estate market

Real estate plays a crucial role in the economy, as evidenced by its ability to influence other financial instruments and economic indicators. According to Brooks & Tsolacos (2010), the real estate market is known for its volatility. There are several unique characteristics of the real estate market that contribute to this. Miles (1994), Lux et al. (2010), and DiPasquale & Wheaton (1996) highlight the following features:

- Heterogeneity: No two properties are the same, even if they are similar in size, construction, or age. This is due in part to the fact that location plays a significant role in the value of real estate. As a result, it is difficult to accurately value properties and there is often an asymmetry of information in the market. This can be mitigated using specialists, such as surveyors and estate agents, but these services come at a high transaction cost.
- High transaction costs: In addition to the cost of the property itself, there are other costs associated with real estate transactions, including property taxes and services like surveys and appraisals.
- Low number of transactions: Due to the high cost of properties and the asymmetry of information in the market, there are fewer real estate transactions compared to other markets.
- Longevity: Real estate tends to depreciate more slowly than other assets, and in some cases the value of a property can increase over time due to location attractiveness. As a result, real estate is often considered a sound investment.
- Dual market: A property can function as both an investment and a consumer good, with the two markets influencing each other (DiPasquale & Wheaton, 1996). For example, someone who rents a property is functioning as a consumer, while someone who buys a property may also be acting as an investor.
- Inelastic supply: The high cost and time required for construction leads to a slow response of supply to changes in demand and prices. This can result in either increasing prices when demand is high or unoccupied properties when demand wanes.
- Collateral: Real estate is often high in value and can be used as collateral for mortgages. This reduces the perceived risk to the lender and may result in more favourable loan terms.

- Externality: An externality is a cost or benefit that is incurred or received by a party that did not directly participate in the transaction Lux et al. (2010). Real estate externalities can have both positive and negative impacts. For example, the construction of a shopping centre near a property may increase the value of that property over time.

These characteristics can have negative effects on the efficiency of the real estate market, both on the demand and supply sides. As a result, market equilibrium is often an ideal rather than a reality.

The real estate market in the CEE region is diverse and multifaceted, with each country having its own unique set of characteristics that influence its market. Some of the key factors that can impact the real estate market in these countries include economic and political stability, the level of development, access to financing, and overall demand for properties. Additionally, the legal and regulatory frameworks in each country can also play a role in shaping the market. For example, some countries in the CEE region may have more lenient regulations regarding foreign investment in real estate, while others may have more restrictive policies. Therefore, it is important for example, for investors to carefully research and understand the specific market conditions in each country before making any real estate investments.

In recent years, the Central and Eastern European (CEE) region has experienced strong economic growth, which has had a positive impact on the real estate market. This growth has been driven by both foreign investment and domestic demand for real estate. However, the Covid-19 pandemic has had a significant impact on the global economy, and the real estate market in the CEE region has not been spared from these effects. The specific impact of the pandemic on the real estate market in the CEE region has differed across countries, but it has disrupted supply chains, reduced demand for certain types of real estate, and caused economic uncertainty. These developments have had implications for the stability of the market and will likely continue to shape the market in the coming years.

3.2 Types of commercial real estate

As mentioned, the focus of this thesis is on the commercial real estate market, specifically the office market. However, it is appropriate to provide a general overview of the various types of commercial real estate. Commercial real estate refers to properties that are used for business purposes, including the sale, lease, or use of the property for profit. This includes not only office buildings and retail spaces, but also multifamily housing and other types of properties. According to Lineman (2011), commercial real estate can be classified into the following categories:

- **Retail:** properties that are used for the sale of goods and services to the public, such as malls and shopping centres. Retail properties come in a wide range of sizes and types, from large regional shopping centres to small individual stores. These properties may offer a variety of goods and services to the public and may be occupied by multiple tenants or a single tenant. It is common to find retail space located on the first floor of office buildings in major cities or combined with office space in mixed-use buildings. Retail properties may be in busy areas with high foot traffic, or in more remote locations with the goal of attracting customers from a wider area.
- **Industrial:** properties that are used for the manufacturing, distribution, or storage of goods, such as warehouses and factories. These properties may include special-purpose buildings designed specifically for industrial use, as well as warehouse and showroom spaces. Industrial and warehouse properties may be used for light or heavy manufacturing and may also be occupied by wholesale distributors. Older buildings that were originally designed for office use may be repurposed as warehouse or light industrial space. Industrial and warehouse properties may be located in industrial areas or near transportation hubs to facilitate the movement of goods.
- **Office:** properties that are used for administrative or professional purposes, such as office buildings and medical centres. Office buildings can vary in size, ranging from smaller buildings that only occupy a single floor to large skyscrapers that contain multiple floors and tenant spaces. They may be located in central business districts or in other areas and can be designed to cater to the needs of a single tenant or multiple tenants. These buildings may offer amenities such as conference

rooms, shared spaces, and on-site maintenance and security. The location and design of an office building can be important factors in attracting tenants and determining the value of the property.

- **Others:**
    - Hospitality: properties that are used for short-term accommodation, such as hotels and resorts. Hotels and motels can vary significantly in terms of size and amenities offered. Smaller hotels and motels, often located near major highways, may have limited amenities, and cater primarily to business travellers or families seeking overnight accommodation. Larger hotels, particularly those located in tourist destinations or resorts, may offer a range of amenities such as dining facilities, swimming pools, and recreational activities. These hotels may attract guests who plan to stay for an extended period of time. Hotels that cater to convention business may be located near major cities or in popular tourist destinations and may offer a variety of dining options and recreational activities to accommodate the needs of convention attendees.
    - Special purpose: refers to properties used for unique or specialized purposes, such as schools, churches, and government buildings, clubs, marinas, sports complexes, gas stations, and car washes etc.

Office spaces/ office buildings

The following description will deal in more detail with the office sector as this work will focus more on prime office buildings. It will therefore be appropriate to mention what the various types of offices are.

There are several ways to classify office buildings, including by size, design, construction type, and location. In more detail:

- Size: Office buildings can be classified by size, such as small, medium, or large. This can be determined by the number of floors, square footage, or number of tenants.
- Design: Office buildings can be classified by design, such as traditional, modern, or eco-friendly. This refers to the appearance and layout of the building, as well as the materials used in its construction.

- Construction type: Office buildings can be classified by construction type, such as high-rise, mid-rise, or low-rise. This refers to the height of the building and the number of floors it has.
- Location: Office buildings can also be classified by location, such as urban, suburban, or rural. This refers to the location of the building and the surrounding area.

3.3 Commercial market linkage

In general, market linkages refer to the relationships and connections between different markets. These linkages can have a significant impact on the prices and performance of firms and assets in those markets. In terms of commercial real estate, market linkages refer to the relationships and connections between different real estate markets.

According to Ball et al. (1998), the commercial real estate market consists of four interconnected markets: the user market, the financial market, the development market, and the land market. The user market, which encompasses the demand for commercial real estate by businesses and other organizations, drives the utilization of properties such as office buildings. The financial market involves the investment and financing activities that support the development and operation of commercial real estate. The development market encompasses the planning, construction, and improvement of commercial real estate projects, including office buildings. The land market encompasses the supply and demand for land suitable for commercial development.

In the context of the office space market, the user market refers to individuals or companies renting office space for their business activities, while the development market involves investors funding the construction of new office buildings to meet increased demand. The availability and price of land can impact both markets, as development projects may compete and with existing properties for access to land. In addition to serving as a physical location for business operations, office space can also be understood as a financial asset, with risk and return characteristics that can be analysed in the financial market. The maintenance and modernization of office space may also be a consideration, as offices may experience wear and tear and become technologically obsolete over time. Implicit rent may be incurred when an individual or company acts as both landlord and tenant for their office space.

The interrelationships between various commercial markets can have significant implications for a variety of stakeholders, including investors, developers, policymakers, and analysts. Examining the linkages between the user market, where office space is rented for business operations, and the development market, where new office buildings are constructed to meet demand, can provide valuable insights for decision-making and risk assessment. In addition, the relationship between land availability and price and the user and development markets can have significant bearing on the feasibility and potential returns of development projects. By studying the connections between commercial markets, it is possible to gain a deeper understanding of the economic impacts and trends within these markets-

3.4 Market overview of CEEs region in recent years

The emergence of shared offices[2] and coworking spaces in 2018 had a significant impact on the office market and the way in which offices are utilized. Another trend in recent years is the adoption of green building technology.

The global event of Covid-19 has had a widespread impact on various sectors, including the real estate market. In the commercial real estate sector, retail stores were the most heavily affected, followed by offices. However, the logistics market saw a positive impact as the increase in online shopping and the need for larger warehouses for delivery companies led to a high demand for logistics areas.

Situation in each CEE region before and after global event (such as Covid-19) will be described in more detail below. The following information is described mainly based on research published by institutions such as ARTN, JLL, CBRE etc.

The Czech Republic

Prior to the emergence of Covid-19, the Czech Republic's real estate market demonstrated favourable trends. The vacancy rate in 2018 and 2019 was approximately 5%, the lowest it had been in two decades, with a similar level last seen in 2007. In 2019, prime rent was 22-23 EUR/m2, a trend that had been steadily increasing since 2015. In 2019, over

[2] ARTN 2020

200,000 sqm of office space were completed, bringing the total supply of office space in Prague to 3.7 million sqm. In 2020, 171,8 thousand sqm of space under construction was allocated. However, the global pandemic of Covid-19 had unanticipated consequences on the real estate market and society at large. When the Covid-19 hit the Czech Republic in March 2020, the government declared a state of emergency, leading to a transition for many employees to working from home and conducting business online. As a result, offices became largely empty and lost some of their value. To reduce costs, some companies turned to offering subleases, which are shorter-term rentals at a lower price than a traditional lease and often come fully furnished. Despite the challenges posed by the pandemic, prime rent remained stable in 2020, although the vacancy rate did increase to 7%. The shift towards remote work has also led to a revaluation of companies' space needs, with a focus on smaller, more flexible spaces.

In terms of investment, in 2021, the total investment volume in the Czech Republic reached EUR 1.64 billion, representing an 11% increase compared to 2020. During the second half of 2021, the industrial and logistics sector was the most active, accounting for 44% of the total volume. The total investment volume in this sector reached EUR 437 million in the second half of the year, a more than fivefold increase compared to the first half of 2021. These figures suggest that the industrial and logistics sectors have experienced strong growth in the Czech Republic in recent years, with a significant increase in investment activity.

Hungary

In 2018, Hungary experienced a significant influx of investment, with just four deals in the first half of the year comprising the highest volume of investment since 2007[3]. These four deals also made up 60% of the total investment volume for the year. Of the total investment volume in 2018, 65%[4] was contributed by Hungarian investors. Among non-resident investors, those from the Republic of South Africa accounted for the largest share, at 14% of the annual investment volume. In recent years, the main foreign investors in Budapest have been from Germany, the Republic of South Africa, and the United States.

[3] Information is based on article, which is available on https://www.mnb.hu/letoltes/commercial-real-estate-market-report-october-2019-eng.pdf (chart 25)

[4]Information is based on article, which is available on https://www.mnb.hu/letoltes/commercial-real-estate-market-report-october-2019-eng.pdf (chart 27)

By the end of June 2019, the average vacancy rate in Budapest was 6.3%, which is the lowest rate on record. Similar to Prague, Budapest has seen strong development activity and robust rental demand, leading to a decreasing vacancy rate due to high demand and low levels of new completions. In 2019, the office sector accounted for 45% of the market, followed by retail at 41%, hotels at 6%, and logistics/industrial and redevelopment properties at 4% each. Like other Central and Eastern European regions, Budapest has been negatively impacted by the Covid-19 pandemic.

In Hungary, the commercial real estate (CRE) investment volume was EUR 1.02 billion in 2020, a decrease of 40% year-over-year. This was a dip from the high levels of activity in the past four years, but remained above the cyclical average since 2010. The office sector was the most dominant, accounting for 61% of the total investment volume, followed by hotels and industrial assets with 17% and 14% each. The retail sector saw the largest decline, with only 7% of the volume going towards such assets due to a lack of large shopping centre deals. Domestic and foreign investors were evenly split in 2020, with Hungarian investors having a consistently increasing share over the preceding four years. The COVID-19 pandemic and economic uncertainty had a negative impact on investor sentiment and caused prime yield shifts of between 25 and 75 basis points depending on the sector in the first quarter of 2020.

Poland

In 2016, Poland maintained a significant presence in the commercial real estate market in Central and Eastern Europe, as evidenced by the fact that over EUR 1.5 billion was invested in the country that year, accounting for 59% of all real estate investment in the region. This trend has persisted for several years, highlighting Poland's attractiveness as a destination for foreign investment in commercial real estate.

In 2020, the COVID-19 pandemic had a profound effect on investor sentiment and caused a shift in the distribution of investment volume by asset class in Poland. Of the total investment volume of EUR 5.27 billion in 2020, 50% (EUR 2.61 billion) was in the industrial sector, 38% (EUR 1.98 billion) was in the office sector, and 13% (EUR 658 million) was in the retail sector. Less than 1% of total volume was invested in the residential sector. The pandemic had a negative impact on the retail sector, leading to a decline in demand and a compression of yields by 75 basis points to 5.75%. The office sector may also have been slightly impacted due to the trend of partial remote work, while

the industrial sector benefited from the growth of e-commerce and saw an increase in demand, resulting in a decrease in prime industrial yields by 25 basis points to 5.50%.

Romania

According to data from 2018, approximately EUR 900 million was invested in commercial real estate in Romania, a slight decrease from the previous year's total of EUR 963 million. This decline can be attributed to a shift in investments into 2018 and a decrease in the number of transactions, although the average size per transaction increased by EUR 31 million.

In 2020, the total investment volume in the Romanian real estate market was EUR 589 million, nearly half of the record amount in 2019 but similar to the amount in 2015, a year of growth. Most of the investment activity (68%) took place in the first half of 2020, with the majority going to Bucharest and only 6% directed towards regional cities. Demand for real estate in Bucharest was highly polarized in 2020, with office projects being the most popular type of property, accounting for 76% of the yearly volume. Prime yields for the office and industrial sectors remained stable at 7.00% and 7.75%, respectively. The retail sector was most affected by the COVID-19 pandemic, experiencing a 50 basis point decompression of yields to 7.00%.

Slovakia

According to data from 2018, the total value of investments in real estate in Slovakia reached 820 million euros. Within this total, investment in retail space accounted for 340 million euros and investment in office space accounted for 265 million euros. This represents an all-time record when compared to the four-year average, possibly due to favourable macroeconomic conditions that have attracted more investors to the Slovak market.

In 2020, the total investment transaction volume in real estate in Slovakia reached EUR 516 million and was spread across 17 transactions. Most of the activity (90%) took place in the first half of the year, which was influenced by the COVID-19 pandemic. The pandemic had a negative impact on construction processes, with speculative construction being postponed or withdrawn. The office and industrial segments continued to dominate in 2020, accounting for 49% and 38% of the total investment volume, respectively, followed by the retail segment with 11%. The hotel, restaurant, and catering services

sector, which was the most affected by the pandemic, made up 3% of the total investment volume. In comparison to the previous year, investment volume in 2020 decreased by 24%. The prime office yield for office properties fell to 5.50% in 2020. There may be a partial correction in secondary real estate and at secondary locations, but retail parks, which are less demanding on hygiene measures in times of pandemic, may be an interesting investment product in the coming months. There is also expected to be strong demand for industrial and logistics properties due to the increasing penetration rate of e-commerce in retail sales.

4. Data description

This thesis presents a database consisting of quarterly data for the period 2002Q1-2019Q4 from five Central and Eastern European (CEE) countries: the Czech Republic, Poland, Slovakia, Romania, and Hungary. A total of 260 observations are included in the database. This database contains prime yield, prime rent expressed in euro per m^2 per year and macroeconomic variables which will be described below.

Many studies on real estate markets tend to focus on the United States and the United Kingdom due to the availability of historical datasets and the transparency of these markets. According to JLL's Transparency Index, these two countries hold the top two positions in the highly transparent category, while CEE countries are classified as transparent or semi-transparent. While publicly available information is available in CEE countries, it can still be difficult to obtain, as certain information is only provided to clients.

4.1 The factors of the commercial property prices

The factors described below are selected based on a review of literature which is addressed to the topic related real estate prices[5] to and research published by Cushman&Wakefield, JLL, Knight Frank (KF), CBRE. The description of these factors is mainly according to JLL reports. Moreover, described factors is chosen

Prime yields

Prime yield refers to the expected rate of return on a high-quality commercial property that is expected to generate stable and consistent rental income. This rate of return is typically calculated as the net operating income of the property divided by the property's value (or is calculated as the annual rent payment divided by the total construction costs. Properties with a high prime yield are considered to be more desirable investments, as they tend to have a lower risk of devaluation and a higher potential for long-term appreciation. Factors that may influence prime yield in commercial real estate include the location and condition of the property, the demand for rental space in the area, the state of the local economy, and the availability of financing. Moreover, prime yields are one of the main indicators for foreign investors and are more important than the total value of

[5] Namely, the research published by Hlaváček et al (2016)

the building. The price of the property in this thesis has been calculated using a formula derived from which it can be seen that as the yield increases, the value of the property decreases.

Prime rents

The concept of "prime rent" refers to the maximum rent that can be obtained for a commercially used property that has been constructed to the highest standards and is situated in an optimal location within a given city.

Real estate agents may also report rents for properties located in various other areas, such as suburbs, industrial zones, and airports, which may be influenced by subjective factors and may not be comparable across cities in Eastern and Central Europe due to a lack of detailed information on each location. For the purposes of this analysis, we have chosen to consider only "prime" rents, as it is generally assumed that rising rents correspond to increasing property prices.

Some specific factors that can influence prime rents for commercial properties include the type of business that will be occupying the space, the size of the space, the terms of the lease (e.g., length of lease, rent escalation provisions), and the availability of comparable properties in the area. In addition, economic conditions, such as the overall strength of the economy and the demand for commercial space, can also affect prime rents.

Volume of office space

The total stock of office space is a measure of the amount of leased and unleased space that is available for use on the market. It can be useful for understanding the supply of office space in a particular location and can be an important factor in determining the demand for office space in that area. The total stock of office space can also be useful for real estate developers, investors, and businesses that are looking to lease or purchase office space. In general, a high total stock of office space may indicate a more competitive market, while a low total stock may suggest that demand for office space is outpacing supply.

Vacancy rate

The vacancy rate in real estate refers to the percentage of available rental units or properties that are not occupied. It is a measure of the demand for rental properties in a given market and can be used to assess the overall health of the real estate market in a specific location. A high vacancy rate may indicate that there is a surplus of rental units or properties and a lower demand for them, while a low vacancy rate may suggest that there is strong demand for rental units and a shortage of available properties. Landlords and property owners may use the vacancy rate to help determine rent prices and make decisions about investments in their properties.

Generally, vacancy rates in the commercial real estate market can be influenced by a variety of factors, including economic conditions, the quality of the properties, competition, and location. For example, during economic downturns, businesses may be less likely to rent commercial properties, leading to a higher vacancy rate. On the other hand, properties in desirable locations or with desirable amenities may have a lower vacancy rate due to higher demand. It is important to note that the specific factors that influence vacancy rates can vary depending on the market and the specific type of commercial property being considered.

4.2 Commercial property price index

Cushman & Wakefield, a real estate company, established the Commercial Real Estate Czech Republic Index (CRECVI) in 2015. This index, which covers the period from 2003 to 2015, measures the capital value of commercial real estate in the Czech Republic. In contrast, the NCREIF Property Index in the United States and the IPD Property Fund index in the United Kingdom both indicate the return on assets.

Valuing property is a multifaceted process that requires a tailored approach for each individual property due to the unique characteristics of each building. However, the market price of real estate is generally influenced by the estimated annual effective rent and the capitalization rate, also known as the investment yield. The estimated price is calculated from a formula that can be derived from the Gordon dividend growth model.

The dividend income stream can be conceptualized as an income stream from rent, with the assumption of an infinite horizon of income receipt, implying the maintenance of the asset in perpetuity. To account for the variability of rent value over time, it is common to assume constant growth of g. The adapted form of Gordon growth formula[6] for this calculation is as follows:

$$V_0 = \frac{R_1}{(1-r_E)} + \frac{R_2}{(1-r_E)^2} + ... = \frac{R_0 * (1+g)}{(1-r_E)} + \frac{R_0 * (1+g)^2}{(1-r_E^2)} + ...$$
$$V_0 = \sum_{t=1}^{\infty} \frac{R_0 * (1+g)^t}{(1-r_E)^t} = \frac{R_1}{(r_E - g)}$$

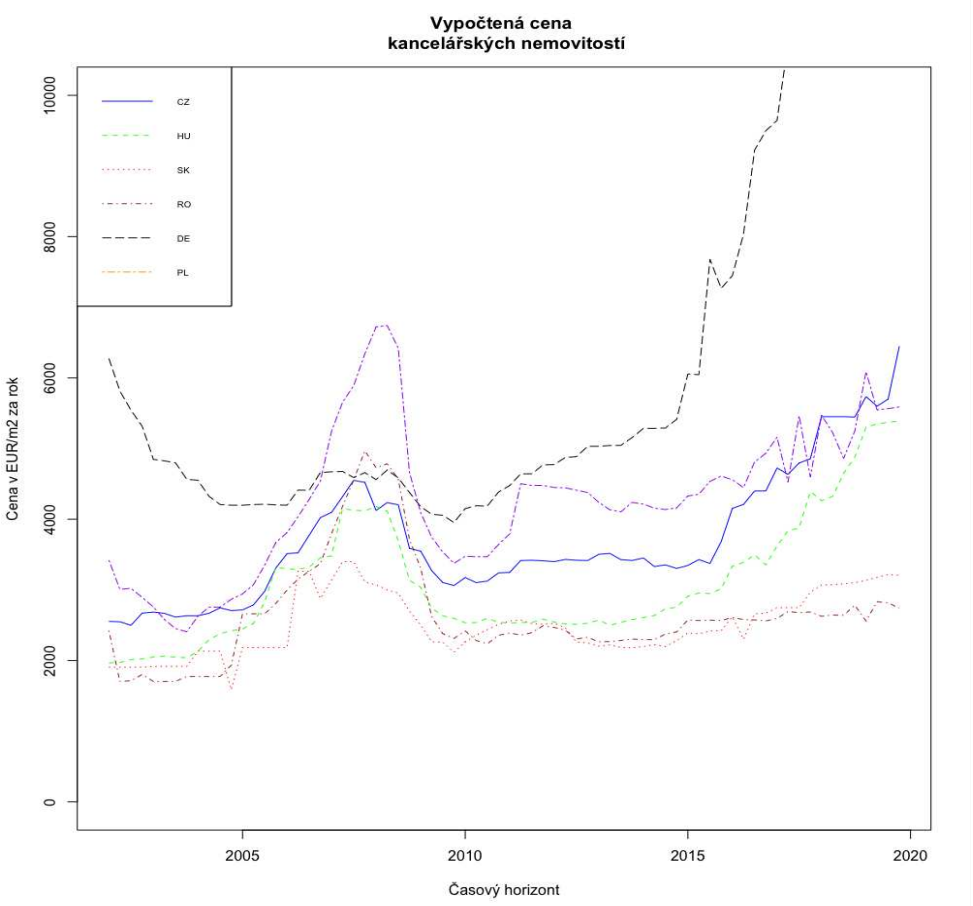
where R1 is the rent, rE is the rate of return g is the growth rate and the yield is expressed as a %.

The expression (r_E - g) is (yield) and we can directly see that it not only includes the discount factor5 but also includes the assumed rental growth. This means that the yield responds to financial events as well as to direct rents.

In this thesis is used a modified formulation of price, following Hlaváček et al. (2016), where they accounted for occupancy rates in their formula as follows:

$$p = \frac{R(1-v)}{výnos/100}$$

[6] The Gordon Growth Model, also known as the dividend discount model, is a way to estimate the intrinsic value of a stock by projecting future dividends and discounting them back to their present value. (Graham, Dodd, Cottle, Murray, Block, & Leibowitz: (1988))



Source: calculated price based on JLL database

The chart above demonstrates a general downward trend in property prices in office market following the 2008 financial crisis across all countries depicted. However, Slovakia and Romania exhibit relatively stable pricing from 2010 to 2020. In contrast, Hungary, the Czech Republic, and Poland experience a marked increase in prices in the period from year 2015 to 2020.

4.3 Macroeconomic factors

There are several macroeconomic factors that can impact the commercial real estate market. The selection of factors was based on their availability in the OECD database, with the goal of obtaining values at the same level for all CEE countries and also based on review of literature and researches published by Cushman&Wakefield, JLL, KF, CBRE.

Gross Domestic Product per capita (GDP)

The GDP[7] is a widely used metric for evaluating the economic prosperity of nations. It is calculated by dividing a country's GDP by its population. GDP per capita can be an important factor in determining the value and potential performance of properties. Higher GDP per capita is often correlated with increased demand for commercial real estate, as businesses and individuals in prosperous nations tend to have more disposable income and may be more likely to invest in properties. As such, commercial real estate investors and analysts may consider GDP per capita, along with other economic indicators, when evaluating the potential returns of a given property or market. However, it is important to note that GDP per capita is just one factor among many that can influence commercial real estate values and performance.

Harmonized Indices of Consumer Prices (HICPs)

The HICPs[8] are statistical measures that track changes in the prices of consumer goods and services over time. They are calculated using harmonized definitions in order to provide a comparable measure of inflation across countries and regions. While HICPs are primarily used as a measure of consumer price inflation, they can also have an indirect impact on commercial real estate markets. For example, if the HICP rises significantly over time, it could lead to an increase in the cost of doing business for commercial property owners, as they may need to pay more for the goods and services they use to operate and maintain their properties. This, in turn, could affect the profitability and value of commercial real estate assets.

Employment rate

The employment rate[9] is a measure of the utilization of available labour resources and is calculated as the ratio of the number of employed persons to the working-age population (defined as individuals aged 15 to 64). A high unemployment rate is often associated with a higher vacancy rate, which can lead to a decline in property prices. A high employment

[7] OECD (2023), Gross domestic product (GDP) (indicator). doi: 10.1787/dc2f7aec-en)
[8] OECD (2023), Inflation forecast (indicator). doi: 10.1787/598f4aa4-en (Accessed on 03 January 2023)
[9] OECD (2023), Employment rate (indicator). doi: 10.1787/1de68a9b-en)

rate generally indicates a strong local economy, which can lead to increased demand for commercial space. This can be especially important for properties that rely on foot traffic or customer demand, such as retail centres or restaurants. On the other hand, a low employment rate may indicate weaker economic conditions, which could lead to lower demand for commercial space and potentially lower property values. It is important to consider the employment rate in the context of other economic indicators and market trends when evaluating the potential performance of a commercial real estate investment.

Short-term interest rates

Short-term interest rates[10] are the rates at which banks lend or borrow money from each other, or from the central bank, on a short-term basis. These rates are typically used as a benchmark for setting other interest rates, such as the interest rates on mortgages and other types of loans. Short-term interest rates are usually influenced by a variety of factors, including the level of economic activity, the level of inflation, and the monetary policy of the central bank. In the context of commercial real estate, short-term interest rates can have a significant impact on the financing and refinancing of properties. For example, if short-term interest rates are low, it may be more attractive for a developer to take out a short-term loan to finance the construction of a new property. On the other hand, if short-term interest rates are high, it may be more costly to borrow money, which could make it more difficult or expensive to finance a real estate project.

Short-term interest rates can also affect the value of commercial real estate indirectly, through their impact on the overall economy. For instance, if short-term interest rates are low, it may encourage more borrowing and spending, which could lead to stronger economic growth and potentially higher demand for commercial real estate. On the other hand, if short-term interest rates are high, it may discourage borrowing and spending, which could lead to slower economic growth and potentially lower demand for commercial real estate.

[10] OECD (2023), Short-term interest rates (indicator). doi: 10.1787/2cc37d77-en

Gross fixed capital formation (GFCF)

Gross fixed capital formation (GFCF)[11] is a measure of the value of additions to the fixed assets of an economy, such as buildings, less disposals of fixed assets. It is an important indicator of an economy's investment activity and its capacity to increase its productive capacity. GFCF is often used as a measure of the level of capital investment in an economy, as it captures the amount of new capital that is being added to the economy through the construction or acquisition of new fixed assets. It is typically expressed as a percentage of the gross domestic product (GDP) of an economy and is often used as an indicator of the level of economic growth.

In the context of commercial real estate, gross fixed capital formation (GFCF) can be an important factor in the construction and development of new properties. When there is a high level of GFCF in an economy, it may indicate that there is strong demand for new commercial real estate, as businesses and organizations are investing in new buildings and other fixed assets. This could lead to more construction activity and potentially higher demand for commercial properties.

On the other hand, if GFCF is low, it may indicate that there is less demand for new commercial real estate, as businesses and organizations are not investing as much in new fixed assets. This could lead to slower construction activity and potentially lower demand for commercial properties.

Composite Leading Indicator (CLI)

The Composite Leading Indicator (CLI)[12] is a statistical measure used to identify trends in the early stages of the business cycle and to provide an indication of the future direction of the economy. It is composed of a weighted average of a selection of economic indicators that have a good track record of leading or anticipating changes in economic activity.

The CLI is designed to provide early signals of turning points in the business cycle, which are fluctuations in economic activity around the long-term potential of an economy. It is

[11] OECD (2023), Investment (GFCF) (indicator). doi: 10.1787/b6793677-en
[12] OECD (2023), Composite leading indicator (CLI) (indicator). doi: 10.1787/4a174487-en

often used as a tool for identifying the beginning and end of recessionary and expansionary periods, as well as for forecasting future economic activity.

CLIs are considered to be qualitative rather than quantitative indicators, as they are based on a combination of economic data rather than a single statistical measure. They are typically used in conjunction with other economic indicators to provide a more comprehensive picture of the state of the economy.

CLIs and other indicators below are typically published by national statistical agencies or international organizations such as the Organization for Economic Cooperation and Development (OECD). They are often used by governments, central banks, and financial market participants to help gauge the strength of an economy and to make informed decisions about monetary and fiscal policy.

Consumer Confidence Index (CCI)

CCI[13] is a statistical measure of the level of consumer confidence in the economy. It is based on a survey of households, in which respondents are asked about their perceptions of current economic conditions and their expectations for the future.

The CCI is typically based on five components: consumers' views on current business conditions, their assessment of the job market, their outlook for the future, their view on their current financial situation, and their willingness to make major purchases. The responses to these questions are used to calculate a composite index, with a value of 100 representing the historical average level of consumer confidence.

A high level of consumer confidence can be seen as a positive sign for the economy, as it indicates that consumers feel optimistic about their prospects and are more likely to make purchases, which can drive economic growth. On the other hand, low consumer confidence may suggest that consumers are more cautious about spending, which can act as a drag on economic growth.

[13] OECD (2023), Consumer confidence index (CCI) (indicator). doi: 10.1787/46434d78-en

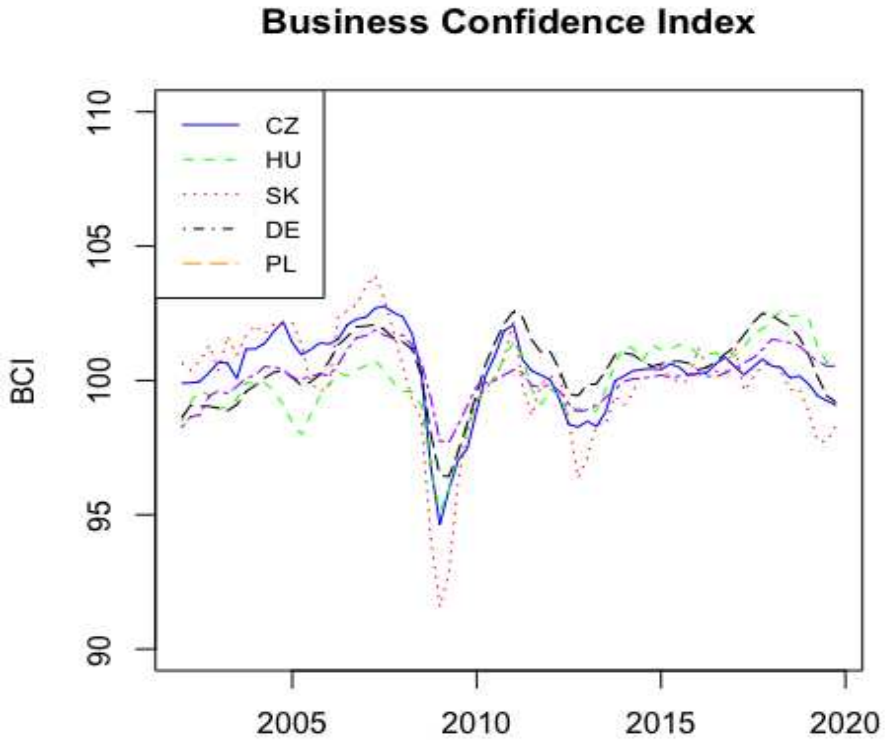
Business confidence index (BCI)

The Business Confidence Index (BCI)[14] is a statistical measure of the level of confidence among businesses in the economy. It is based on a survey of business owners and managers, in which they are asked about their perceptions of current economic conditions and their expectations for the future.

The BCI is typically based on a variety of factors, including the current and expected level of sales and profits, the outlook for the economy, and the level of demand for products and services. The responses to these questions are used to calculate a composite index, with a value of 100 representing the historical average level of business confidence.

In terms of commercial real estate, the Business Confidence Index (BCI) can be an important factor in the demand for properties. When there is a high level of business confidence, businesses may be more likely to invest in new projects, such as constructing new buildings or expanding their operations, which can increase demand for commercial real estate. On the other hand, if business confidence is low, businesses may be more hesitant to invest in new projects, which could lead to lower demand for commercial real estate.

[14] OECD (2023), Business confidence index (BCI) (indicator). doi: 10.1787/3092dc4f-en



Source: OECD database

As depicted in figure above, the Business Confidence Index (BCI) experienced a decline during the financial crisis and further decreased in 2013 during the Eurozone recession. This variable may have added value and warrants further investigation. Its inclusion in the analysis may provide new insights and contribute to a more comprehensive understanding of the factors affecting real estate pricing.

Other variables have been previously examined in the literature on similar topics, however, many of these are not consistently available on a regional and quarterly basis in the selected countries, which may potentially impact the accuracy of the empirical analysis. As a result, these factors were not considered in our analysis. It is important to note that the inclusion of some of these variables may have had a significant impact on the analysis of property price, and their absence may have been a limitation in this regard.

5. Methodology

Descriptions of methodology is mainly based on book Wooldridge, J. M. (2013) and others literature mentioned below. This section is sorted from the simpler models to the more complex models.

5.1 Time series

In general, the data are divided into time series and cross-sectional data. A time series is a collection of data points measured at successive time intervals, often with a uniform frequency. It is a widely used statistical tool for analysing and modelling data collected over a period of time and can be used to forecast future trends and patterns. Time series data can be continuous, with data points collected at regular intervals, or discrete, with data points collected at irregular intervals. Time series analysis is a key component of many fields, including economics, finance, and the natural and social sciences, and has a wide range of applications in areas such as prediction, trend analysis, and decision-making. Time series data can exhibit characteristics such as seasonality and cyclicality and may also be subject to non-stationarity. These features can make statistical analysis of time series data more complex, as most time series related to the economy or real estate are not independent of their prior value[15].Cross-sectional data refers to data that is collected at a specific point in time, rather than over a period of time. This type of data includes information about a group of individuals or objects at a single point in time.

5.2 Panel data

Panel data, also known as longitudinal data, is a type of data that combines cross-sectional and time series data. It involves observations of multiple variables over time for each cross-sectional unit, such as individuals, urban firms, etc. For example, variables such as office space inventory for each city might be collected from 1992 to 2006. It is important that the units of observation over time come from the same cross-sectional unit to avoid potential issues with independence of observations. One of the notable features of panel data is the ability to address unobserved effects, such as time-independent specific effects

[15] This information is also according to many studies, for example, it is mentioned in study published by Davis and Zhu (2004)

related to a unit's characteristics (e.g., gender or city distance to the nearest airport). These effects can potentially lead to biased and inconsistent parameter estimates in a model. Panel data can be analysed using techniques such as first differencing or cross-sectional fixed effects estimation to eliminate such effects. The Ordinary Least Squares (OLS) model is commonly used to analyse panel data, but it is important to ensure that the data meets the assumptions of the Gauss-Markov theorem. One assumption that must be verified is the presence of homoskedasticity, which can be tested using the Breusch-Pagan test. If heteroskedasticity is detected, standard errors and test statistics may not be valid. Similarly, serial correlation must also be tested using the Breusch-Godfrey test, with the null hypothesis being the absence of serial correlation in idiosyncratic errors. If heteroskedasticity and serial correlation are present, robust standard errors can be estimated using the method of Arellano (1987) to ensure that the OLS estimator is the Best Linear Unbiased Estimator (BLUE).

In terms of commercial real estate, panel data analysis is a statistical method used to analyse trends and changes in commercial property prices over time. It involves collecting data on multiple variables, such as location, property type, size, and economic and market factors, for a set of properties over a period. By controlling for various factors that may influence property prices, panel data analysis can help identify the impact of specific variables on property prices. However, it is important to be aware of the limitations of panel data, such as potential limitations in the data sources and sample selection, when analysing commercial property prices. There have been numerous studies that have used panel data analysis to study trends and changes in commercial property prices. Also, a few studies mentioned in the section literature review used panel data analysis

5.3 Fixed and random effect model

The fixed and random effect refer to different approaches to taking unobserved heterogeneity into account in a linear regression analysis and can be described by Wooldridge (2013) using the following equation:

$$y_{it} = \beta_o + \sum_{j=1}^{k} \beta_j x_{jit} + a_i + u_{it}$$

Where i = 1,...n denotes the i-region, t = 1,...T denotes the time period and j = 1, ... kth variable. Ai is usually understood as an uncorrelated effect or uncorrelated heterogeneity that is specific to each region and does not vary over time, hence does not need a time index t. While the error component uit denotes the opposite, that is, it is invariant over time. Collectively, the expression ai + uit is called the composite random component, it comes from an independently identical distribution with zero mean and constant variance (called iid (0,σv2)).

According to the previous equation, if ai = 0 (unobserved effect does not exist), then the pooled OLS2 method is used, which will be efficient and consistent because it assumes that there is no difference between the groups being analysed. Otherwise, another method must be found, and it differs whether the given equation is FE or RE. FE examines differences in intercepts and assumes that the error variances in the regions are constant. Conversely, RE assumes the same intercepts and takes into account the differences in error variances across regions. In addition, RE assumes that regressors are not correlated with region-specific error (Cov(xjit, ai) = 0, ∀j). If the condition is satisfied, RE is more efficient than FE, otherwise RE is not consistent and is worse than FE.

The pooled OLS method is a statistical technique used to analyse data from different groups, and the FE and RE methods are used when there are unobserved differences between the groups being analysed. The appropriateness of the model selection should be determined based on economic intuition or statistical testing (e.g., using Hausmann test).

5.4 Stationary and spurious regression

Macroeconomic time series, such as GDP or inflation, are rarely stationary because they are influenced by a wide range of factors that can change over time. These factors can include economic policy, demographic trends, technological innovations, and international events, among others. As a result, macroeconomic time series tend to exhibit trend and seasonality, which can make them non-stationary.

It's important to note that stationarity is a key assumption of many statistical and machine learning models, so non-stationary time series can be more challenging to analyse and forecast. However, techniques such as differencing and transformation can often be used

to make non-stationary time series stationary, which can make them easier to model and understand.

AS mentioned, macroeconomic time series are often non-stationary, meaning that the mean, variance, and autocovariance of the series are not constant over time. Regressing non-stationary variables can produce biased results, as the stationarity of the errors is inconsistent and the requirements for performing ordinary least squares (OLS) regression are not met. This can lead to the identification of spurious relationships, which are characterized by high R-squared values and low Durbin-Watson statistics (Granger a Newbold Granger & Newbold (1974)). To avoid these issues, it is important to perform unit root tests on all included variables in an analysis. These tests, such as the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP)[16] test, are used to determine whether a time series is stationary or non-stationary. Therefore, i tis appropriate to plot and examine the series prior to testing, as this can provide insight into the.

5.5 Tests for stationarity in time series

In more detail, the Augmented Dickey-Fuller (ADF) test is a statistical test used to determine whether a time series is stationary or non-stationary. It is a type of unit root test, which tests the null hypothesis that a time series has a unit root, i.e., that it is non-stationary. If the null hypothesis is rejected, it means that the time series is stationary. The ADF test[17] is performed by regressing the time series on its own lags and a constant term. The test statistic is calculated based on the coefficient of the time series' first lag, and the test is performed by comparing the test statistic to a critical value from a t-distribution. The ADF test is widely used in economic and financial analysis, but it can be sensitive to the presence of certain types of autocorrelations in the data. In these cases, the Phillips-Perron (PP) test may be preferred. Phillips-Perron (PP) test has similar concept as ADF test. One advantage of the Phillips-Perron (PP) test is that it does not require the specification of a lag length for the regression, unlike the Augmented Dickey-Fuller (ADF) test. The PP test automatically adjusts for serial correlation in the data by using a Newey-West correction (Newey & West 1986), which allows it to be more robust to the presence of autocorrelation.

[16] Phillips & Perron (1988)
[17] Dickey & Fuller (1979)

As mentioned, the PP test is asymptotically equivalent to the ADF test, meaning that the two tests should produce similar results in large samples. However, there may be differences in the results of the two tests for smaller sample sizes due to the different ways in which they correct for serial correlation (Schwert 1989). As a result, it is important to carefully consider the assumptions of the PP test and choose the appropriate version based on the characteristics of the time series being tested.

5.6 Unit root tests for panel data

Unit root tests are statistical tests that are used to determine whether a time series is stationary or non-stationary. In panel data, unit root tests are used to test for the presence of a unit root in the data of each individual panel unit, as well as to test for the presence of a common unit root across all panel units.

There are several unit root tests that are commonly used for panel data, for example:

- Augmented Dickey-Fuller (ADF) test: This test is commonly used to test for the presence of a unit root in panel data. It assumes the presence of a common intercept across all panel units and does not allow for the possibility of a structural break.
- Phillips-Perron (PP) test: This test is similar to the ADF test, but it allows for the possibility of autocorrelation and heteroscedasticity in the errors. It also assumes the presence of a common intercept across all panel units.
- KPSS test: This test is used to test the null hypothesis that a time series is stationary against the alternative hypothesis that it has a unit root. It does not assume the presence of a common intercept across panel units.
- Zivot-Andrews test: This test is similar to the ADF test, but it allows for the possibility of a structural break in the data.
- Levin-Lin-Chu test: This test is based on the concept of a dynamic equilibrium relationship between the variables in the model and allows for the possibility of both a unit root and a structural break in the data.
- Im-Pesaran-Shin test: This test is based on the concept of a "common correlated effects" model and allows for the presence of both cross-sectional dependence and a unit root in the data.

- Hadri test: This test is specifically designed for panel data and is an extension of the ADF test. It allows for the possibility of a different intercept for each panel unit.

One important consideration when conducting unit root tests for panel data is the choice of the appropriate error correction term. In panel data models with unit roots, it is common to include an error correction term in the model to account for the presence of long-run equilibrium relationships between the variables. The choice of the error correction term can have a significant impact on the results of the unit root test, and it is important to carefully consider this choice in order to obtain reliable results.

It is important to note that each of these tests has its own assumptions and limitations, and it is important to carefully consider which test is most appropriate for a given dataset. In general, it is a good idea to consider a variety of different unit root tests in order to get a more robust understanding of the nature of the data. (See the appendix for the results of the some unit root tests on the given dataset)

5.7 Cointegration

The cointegration of non-stationary variables represents a special case where the regression of these variables is not spurious. This occurs when the variables exhibit a long-run equilibrium relationship, characterized by similar stochastic trends, and possess the same order of integration. In this case, there exists a linear combination of the variables that is stationary, and the joint movement of the variables over time tends towards a certain equilibrium state.

The Engle and Granger test is a statistical procedure used to determine whether two or more time series are cointegrated, which means that they have a long-run relationship. This test involves examining the stationarity of the variables under consideration, and then regressing the dependent variable on the independent variables. (Engle & Granger (1987)). If the residuals of this regression are found to be stationary, it indicates that the variables tend to return to equilibrium after a shock and that a long-run relationship exists between them. On the other hand, if the variables are not cointegrated, the residuals will exhibit a unit root.

Several approaches have been proposed for applying the Engle and Granger method to panel data, including those by Pedroni (2004), Kao (1999), and Westerlund (2007). Pedroni's approach involves assuming heterogeneous capture, slope, and trend coefficients, while Kao's method is similar and assumes that all variables are non-stationary. These approaches will be briefly discussed below.

Pedroni's approach[18], known as the panel cointegration test, involves allowing for different capture, slope, and trend coefficients for each individual in the panel. The capture coefficient measures the long-run relationship between the variables, the slope coefficient measures the short-run dynamics, and the trend coefficient captures any deterministic trends in the data. This method allows for the possibility of different long-run relationships between the variables for different individuals in the panel.

Kao's approach[19], known as the panel unit root test, is similar to Pedroni's approach but assumes that all variables in the panel are non-stationary. This method tests for the presence of a unit root in the data, which indicates a non-stationary time series.

Westerlund's approach[20], known as the panel autoregressive distributed lag (ARDL) bounds test, allows for both short- and long-run dynamics in the panel data. This method estimates a dynamic panel model with both short- and long-run relationships between the variables, and then tests for cointegration using the ARDL bounds test.

5.7.1 ECM

A special case of the model is the error correction model (ECM), which is subsumed by the cointegrating relation.
This methodology has been used in publications by Égert and Mi-haljek (2007), Bill and Ivarsson (2009) and Stohldreier (2012). It is important to note that if the tests from the

[18] Pedroni (2004)
[19] Kao (1999)
[20]Westerlund (2007)

previous section showed no cointegration, it would not make sense to proceed further to the ECM.

An error correction model (ECM) is a type of dynamic panel data model that is used to analyse the long-run relationships between variables. In an ECM, the dependent variable is modelled as a function of both its own lagged values and the lagged difference between the dependent variable and its equilibrium value. The equilibrium value is the long-run equilibrium level of the dependent variable, which is determined by the underlying economic relationships between the variables.

ECMs are commonly used in panel data models because they allow for the analysis of both short-run and long-run relationships between variables. They are particularly useful for analysing cointegrated variables, as they can help to identify the long-run equilibrium relationships between the variables.

Long run

In this study, the long-run relationship between variables has yet to be examined. This relationship can be represented by the equation:

$$yit = \sum \beta jxjit + ai + uit \quad (5.10)$$

where ai denotes fixed effects and xjit represents both supply and demand factors for prices. Ordinary least squares (OLS) cannot be utilized to estimate this equation because the estimates would be inconsistent and biased in the presence of cointegrating relationships. This is due to the likelihood that the error components are cointegrated with the explanatory variables as a result of shared stochastic trends. To address this endogeneity problem, panel dynamic OLS (DOLS) or panel fully modified OLS (FMOLS) estimators are often employed. The panel dynamic OLS (DOLS) method is employed in this study to address the endogeneity problem in the presence of cointegrating relationships. This is achieved by adding lagged first differences of the explanatory variables to the equation and estimating it using OLS. Alternatively, the panel fully modified OLS (FMOLS) method reduces bias through a non-parametric approach that is more computationally intensive and harder to understand. While both methods are asymptotically equivalent, the DOLS panel is preferred in this study due to its superior performance in finite samples. Heteroscedasticity and self-consistent autocorrelation (HAC) are also taken into account to enhance the robustness of the results.

Short run

An Error Correction Model (ECM) is applied in this study to examine the short-term process of correcting deviations from the estimated equilibrium. This model combines the short-term and long-term dynamics of the system by estimating the following equation:

$$\Delta yit = bi + \sum \gamma j \Delta xjit + \Phi ECTi,t-1 + vit \quad (5.11)$$

where bi is the area-specific fixed effect and the correction term (ECTi,t-1) represents the lagged residual from equation 5.11, which is defined as:

$$ECTi,t-1 = yi,t-1 - a\hat{}i - \sum \beta\hat{}jxji,t-1 \quad (5.12)$$

The coefficient Φ of the correction term (ECT) is used to evaluate the rate of correction to equilibrium. It is expected to be between -1 and 0, with values closer to -1 indicating a faster adjustment process. For example, if real estate is overpriced in the previous period and the determinants remain unchanged, prices would need to be lowered in order to return to equilibrium, implying $\Phi < 0$. The lower bound of -1 is due to the fact that values below this threshold would indicate a lack of convergence, with the relationship "jumping" between positive and negative disequilibrium. However, it is important to note that there is no constraint on the estimates of Φ to be within this expected range, and values less than -1 or greater than 0 would indicate instability and a lack of convergence to equilibrium in the long run.

6. Data analysis and result interpretation

This section describes the different models that is used in this thesis and presents the results of these models. The appendix will contain additional information, such as the specific results of each model.

6.1 Pooled OLS

First, we tested the variables for comparison using the ordinary least squares (OLS) method. Most variables were differenced to remove the growth trend. The resulting equation is as follows:

$$\begin{aligned}\Delta cena_{it} =& \beta_0 + \beta_1 \Delta stock_{it} + \beta_2 \Delta cpi_{it} + \beta_3 \Delta gdp_{it} + \beta_4 unempl_{it} \\ &+ \beta_5 gfcf_{it} + \beta_6 \Delta short_int_{it} + \beta_7 \Delta BCI_{it} + \beta_8 \Delta CCI_{it} + \beta_9 \Delta CLI_{it} + \\ &+ u_{it}\end{aligned}$$

After regression it was found that some factors are significant such as GDP, unemployment, short interest and CCI. However, upon conducting the Durbin-Watson test, it was determined that there was autocorrelation present in the random component of the model. This implies that the OLS estimator is biased and inconsistent. See Table 1 in appendix for result of the model). As a result, the fixed and random effects methods were then utilized.

In the initial model, Romania was not included due to the lack of BCI, CCI, and CLI variables for this country. Upon including Romania and removing these determinants, a new model was obtained:

$$\begin{aligned}\Delta cena_{it} =& \beta_0 + \beta_1 \Delta stock_{it} + \beta_2 \Delta cpi_{it} + \beta_3 \Delta gdp_{it} + \beta_4 unempl_{it} \\ &+ \beta_5 gfcf_{it} + \beta_6 \Delta short\_int_{it} + u_{it}\end{aligned}$$

But again, the Durbin-Watson test revealed autocorrelation in the random component. The R squared value of this model was lower than that of the previous model, potentially indicating the removal of a significant variable (see table Table 2 in appendix). Nonetheless, some explanatory variables showed the expected effects: an increase in

inventory (stock) was found to decrease the price of office space, while unemployment had a negative effect on price and GDP had a positive effect on price.

6.2 Fixed effect model

n this study, the fixed effects method was utilized due to the inherent restriction in random effects models that the number of variables cannot exceed the number of parameters. Therefore, we focused solely on the fixed effects model. In order to prevent spurious regression, the non-stationary variables were differenced to attain stationarity, which was achieved by calculating the differences between consecutive observations in the time series. If the differenced series was found to be stationary, then the original time series was also considered stationary. In addition, the order of integration of variables[21] was determined through the application of unit root tests, as previously described in the methodology section.

The fixed effects model is represented by the following equation:

$$\begin{aligned}\Delta cena_{it} =& \beta_0 + \beta_1 \Delta stock_{it} + \beta_2 \Delta cpi_{it} + \beta_3 \Delta gdp_{it} + \beta_4 \Delta unempl_{it} \\ &+ \beta_5 gfcf_{it} + \beta_6 \Delta short\_int_{it} + \beta_7 \Delta BCI_{it} + \beta_8 \Delta CCI_{it} + \beta_9 \Delta CLI_{it} + u_{it}\end{aligned}$$

According to the results shown in Table A below, it is apparent that GDP and CPI have a positive impact on price, while an increase in the stock of office space is associated with a decrease in office space prices. Additionally, unemployment and the business confidence index were found to have a significant effect on the dependent variable. This aligns with previous findings, further reinforcing the importance of these variables in price determination

[21] The order of integration of a variable refers to the number of times that the variable must be differenced in order to make it stationary.

	Dependent variable:
	diff(price)
diff(stock)	−0.268*
	(0.149)
diff(cpi)	24.756**
	(11.778)
diff(gdp)	0.108***
	(0.027)
diff(unempl)	−81.112***
	(18.740)
diff(gfcf)	−6.348
	(4.940)
diff(short_int)	98.963***
	(20.964)
diff(BCI)	132.675***
	(20.416)
diff(CLI)	−39.167*
	(19.910)
diff(CCI)	−31.047
	(28.016)
Observations	284
R^2	0.641
Adjusted R^2	0.625
Note:	*p<0.1; **p<0.05; ***p<0.01

Table A: Fixed effect model – results

The previous model not included data from Romania due to the lack of BCI, CCI, and CLI variables for this country (as previous section). Upon recalibrating the model to include Romania, the equation for Romania is as follows:

$$\Delta cena_{it} = \beta_0 + \beta_1 \Delta stock_{it} + \beta_2 \Delta cpi_{it} + \beta_3 \Delta gdp_{it} + \beta_4 \Delta unempl_{it} + \beta_5 gfcf_{it} + \beta_6 \Delta short_i nt_{it} + u_{it}$$

While certain variables were not included in this adjusted model, the significance of the remaining variables was retained with the exception of the stock of office space. The results of this adjusted model are presented below in Table B.

	Dependent variable:
	diff(price)
diff(stock)	−0.100
	(0.153)
diff(cpi)	23.496*
	(12.122)
diff(gdp)	0.098***
	(0.028)
diff(unempl)	−67.640***
	(19.360)
diff(gfcf)	1.549
	(5.077)
diff(short_int)	113.739***
	(22.158)
Observations	284
R^2	0.579
Adjusted R^2	0.566
Note:	*p<0.1; **p<0.05; ***p<0.01

Table B: Fixed effect model – results (Romania included)

6.3 ECM

In order to create an error correction model (ECM), it is necessary for the variables being analysed to be non-stationary, stationary in differences, and have a cointegrating relationship with one another. As demonstrated, a cointegrating relationship was found between the variables of GDP, unemployment, short interest rate, CPI, office inventory, and business confidence index (see Table 5 and Table 6 in appendix).

Once these conditions have been met, a model can be constructed to represent the long-term relationship between these variables, as represented by the following equation:

$$price_{it} = a_i + \beta_1 GDP\_pc_{it} + \beta_2 unempl_{it} + \beta_3 short\_int_{it} + \beta_4 STOCK_{it} + \beta_5 BCI_{it} + \beta_6 CPI_{it} + u_{it}$$

The results of the PDOLS estimation are summarized in Table C. In the long term, the majority of the aforementioned determinants were found to be significant, with the exception of GDP and office inventory. This finding contradicts the results presented by Hlaváček et al. (2016). However, we do agree with their conclusion regarding the significance of the CPI indicator, which generally reflects inflationary pressure in the economy. Briefly, the results of the analysis revealed that with a decrease of

unemployment rate caused decrease in property prices. In other words, when there is a smaller number of employees, there is less demand for large buildings, leading to higher vacancy rates and subsequently lower real estate prices. Furthermore, the short-term interest rate was found to have a positive effect on real estate prices as well. It could be interpreted as when the short-term interest rate is low, businesses may be more willing to invest in real estate because it is less expensive for them to borrow money. This increased demand for real estate can lead to higher prices. On the other hand, when the short-term interest rate is high, the cost of borrowing money may be too expensive for some businesses, which could decrease their demand for real estate and result in lower prices. The last one is BCI, which is indicator published by OECD as other macroeconomic factors. As mentioned, BCI has positive effect on property prices since BCI stands for confidence in near future good business performance[22]

	Dependent variable: price
	PDOLS
GDP_pc	0,023
	(0,027)
unempl	−101,382***
	(22,747)
short_int	227,238***
	(38,0788)
CPI	63,73***
	(14,174)
STOCK	−0,244
	(0,163471)
BCI	121,49***
	(44,236)
R^2	0,91
Adjusted R^2	0,892
Note:	*p<0.1; **p<0.05; ***p<0.01

Table C: PDOLS - Long run

[22] OECD (2023), Business confidence index (BCI) (indicator). doi: 10.1787/3092dc4f-en

The following is the equation for the short-term relationship in which the ECT obtained from the long-term relationship was estimated:

$$\Delta price_{it} = b_i + \gamma_1 \Delta GDP\_pc_{it} + \gamma_2 \Delta unempl_{it} + \gamma_3 \Delta short\_int_{it} + \gamma_4 \Delta STOCK_{it} + \gamma_5 \Delta BCI_{it} + \gamma_6 \Delta CPI_{it} + \Phi ECT_{i,t-1} + v_{it}$$

The results of the statistical analysis (see Table D below) reveal that the stock of office space has a significant effect on the price of office space in the short-run. The use of a robust estimator[23] to control for autocorrelation and heteroskedasticity enhances the reliability of the results. The coefficient on the lagged residual (-0.141) suggests that the prices of office space tend to converge towards their long-run fundamental value over time, with a rate of convergence of approximately 14.1% per quarter. This finding is slightly higher than the coefficient reported in a similar study by Hlaváček et al. (2016), who found a coefficient of -0.086.

In addition to providing insight into the factors influencing the price of office space, the model also allows for the determination of whether prices are overvalued or undervalued relative to their fundamental value. By comparing actual transaction prices to the estimated fundamental prices, it is possible to assess the extent to which the market is overvalued or undervalued.

	*Dependent variable:*Δ *price*	
	PDOLS	Robust
ECT	−0.141**	−0.141
	(0.043)	(0.105)
diff_GDP_pc	0.056	0.056
	(0.054)	(0.089)
diff_unempl	−132.793***	−132.793*
	(36.761)	(51.420)
diff_short_int	23.020	23.020
	(23.352)	(14.260)
diff_STOCK	−0.487	−0.487**
	(0.433)	(0.153)
diff_BCI	67.893***	67.893**
	(18.518)	(24.287)
diff_CPI	5.407	5.407
	(19.716)	(16.671)
Constant	20.279	20.279
	(28.514)	(24.926)
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table D: Short run

[23] Given that Breusch-Godfrey test and Breusch-Pagan test revealed autocorrelation and heteroskadasticity in the original model.

7. Conclusion

The research conducted suggests that there is a relationship between the commercial real estate market and financial stability. Using panel fixed effects models and an error correction model, the short-term determinants of the market were found to be the stock of office space, the unemployment rate, and the business confidence index. In the long-term, the significant determinants were found to be the short-term interest rate, the consumer price index, and, as in the short-term, the unemployment rate and the business confidence index. Interestingly, GDP was not found to be a significant factor in either the short-term or long-term.

It is important to exercise caution when interpreting these results, as they may be sensitive to the choice of variables and data used. In order to more accurately assess the relationship between the commercial real estate market and financial stability, it may be necessary to consider a longer time series that includes multiple business cycles. This would allow for a more comprehensive analysis of the determinants of the market and their impact on financial stability.

As mentioned the analysis presented in this thesis was conducted prior to the onset of the Covid-19 pandemic. The impact of the pandemic on the commercial real estate market and financial stability is likely to be significant and should be taken into account in any further analysis of the topic.

Data related to the Covid-19 pandemic could potentially provide more accurate results when analysing the relationship between the commercial real estate market and financial stability. For example, the widespread closure of businesses and implementation of lockdowns during the pandemic may have had a significant impact on the demand for office space, potentially leading to changes in the commercial real estate market. Additionally, the economic recession caused by the pandemic is likely to have affected unemployment rates and consumer spending, which could in turn impact the market.

Incorporating data on the Covid-19 pandemic into the analysis of the commercial real estate market and financial stability could help to more accurately reflect the current state of the market and its potential impact on financial stability.

8. Appendix

Appendix no. 1: Pooled OLS (table)

Appendix no. 2: Pooled OLS + RO (table)

Appendix no. 3: Yearly analysis: Pooled OLS (table)

Appendix no. 4: Fixed effect model (table)

Appendix no. 5: Cointegration testing (table)

Appendix no. 6: Unit root/ Stationarity testing (table)

Table 1: Pooled OLS

	Dependent variable:
	diff(price)
diff(stock)	−0.249*
	(0.149)
diff(cpi)	25.877**
	(11.750)
diff(gdp)	0.104***
	(0.027)
diff(unempl)	−82.452***
	(18.599)
gfcf	5.043
	(7.230)
diff(short_int)	99.965***
	(20.888)
diff(BCI)	125.435***
	(20.369)
diff(CLI)	−39.787**
	(19.858)
diff(CCI)	−34.781
	(27.818)
Constant	−6.029
	(30.486)
Observations	284
R^2	0.639
Adjusted R^2	0.627
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 2: Pooled OLS + RO

	Dependent variable:
	diff(price)
diff(stock)	−0.070
	(0.151)
diff(cpi)	25.645**
	(11.969)
diff(gdp)	0.091***
	(0.027)
diff(unempl)	−64.405***
	(19.038)
gfcf	15.317**
	(7.434)
diff(short_int)	112.137***
	(21.884)
Constant	−14.666
	(32.434)
Observations	360
R^2	0.585
Adjusted R^2	0.576
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 3: Yearly analysis: Pooled OLS

	Dependent variable:Δ price
diff(stock)	−1.221**
	(0.572)
diff(cpi)	−15.933
	(36.952)
diff(gdp)	0.204**
	(0.099)
unempl	−4.518
	(15.436)
gfcf	48.998*
	(27.483)
diff(short_int)	159.379***
	(55.226)
diff(BCI)	81.360*
	(43.341)
diff(CLI)	−57.036
	(39.257)
diff(CCI)	−13.401
	(58.363)
Constant	150.525
	(228.726)
Observations	68
R^2	0.464
Adjusted R^2	0.381
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 4: Fixed effect model

	Dependent variable:
	(diff(price))
diff(stock)	-1.277^{*}
	(0.642)
diff(cpi)	3.762
	(33.583)
diff(gdp)	0.147^{*}
	(0.083)
diff(unempl)	-171.461^{***}
	(43.100)
gfcf	30.841
	(24.444)
diff(short_int)	123.536^{**}
	(48.326)
diff(BCI)	98.274^{**}
	(38.918)
diff(CLI)	-73.323^{**}
	(34.607)
diff(CCI)	-24.690
	(50.177)
Observations	68
R^2	0.607
Adjusted R^2	0.522
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 5: Cointegration testing

Kao	**statistic**	**p-val**
Modified Dickey-Fuller t	-4.4702	0
Dickey-Fuller t	-2.2147	0.0134
Augmented Dickey-Fuller t	-1.7452	0.0405
Unadj. Mod. Dickey-Fuller t	-5.3176	0
Unadj. Dickey-Fuller t	-2.4036	0.0081
Pedroni	**statistic**	**p-val**
Group		
Modified Phillips-Perron t	-1.013	0.1555
Phillips-Perron t	-2.1638	0.0152
Augmented Dickey-Fuller t	-2.0662	0.0194
Panel		
Modified variance ratio	3.7329	0.0001
Modified Phillips-Perron t	-1.277	0.1008
Phillips-Perron t	-2.022	0.0216
Augmented Dickey-Fuller t	-2.0177	0.0218
Westerlund	**statistic**	**p-val**
Group		
Variance ratio	-1.6343	0.0511
Panel		
Variance ratio	-0.8702	0.1921

Table 6: Unit root/ Stationarity testing

IPS	levels		differences	
	statistic	p-val	statistic	p-val
PRICE	2.8707	0.998	-9.7996	0
GDP_pc	8.5318	1	-8.1593	0
unempl	3.3722	0.9996	-5.0184	0
short_int	-1.8394	0.0329	-7.5877	0
CPI	0.49	0.6879	-9.288	0
STOCK	1.1754	0.8801	-9.7539	0
BCI	-1.499	0.0669	-6.6865	0

Hadri	levels		differences	
	statistic	p-val	statistic	p-val
PRICE	35.3967	0	-2.0534	0.98
GDP_pc	89.7665	0	-2.0919	0.9818
unempl	61.7066	0	-1.9042	0.9716
short_int	77.7459	0	-2.0805	0.9813
CPI	89.4061	0	-2.1031	0.9823
STOCK	90.8859	0	-2.007	0.9776
BCI	13.5488	0	-2.058	0.9802

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