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SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

MISALIGNMENT INDICATOR BETWEEN THE FUNDAMENTAL AND MARKET VALUE FOR SLOVENIAN COMMERCIAL REAL ESTATE

Ljubljana, July 2023   ŠPELA ROZMAN

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LIST OF ABBREVIATIONS

AIC – Akaike Information Criteria

ARIMA – Autoregressive Integrated Moving Average

CCBMIS – Chamber of Construction and Building Materials Industry of Slovenia

CDO – Collateralised Debt Obligation

CEE – Central and Eastern European

CMBS – Commercial Mortgage-Backed Security

CRE – Commercial Real Estate

EBITDA – Earnings Before Interest, Taxes, Depreciation and Amortization

ECB – European Central Bank

ESRB – European Systemic Risk Board

EU – European Union

FDI – Foreign Direct Investments

GDP – Gross Domestic Product

GFC – Global Financial Crisis

GOS – Gross Operating Surplus

HP – Hodrick-Prescott

LTV – Loan-To-Value

NFC – Non-Financial Corporations

OECD – Organisation for Economic Co-operation and Development

OTC – Over-the-Counter

PC – Principal Component

PCA – Principal Component Analysis

PPI – Producer Price Index

REIT – Real Estate Investment Trust

RRE – Residential Real Estate

SMA – Surveying and Mapping Authority of the Republic of Slovenia

SORS – Statistical Office of the Republic of Slovenia

UK – United Kingdom

US – United States

VAR – Vector Autoregression

VECM – Vector Error Correction Model

INTRODUCTION

The emergence of the Covid pandemic left commercial real estate (CRE) owners in a state of shock. As preventive measures were implemented, their once vibrant office buildings suddenly transformed into desolate ghost towns. Just when they began to believe that the worst was behind them and the situation was gradually stabilizing, a fresh set of challenges emerged. The backdrop of heightened geopolitical tensions, surging inflation rates, rapid tightening of financial conditions and moderating economic activity has thrust the issue of CRE sector stability into the spotlight. However, it was not always this way. For a significant period of time, property market experts and academics failed to recognize the significance of studying the CRE market. Nevertheless, a notable shift in perspective has occurred, as a solid understanding of CRE market dynamics has become crucial for real estate professionals (Ball, Lizieri & MacGregor, 1998). Apart from the fact that most economic crises have been triggered by booms and busts in the residential real estate (RRE) market, Olszewski (2013) highlights that the CRE market can also have negative impact on the economy. As the growth of economic activity begins to moderate from the record levels achieved during the post-pandemic recovery, and financial conditions tighten due to high inflation, policymakers are becoming increasingly concerned about the risks originating from real estate markets. In recent years, the valuations of these markets have soared, not only in Slovenia but also on a global scale.

Since the final months of 2022, there has been a discernible cooling down in the European CRE market. This is evident from the notable decline in investment flows across several European countries during the first quarter of 2023, as compared to the same period the year before, continuing the trend observed in the end of 2022. The prevailing cautious sentiment among investors, influenced by the aforementioned risk factors, was further exacerbated this spring by the banking sector stress on both sides of the Atlantic in late March 2023 (Colliers, 2023). As such, it has become increasingly important to gain a comprehensive understanding of the current market situation. Therefore, regulators and central banks should keep an eye not only on the residential property but also on the CRE sector.

One approach to track the state of the market involves assessing the extent of price misalignment with underlying fundamentals. Detecting divergence in real-time has always been a challenging task. However, it is crucial for policymakers to prioritize the development of suitable methodologies to measure these divergences, as the failure to do so may have real negative economic consequences. By identifying the primary drivers of CRE prices, it is possible to decompose the deviations from equilibrium and generate early warning systems that will allow for timely intervention and mitigation of potential adverse societal effects. The study of price misalignment in real estate, including the determination of fundamental price, is a crucial area of research with significant implications for all relevant stakeholders. However, detecting price misalignments as they occur is difficult because fundamental

prices cannot be directly observed. Researchers use different methods to estimate them, which has led to a vast body of literature focused mainly on residential property. Given the important role of CRE in the economy, it is essential to examine this subsector of the real estate as well. Hence, this master thesis aims to examine the commercial property market in Slovenia and develop a robust tool capable of estimating the extent of misalignments within the market. The results of this thesis and the constructed indicator will fill the previously addressed gap and provide policymakers with a tool that will enable them to track the state of the Slovene CRE market in real-time. The advantage of the methodology applied is also the easy application to other countries and markets, what is, among other things, the added value of this master's thesis.

The Slovenian CRE market is characterized by its unique features and dynamics. The market is relatively small and lacks liquidity, with a focus on office spaces, catering establishments, and retail properties located in major retail centres and central population areas. The limited availability and heterogeneity of commercial properties contribute to significant price fluctuations, even with individual transactions, leading to high volatility in both prices and transaction volumes. The recent economic challenges, including the impact of the COVID-19 pandemic and rising interest rates, have had an influence on the market dynamics. For instance, the pandemic has disrupted various sectors, while the increase in interest rates has resulted in higher debt financing costs for non-financial corporation (NFC) loans for CRE, which are tied to variable interest rates. As a result, stakeholders in the CRE market may face additional financial burdens compared to previous periods. Understanding the dynamics and development of the CRE market in Slovenia is essential, as it has significant implications for various stakeholders. To accurately track its movements, a comprehensive approach is required, considering both the demand and supply side, as well as the broader economic context. The CRE market plays an important role in shaping the business cycle. The value of CRE in Slovenia also influences the creditworthiness of businesses, affecting their ability to secure loans and manage financial obligations. Additionally, fluctuations in the CRE market can pose risks to the balance sheets of banks, potentially impacting the stability of the financial sector. By recognizing the potential implications of its movements, stakeholders can proactively anticipate and respond to changes in economic conditions, fostering stability and contributing to the overall growth of the economy.

The subsequent sections of this thesis are organized as follows: Section 1 delves into the theoretical concepts relevant to the CRE markets. Firstly, it explores the relationship between commercial and residential real estate, as well as the interconnection between CRE markets, financial stability, and financial crises. Additionally, it examines the focus and characteristics specific to the Slovene CRE market and concludes by presenting various approaches employed by other authors in calculating fundamental value and assessing price misalignment. Section 2 presents and examines the data utilized for the analysis, providing a comprehensive description of its sources and of the construction and derivation of the fundamental factors. Additionally, it details the methodology adopted for constructing the

aggregated misalignment indicator. Section 3 unveils the results of the analysis, along with the validation of their robustness and sensitivity. Lastly, Section 4 concludes and outlines potential opportunities for future research.

1   LITERATURE REVIEW

This section presents a comprehensive literature review of the researched topic, including both theoretical and empirical studies. The first part of the review focuses on CRE markets in general, including their structure, economic features, and their relationship with the RRE market. Additionally, the review explores the broader effects of commercial property markets on the economy and financial stability, particularly in the context of financial crises and current economic challenges. Given that the Slovene CRE market is the primary focus of this thesis, the following section examines its distinctive unique characteristics and historical trends. Empirical evidence is also presented on the determinants of commercial property prices and their relationship with misalignment. The review begins by examining approaches applied to the residential market to provide a comprehensive understanding of the field. The literature on commercial price misalignment with fundamentals is then analysed, with a focus on identifying common methods, research conclusions and the approaches that have been applied to Slovenia's real estate market.

1.1   CRE markets

European Central Bank (ECB) defines CRE as a property that generates income, such as office buildings, restaurants, retail malls, hotels, industrial parks, warehouses and factories. It suggests that the definition should not focus on the ultimate use of the property but should consider the risk profile of the asset type. If a property is owned or developed for business uses, it is considered a commercial property, even if it is used for residential purposes. Therefore, it is important to distinguish between residential property owned and occupied by households and real estate owned by legal entities, which is more frequently purchased by professional investors as a speculative investment. Firms that are primarily involved in the ownership, trade, and development of income-producing real estate are referred to as commercial property companies. They play a significant role in CRE markets along with other kinds of property investors, such as banks, insurance companies, pension funds, hedge funds, real estate investment trusts (REITs), commercial mortgage-backed securities (CMBSs) and property derivatives (ECB, 2008).

CRE services are crucial for the operation of companies and the economy. As a vital source of employment and economic development, it provides and manages the infrastructure required for entrepreneurship and community growth. In 2021, the commercial property sector in the EU and UK combined contributed €427 billion EUR (2.8% of total) in gross value added to the economy. This is comparable in size to the automotive and telecommunications sectors combined, making CRE a significant contributor to the

economy. Moreover, it can be a key component in solving two pressing problems of modern society: sustainable building practises can support the green transition, while smart planning can contribute to a well-functioning urban environment (INREV & EPRA, 2022).

CRE markets are characterized by boom-bust cycles that can spill over into general economic activity. These markets are driven by complex forces that include the general state of the economy and capital markets, which are constrained by institutional framework. Others arise from the real estate market, from the behaviour of agents in response to the opportunities and restrictions they face at specific periods. These forces generate locally specific outcomes that influence the functioning of the community (Ball et al., 1998).

1.1.1 Relation between commercial and residential real estate

Existing studies often focus only on RRE and neglect the commercial part of the market. There are two main reasons for this. First, residential property is considered to have a tighter and simpler relationship between pricing and fundamental value, since the CRE market is frequently influenced by factors beyond local supply and demand, such as international corporations and franchises. The second reason is that researchers often choose to study only residential property to make their findings consistent with previous studies and avoid the challenges of assessing commercial property (Belke & Keil, 2018). However, the decision to limit the analysis to RRE should be taken with caution, as it may overlook important aspects of the real estate market.

Given the similarities between residential and CRE, one should ask whether the two sectors follow the same trends in terms of price peaks and troughs. History shows that when a rapid decline in residential property prices occurred it has raised concerns about the potential impact on income-producing properties that have already suffered a considerable decline in value. This implies that the fundamentals driving the two real estate sectors are similar, but the constraints to housing arbitrage may lead to larger volatility in house prices that are unrelated to fundamentals. Nevertheless, the existing research indicates that the similarities between the two sectors outweigh the differences. This is evidenced by the fact that the cycles of both sectors are long and their rates of appreciation are positively correlated. Additionally, the values and returns of CRE show a persistence in the short-run and medium-term mean reversion that are remarkably comparable to what has been observed for owner-occupied properties. Using common elements like land, capital, and production technologies can help lead to outcomes that are comparable across real estate sectors in the same market area (Gyourko, 2009).

Although the production characteristics and the cycles of commercial and RRE are similar, the latter receive much more attention due to their political and economic importance. Moreover, the CRE market has been shown to pose greater risks for banks, particularly in EU, as they devote a sizeable portion of their assets to CRE loans, which are more volatile than many other types of loans. CRE is also substantial and heavily leveraged. Banks are

exposed to additional risks because they may use the CRE market as collateral for other loans. In the period before the global financial crisis (GFC), the development of new financial products and the period of Great Moderation gave the false impression that the CRE market was more stable than the housing one. The GFC proved otherwise and showed that CRE markets can still harm the economy (Olszewski, 2013).

Property market experts and academics did not acknowledge the significance of studying the CRE market until the mid-1980s. Today, however, understanding how this market works is crucial for real estate professionals. Other academic fields such as geography, economics and finance have also recognized the value of researching CRE markets. This has led to a rapidly expanding literature and academic status for leading property journals (Ball et.al., 1998). Apart from the fact that many economic crises have been triggered by booms and busts in the RRE sector, Olszewski (2013) highlights that the CRE market can also have negative impact on the economy. Therefore, regulators and central banks should keep an eye not only on the RRE market but also on the CRE sector.

1.1.2   Stylised facts about the CRE market

One of the unique factors that distinguish CRE market from other markets is its structural and economic characteristics. At first glance, the dynamics of supply and demand in the CRE market may look similar to those in other markets. Namely, the cost of inputs such as land and building materials plays an important role in determining supply, economic activity shapes demand, while financial conditions are important for both. However, longer construction delays, long-term leases and unpredictability of income streams are just a few of the distinct characteristics of the CRE markets. The value of this type of property is mostly determined by the present value of its expected rental income. During an economic downturn, weakened macroeconomic conditions limit business activity and reduce demand for CRE, which results in higher vacancy and declining rental rates. As a result, the fundamentals of the real estate market decline, and prices decline. Commercial properties tend to be more sensitive to economic changes compared to residential properties due to their relatively lower value to users. They have higher maintenance costs and do not provide as much benefit as residential properties. Consequently, investors may be less willing to pay a premium for them making them more susceptible to market fluctuations. Besides that, also the level of indebtedness of companies that operate in the CRE market can contribute to their vulnerability to macroeconomic conditions (Zhu, 2003).

Newly constructed commercial properties make up a small portion of the entire CRE market. These properties have a long-life span and the process of building new structures can take several years due to various factors such as transaction costs (design and construction costs, delivery delays, selling costs and demolition costs, to name a few). Strongly cyclical behaviour can arise due to the construction activity's dependence on current property prices. When real estate prices exceed the cost of replacement, developers and builders are

motivated to start new construction projects. However, the lengthy construction process means that the market may have shifted by the time the project is completed. This can result in an oversupply of properties, leading to a subsequent drop in prices. The delayed responsiveness and functioning of the market are a result of the lack of immediate supply response (Davis & Zhu, 2011). Short-term price arbitrage and short selling via derivatives are limited due to the delayed adjustment mechanisms (ECB, 2008). Because of differences in supply elasticity, development lags, durability of assets, and funding methods, commercial property cycles may be asynchronous across regions and sectors. Additionally, both supply and demand may be affected by price discrimination and market power, leading to significant variations depending on the location. These aspects are making the CRE market mainly demand-driven in the short term, while this does not remain true over the long term when supply is more elastic (Zhu, 2003).

The built environment is shaped by various challenges related to property, making it essential to comprehend the economics of CRE markets. Ball et al. (1998) analysed the crucial economic issues in commercial property and divided them into three categories: microeconomic, macroeconomic and financial issues. The authors claim that location requirements, demand structure and the way land and property markets respond to these changes are the main microeconomic aspects in CRE markets. Understanding market adjustment processes in CRE markets is essential for studying these events, because, while demographic and economic shifts drive demand for real estate, developers', investors' and landowners' responses define the spatial consequences and have an impact on the competitiveness and profitability of various industries in a city, region, and country. The next category are macroeconomic issues, including the importance of CRE to the economy, the risk of overinvesting, property cycles and the necessity of modelling property market behaviour. Property collapses can result in company failures, decreasing asset values, and high-end but empty office space, whereas property booms can divert funds from other areas of the economy. The late 1980s and early 1990s global property cycle brought to light the important connection between the macroeconomy and commercial property markets. Economic modelling is essential for analysing this relationship and to understand the behaviour of CRE. The last group deals with financial issues. Compared to other asset types, CRE has unique and challenging financial characteristics. There are many increasing trends in this area, such as combining property asset management with that of other financial assets, increasing prevalence of cross-border investment and the emergence of new types of investment vehicles that enable investors to indirectly invest in properties.

Although equity financing is theoretically possible, debt financing has been more popular for investments in the CRE in the past, since it can enable much higher profitability than equity financing alone, with investors occasionally using high leverage. This is in part due to the common practice of non-property corporations putting their real estate holdings up as collateral when borrowing money, making a relationship between CRE prices and borrowers' financial positions. The credit market imperfections arise from the information asymmetry

between borrowers and lenders. Banks tie loan terms to borrowers' net balance sheet values, to reduce the problems of moral hazard and adverse selection. As a result, borrowing capacity and external financing costs are significantly influenced by the value of collateral assets. This creates a strong interplay between bank credit and borrowers' balance sheets, with higher collateral values leading to improved balance sheets, more favourable financing terms, and even higher property prices. In contrast, declining property values worsen borrowers' financial situations, limit bank lending to the real estate industry, and cause property values to drop even further. This amplification effect, also known as the "financial accelerator," (Bernanke, Gertler and Gilchrist, 1996) can considerably contribute to the high volatility seen in CRE markets (Zhu, 2003).

The principal-agent problem is also a potential issue in CRE markets, where decision-making agents are incentivized for short-term performance and act on behalf of investors without proper monitoring, which can result in a disconnect between decisions and outcomes. This is another way that CRE markets differ from other markets (ECB, 2008). The unique characteristics of CRE markets can cause prices to periodically deviate from their fundamentals, creating cycles and even price bubbles.

1.1.3   Cycles and bubbles in CRE market

The study of CRE markets often involves the use of the terms "cycles" and "bubbles". For example, ECB (2008) defined cycles as repetitive fluctuations around a fundamental trend, which may not necessarily involve sudden and drastic changes in value, but rapid changes in fundamentals can cause sudden changes in value. Bubbles, on the other hand, are characterized by substantial and unsustainable price increases that deviate significantly from the fundamental value and eventually reverse, converging back to it. Both cycles and bubbles can coexist in CRE markets, with cycles being seen as a normal part of the market and bubbles as exceptional periods. However, distinguishing between the two can be challenging, since the prices exceeding the fundamental value of an asset are referenced in both cases. Traditional asset pricing models don't consider property price cycles or bubbles and they assume reasonable expectations and a shared distribution of past beliefs of market players. If rational investors are present in the market, cycles and bubbles should not occur. However, there are certain characteristics of CRE markets that can allow cycles and bubbles to form, even among rational market participants.

There are several explanations for commercial property market cycles. Real estate in general, is a significant part of the economy and its cyclic nature has been studied extensively. Wheaton (1999), for example, has shown that different types of real estate can have very different cyclical characteristics, as displayed by the results of his stock-flow model. This model considers several key factors that influence the dynamic behaviour of the real estate market, including agents' future expectations, development lag, durability, and market elasticities. Based on experiments, it was found that fluctuations are more likely when supply

elasticity exceeds demand, development lags are prolonged and asset durability is low. Conversely, stability is achieved when agents use forward forecasting, rather than myopic behaviour. Another explanation is according to Davis and Zhu (2011), who argue that the cycles in CRE markets are caused by two mechanisms: exogenous business cycle shocks and intrinsic characteristics of the real estate market. The former encompasses external factors such as changes in output, inflation, and interest rates that affect property prices. The latter amplifies these exogenous shocks, resulting in overproduction of properties and endogenous cycles. These two types of processes can occur simultaneously and their relative importance may vary across sectors and regions. As found by Wheaton (1999), there are various factors that can explain cycles in the CRE market. However, these explanations differ depending on which factors are included or excluded from the analysis, and since commercial property prices show different cyclical patterns depending on the type of property, this may suggest that there are different explanations for each market segment.

Cycles and bubbles often go hand in hand and there are numerous explanations for bubble formation as well. One explanation is the development of "rational bubbles," where investors are willing to pay more for an asset than its discounted present value, due to belief in future higher prices. This is possible due to informational asymmetries and restricted short selling, leading to exploitation by knowledgeable participants and persistence due to uninformed investors believing in unrealistic profits. The efficient market theory, which argues that bubbles cannot persist due to informed investors arbitraging away mispricing, is challenged by limitations of arbitrage, risk of short selling, irrational noise trading, limited liquidity of the market, high transaction costs and synchronization risk, where, with a lack of widespread knowledge about the formation of a bubble, rational traders may choose to wait and "ride the bubble" rather than trying to burst it. Another explanation is based on heterogeneous beliefs, where investors have differing assumptions about an asset's fundamental value. Whenever there are restrictions on short sales, as there are in markets for CRE, optimists will push prices higher while pessimists are unable to counteract this upward price movement (ECB, 2008).

The existence of a bubble in the markets for CRE has been the subject of numerous research. Hendershott (2000) conducted a study on the fundamental values of the Sydney office market from 1985 to 1995. The market tends to revert to its mean due to developers' incentives to build during high value and halt during low value, but Sydney investors failed to account for this mean reversion in their vacancy rate forecasts, leading to undervaluation of properties. The results showed that office values during the late 1980s and early 1990s were sharply in contrast with their fundamental values. Another study done by Semlali and Collyns (2002) looked at East Asian countries, where property price booms in the 1990s were followed by sudden sharp declines, as well as financial crises after asset markets started to reverse and economic growth suffered. The article explores the influence of the credit channel on the real estate market and suggests that flaws in financial markets, insufficient regulation, and frictions in the real estate market can contribute significantly to the rise in

asset prices and subsequent crisis. It highlights that the real estate market is more vulnerable to the effects of the credit channel than the equity market and the response of property prices to credit is asymmetric and is stronger during the boom phase. It also concludes that property market returns are linked to overall market returns.

Levitin and Wachter (2013) build upon these previous studies by analysing the commercial and RRE price bubbles in the United States (US). They argue that there were the two parallel bubbles between 2004 and 2008, with the commercial one attracting much less public, academic, and policy attention. They claim that the CRE boom was driven by a change in financing sources, with securitization becoming increasingly important from 1998 onwards. By 2004, innovations in the CMBS markets enabled collateralised debt obligations (CDOs) to overtake traditional investors in the CRE markets as underwriting standards declined.

1.2   CRE markets and financial stability

As noted before, commercial property is referred to as the "income-producing type of property", since it is frequently purchased by investors for the purpose of leasing it to other businesses. Due to the direct link between this sort of income and business cycles, there are often sharp price fluctuations that can trigger crises, especially when the economic activity is declining. Note that the use of leverage further exacerbates the risks to financial stability. CRE cycles can be seen practically everywhere and at any moment, but as previously stated, they are a normal component of economic progress, as long as they do not lead to extreme bubbles (Olszewski, 2013). While CRE provides the physical infrastructure for commercial economic activity, lending to this sector entails inherent risks that could threaten financial stability. The GFC and other crises in the past have shown that CRE loans are frequently the main reason for loan losses (Dunstan & Skilling, 2015).

According to the ECB (2008), there are four key channels through which developments in the commercial property market might impact financial stability. Firstly, a sizeable share of the assets of many EU banks are loans for investments in CRE. For example, in the fourth quarter of 2020, CRE loans, on average made up about almost one-tenth of total loans and more than 20% of total corporate loans (ECB, 2022). Second, compared to other types of bank lending, CRE loans exhibit greater volatility due to the instability of commercial property prices and their close correlation with business cycle conditions. Thirdly, changes in commercial property prices can have an indirect impact on the balance sheets of banks, as well as on the activities of real estate developers and construction firms. Moreover, this can also affect the gross domestic product (GDP) indirectly by influencing households and NFC and is particularly relevant in countries where the real estate and construction sectors play a significant role in driving economic growth. Lastly, the financial stability can also be influenced by unfavourable developments in CRE markets through institutional investors that frequently have sizable direct and indirect investments in this sector. Other factors can either intensify or reduce the impact of these channels. For example, real estate financial

innovations like REITs, property funds, CMBSs and CDOs have made a previously illiquid asset class accessible to more investors. This can promote risk diversification, but there are also new risks, like sudden fund withdrawals and high market volatility that can limit liquidity (ECB, 2008).

CRE lending often involves loans for corporate construction and development (C&D) and non-residential buildings that investors keep for the long term (for example REITs). Existing CRE owners can obtain finance from the capital markets, which lessens their reliance on banks, unlike residential property owners. Moreover, some firms undertake C&D projects for the development of new housing properties but are classified as CRE exposures. This market conditions are causing banks to have a higher concentration of CRE exposures for financing new developments rather than long-term investors. New entrants, such as foreign and second-tier domestic banks, find it easier to enter the CRE lending market because many loans are for specific projects and are often syndicated loans. However, they frequently end up lending to less-established borrowers, which increases the riskiness of their loan portfolio (Ellis & Naughtin, 2010).

Number of factors contribute to the high risk of lending to commercial property, as pointed out by Dunstan and Skilling (2015). They classified these factors into three categories, which are the drivers, effects, and risks. It is important to note that any impact on financial stability is a link that begins with the drivers, which in turn lead to effects, ultimately culminating in risk. The first connection is the potential for huge price changes in real estate over the course of an average cycle. Long periods where prices exceed economic fundamentals may come from irrational exuberance, which means that investors overpay as a result of false expectations regarding the future profits. In an efficient market, this would cause a supply reaction that would control price growth, but in practice, long construction lags prevent this from happening. When prices eventually start declining, low liquidity, due to high average values and significant transaction costs, can additionally amplify downward price movements. As explained by Ellis and Naughtin (2010) commercial property construction takes longer compared to residential property, as buildings like shopping centres, offices, and apartments take more time than single-family homes. If the market declines before a construction project is finished, it can result in cycles where building work becomes unnecessary due to a downturn in demand, leaving the site incomplete and with little value beyond the land. As a result, the bank may wind up losing all, depending on the costs to complete or remediate the location.

The next link that impacts the financial stability, is between commercial property industry, actual economic activity and financial institutions that fund the industry. To illustrate, when the value of CRE declines, development projects become less profitable and this increases uncertainty among developers. As a result, economic activity declines even more, which causes the fall in real estate prices. Also, this leads to a drop in rental demand, which worsens losses on loans for CRE. Typically, real estate-based property investments that are funded through debt are secured by using the underlying property as collateral (Dunstan & Skilling,

2015). This exposes banks to the CRE market through loans made for CRE purposes and the use of CRE as collateral. Through the collateral channel, a link is established between the dynamics of the CRE market and broader credit conditions. According to economic theory, using CRE as collateral could have a financial accelerator effect that would amplify excesses during an upswing and losses during a downturn. When CRE prices fall, banks may be less willing to lend to companies that rely on CRE as collateral, which can restrict their capacity to fund further CRE purchases and create a feedback loop. Collateral channel may also create a relationship between CRE prices and broader credit conditions by limiting enterprises' ability to borrow for other purposes (Ryan, Horan & Jarmulska, 2022).

Another characteristic of the CRE market that sets it apart from the RRE market is a higher default correlation across commercial property loans. This is because commercial property investors are dependent on rental income to service their debt, which is closely linked to both economic conditions and property values. The decline in economic activity can worsen the solvency of tenants, impact the risk for owners and consequently pose a risk to financial stability. While large investors may attempt to diversify their assets, in reality, CRE portfolios tend to be highly correlated (Dunstan & Skilling, 2015). To illustrate, people usually take out long-term mortgages to buy homes, while banks often lend money for commercial property on a shorter-term basis, even for existing properties, which do not have the short-term horizon of a construction. This means that CRE borrowers are at greater risk of needing to refinance their loans. During the periods of financial stress borrowers need to refinance, often with more stringent covenants, further increasing default correlation (Ellis & Naughtin, 2010).

The impact of CRE on financial stability can be a precursor to a wider financial crisis if vulnerabilities in the sector are not appropriately addressed. For example, evidence from past crises, including the GFC, indicates that CRE loans have typically been the main source of loan losses. According to Dunstan and Skilling (2015) commercial property has been a major factor in numerous post-war advanced economy financial crises, prior to the GFC, in countries such as Sweden, Finland, Norway, Japan, in the 1990s, and New Zealand in the 1980s. The pre-crisis period was generally characterised by the rise in CRE prices, increased construction activity and lending following the liberalisation of financial markets. These conditions created excessive leverage in financial systems, which exacerbated the decline in property prices when a combination of slowing economic activity and rising interest rates dampened market optimism. In most post-war financial crises, commercial property accounted for a significant portion of losses in the financial system (Kragh-Sørensen & Solheim, 2014).

The GFC started in the US residential property market, but also revealed the close connection between CRE and financial stability. In the years leading up to the crisis, loose financing conditions and strong demand for office and retail space drove up CRE values in many advanced economies. This resulted in a surge in bank lending and the growth of commercial mortgage-backed securities, which increased the leverage of commercial property investors

in some countries. The resulted in a decline in CRE prices in many member states of the Organisation for Economic Co-operation and Development (OECD), with a stronger impact compared to housing prices. Tighter bank lending and the sudden stop in the issuance of CMBSs meant that many investors were unable to refinance their loans, leading to a slowdown in investment and development and further decline in property prices. Consequently, a significant proportion of borrowers, especially those financing new developments, found themselves with empty buildings that were worth less than their debts. This resulted in an increase in the share of non-performing loans to CRE. During most financial crises, commercial property lending has played a significant role in causing loan defaults. However, recent data shows that risks associated with CRE have decreased globally since the GFC, largely due to a reduction in the use of leverage to finance new purchases and developments (Dunstan & Skilling, 2015).

The COVID-19 pandemic and the short-lived economic shock created significant challenges for the CRE market, potentially amplifying financial instability and increasing the risk of a crisis in the sector. While the pandemic has had varying effects on different real estate markets, it is important to remember that commercial and RRE markets can differ significantly due to factors such as purchasers, end users and finance sources. While the COVID-19 pandemic caused a surge in demand for RRE, the CRE market experienced a period of risk utilization. Lockdowns and changes in behaviour resulting from the pandemic, such as remote work and store closures, posed a medium-term threat to prices for office and retail assets (Ryan et al., 2022). The market for offices and retail properties could experience structural changes as a result of the rise in remote working and online shopping, potentially leading to a medium-term decrease in rents. This could have adverse effects on the financial positions of borrowers and result in increased credit losses for banks with a significant portion of non-traditional loans (such as bullet loans, fully unsecured loans, non-recourse loans[1]) (ECB, 2022).

In 2020, prime retail commercial property markets experienced a significant drop, namely the annual price growth decline for almost one-fifth. The pandemic exacerbated challenges as banks restricted financing to the CRE sector, potentially worsening the initial shock of the crisis. Although new bank lending in the euro area increased after the start of pandemic, this did not include loans for CRE purchases. In fact, lending for CRE was low in 2020, while total new lending by the banking system more than doubled. During the pandemic, banks were also cautious about lending to firms that relied on CRE collateral. The reason for both these occurrences is because market shock increases the credit risk on exposures to CRE markets. In addition, the use of CRE as collateral can lead to increased losses for banks if borrowers default while there is a drop in collateral values. CRE market prices become connected to the borrower's access to credit, potentially amplifying the excesses in the

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[1] Bullet loans are loans where the repayment of interest is paid at regular intervals and of principal on maturity, unsecured loans do not require collateral, but because of that usually have higher interest rates and non-recourse loans are when in the case of default, the lender can seize the loan collateral, but not any other borrowers assets (Nickel, 2017).

upswing of the cycle and magnifying losses during a downturn. Moreover, the collateral channel can connect CRE market dynamics to wider credit conditions. This might have had unfavourable effects on CRE firms during the pandemic as well as on businesses that used CRE as collateral (Ryan et al., 2022). The ECB (2022) has recognized banks' vulnerability to CRE as a significant risk factor for the upcoming years, due to the impact of the pandemic. It highlights several concerns, such as the prolonged supply chain issues, due to pandemic, that have resulted in a considerable increase in construction costs. Because of that banks with high exposure to properties under development are at a greater risk. Aside from the pandemic, the CRE sector is also susceptible to climate-related transition risk, since in the EU, buildings account for roughly 40% of energy consumption and 36% of greenhouse gas emissions. Additionally, roughly 35% of these buildings are over half a century old. The negative impact of climate-related transition risk on the CRE sector can be observed through the poor outlook for this segment, which has already experienced a decrease in demand.

There are also other current economic challenges that need to be considered, since they can affect CRE valuations. With the moderation in economic activity following the strong post-pandemic economic recovery and the record pace of monetary tightening, there is growing concern among policymakers about the risks posed by real estate markets, whose valuations have soared in recent years. The main risks to growth are the moderating international macroeconomic outlook, compared to the robust and fast recovery in the post-pandemic period, and persistently high inflation, which has brought an abrupt end to the accommodative monetary policies of major central banks. In response, the ECB, together with other major central banks, has embarked on aggressive monetary tightening campaign. As expected, the interest rate increases also affected mortgage rates, which attracted the attention of researchers. Battistini, Gareis and Roma (2022) address the transition from lower to higher mortgage rates. Although their primary focus is RRE analysis, the two markets are related, so it makes sense to consider these findings as well. Their results show that the response of house prices and investment to an increase in lending rates is both significant and non-linear. Normally, a one percentage point increase in interest rates would cause house prices and investment to fall by 5 and 8 percent respectively after two years. This effect is around two times larger in a low interest rate environment. However, the housing market is influenced by other factors and these should be also considered as they can make the market future more unpredictable. Increased mortgage rates could be offset by changes in home choices brought on by a pandemic, which could also account for part of the market resilience seen in the euro area.

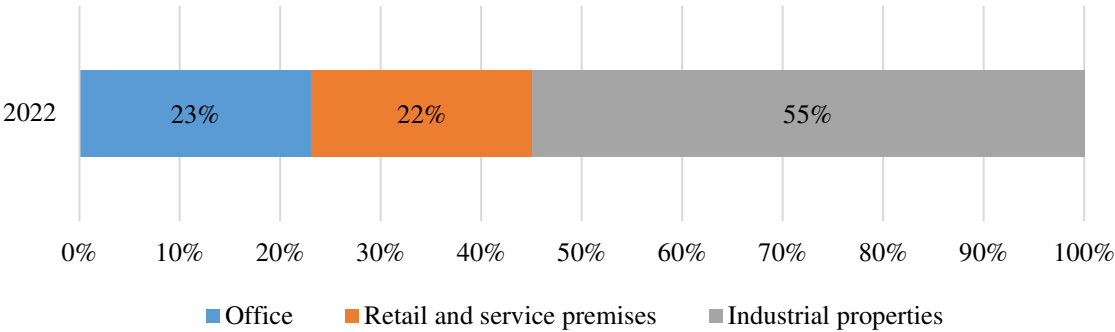## 1.3   Slovene CRE market

Since the analysis of the Slovenian CRE market is the main objective of this thesis, let us now turn to it and present some stylised facts. In Slovenia, the CRE market is relatively small and primarily centred around office spaces, as well as catering and retail establishments located in major retail centres and in the central areas of larger towns and cities. Due to the

limited number and heterogeneity of commercial properties available, even a single major deal can lead to significant price fluctuations. As a result, high volatility in both prices and transaction volumes is typical. Furthermore, the rental market is highly competitive due to the limited supply of commercial premises aimed at the market (Bank of Slovenia, 2022a). The Surveying and Mapping Authority of the Republic of Slovenia (SMA) monitors three primary categories of CRE: offices, retail and service premises, and industrial facilities. However, these categories are not evenly distributed across different geographic locations. Office spaces are primarily concentrated in Ljubljana, the capital city, and other major administrative centres. Industrial properties, due to their larger size, are typically built in areas with lower land prices and good infrastructure. On the other hand, retail and service premises are more uniformly distributed and situated in locations that are readily accessible to consumers.

Industrial properties, which have the highest stock of all CRE properties, but they account for the smallest sales and rental transactions. Their low liquidity stems from the fact that these buildings were primarily constructed to meet the specific needs of their original users, which means high reinvention costs for potential new occupants. On the other hand, retail locations, particularly shopping centres, are mostly owned by large real estate funds and were constructed after Slovenia gained independence in 1991, especially during the years of great economic growth between 2000 and 2008. However, due to excessive investments, larger Slovenian retail companies were forced to sell and lease back their premises to foreign-owned Slovenian or foreign real estate funds after the GFC. As for office space, an average of one hundred thousand square meters is constructed annually, representing an approximately one percentage of total stock. However, most of the larger administrative buildings were built before Slovenia gained independence for the needs of large social enterprises that are now operating on a smaller scale or have ceased to exist. As a result, the ownership of these older buildings is fragmented, posing difficulties in managing them. Nevertheless, office space remains a crucial factor in transactions, since in 2022 they accounted for more than 60% of all rental transactions and just under 45% of all sales, primarily because of their versatile nature (SMA, 2023).

Figure 1: Share of CRE stock, by m^2, by type of real estate, in Slovenia, in 2022


Source: SMA (2023).

Since the GFC, Slovenian CRE market has exhibited the period of fluctuation and volatility. In 2008, CRE prices were at their highest, but in the aftermath of the crisis, prices steadily declined until reaching their lowest point in 2014. During this time, over-indebtedness of companies and weak economic activity were limiting the demand in the CRE market. As a result, the CRE price index was subject to considerable fluctuations and valuations were difficult due to the illiquidity of the market (Bank of Slovenia, 2014). Since then, average nominal CRE prices have risen steadily, albeit with some temporary declines. The price movements of commercial and RRE in Slovenia were similar between 2008 and 2015, but there were some notable differences afterwards. Specifically, market valuations of residential property started to rise faster than commercial property prices. As of 2020, housing prices had already surpassed their 2008 levels, while CRE prices had not yet reached the same level. Also, the size of the real estate market has a notable effect on the volatility of the indices and because of the COVID-19 pandemic the number of sales was even smaller in the first quarter of 2021 (SORS, 2021). Nevertheless, currently prices of CRE are on the rise. In 2022, the year-on-year growth rate reached approximately 16%, marking the increase since 2008 (Bank of Slovenia, 2023).

The Statistical Office of the Republic of Slovenia (SORS) gathers the data for two specific subcategories of CRE – offices and retail. These two subcategories are the only ones that are considered for the calculation of price indices for CRE in Slovenia, as the low liquidity of industrial, tourist, transportation, and communication buildings prevent the calculation of reliable price indices. The category of "offices" encompasses spaces used for diverse range of business activities such as banking, insurance, and post offices, among others. On the other hand, "retail spaces" include shopping areas of different sizes, restaurants, bars, and spaces for various services such as hairdressers, dry cleaners, and fitness studios. From the peak in 2008, office prices kept decreasing until 2014, then they increased for short period, but again declined in 2016. From there on they keep rising and by the third quarter of 2022, reached a level that was almost two-fifths higher than in 2015. On the other hand, the price of retail spaces started to rise only after 2017 and it took until 2020 for them to reach a level higher than in 2015. In the third quarter of 2022 they were 16.6% higher than in 2015. The significant sales of three retail chains, namely Mercator, Tuš and Merkur, with a large number of shopping malls across Slovenia in the 2019–2020 timeframe is one of the causes of the constant increase in retail space prices since 2015. These properties were purchased by foreign REITs, and the achieved prices were modest which had a "price stabilizing" effect on the market (SORS, 2021; SORS, 2022). This means that it helped to prevent or minimize significant fluctuations in the market prices of similar properties. This effect can be beneficial for both buyers and sellers, as it helps to create a more stable and predictable market environment.

Following the GFC, there was a low number of building permits issued for non-residential buildings until the end of 2014. From this point onwards, the number of permits began to increase and reached its peak in the second quarter of 2016. During this peak, the number of

permits issued was approximately five times higher than in 2013. Since then, the number of permits issued has remained relatively stable, with a minor decrease observed in 2020. As illustrated in Figure 3, the majority of non-residential building permits are issued for other types of non-residential buildings, such as non-residential farm buildings, buildings used for religious activities and worship, historic or protected monuments, and other structures. The other two categories with a significant portion of permits issued are transport and communication buildings, as well as industrial buildings and warehouses.
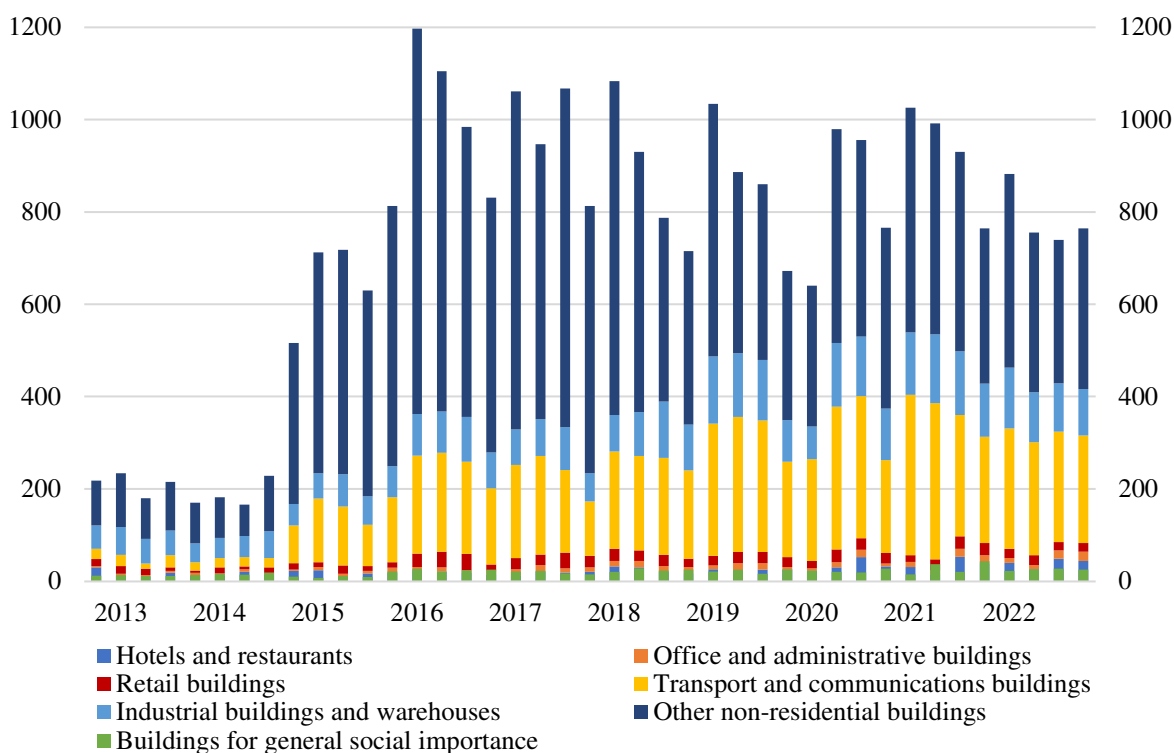
Figure 2: Yearly price indices, Slovenia, 2015 = 100
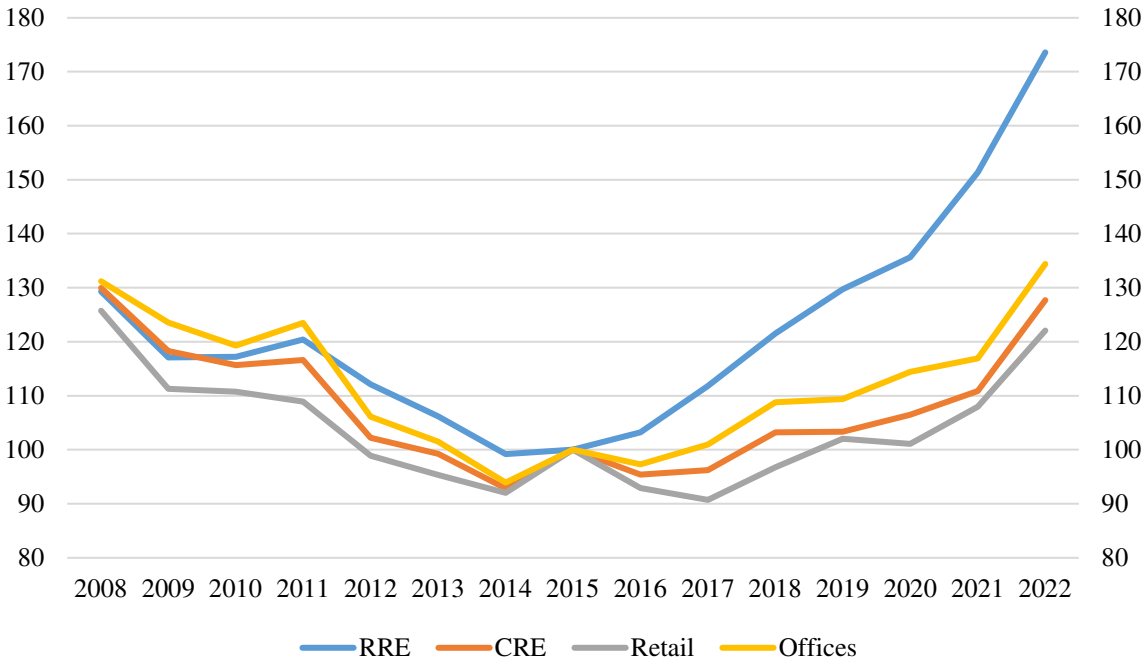
Adapted from SORS (2023).

Due to its advantages, the highly competitive CRE rental market led to a decline in office space prices in 2016 as more people chose to rent compared to the sales market. In 2018 and 2019, there was a slowdown in the rental market with a decrease in newly concluded contracts, but still considerable demand in Ljubljana due to lack of supply. COVID-19 may have a long-term impact on the market by increasing the flexibility of the rental market (Bank of Slovenia, 2016; Bank of Slovenia, 2019; Bank of Slovenia, 2020; Bank of Slovenia, 2021a). Office rental contracts are typically short-term, with a duration of less than five years, or indefinite with short notice periods. Annual rental deals for office spaces outnumber sales deals by a significant margin, and Ljubljana is the most active market. For example, in 2022, around 55% of all rental transactions were realized in Ljubljana, based on the total leased space. During the pandemic, there was a reduction in the demand for office space due to work from home, mainly the number of transactions decreased. But there is no indication that the pandemic will have a long-term negative impact on the office space market.

Figure 3: Number of non-residential buildings for which building permits were issued

Legend:
- Hotels and restaurants
- Office and administrative buildings
- Retail buildings
- Transport and communications buildings
- Industrial buildings and warehouses
- Other non-residential buildings
- Buildings for general social importance

Adapted from SORS (2023).

However, the number of office lease agreements has been decreasing in recent years, indicating declining demand for rental spaces. This trend may be due to the increasing number of indefinite rental contracts. In the retail and service sector, tenants in shopping centres are notably stable, with lease contracts typically ranging from 5 to 10 years, and up to 20 years for main tenants. Retailers in shopping centres prefer longer lease agreements to maintain their sales locations and rent prices are usually adjusted annually to reflect inflation. Despite the COVID-19 pandemic, in retail, there have been no significant changes in the rental market, such as mass termination of rental contracts or forced sales. Landlords and tenants have dealt with the issue of limited movement or "lockdowns" by offering one-time discounts on rents and operating expenses. Moreover, some home furnishing retailers even experienced an increase in traffic during the pandemic, as reported by SMA (2023).

Bank lending for CRE in Slovenia has declined significantly in the years following the GFC. Namely the value of loans issued for this sector fell from one billion euros in 2011 to 100 million euros in 2016 and remained low for several years thereafter. From 2016 to 2019, only about five million euros in new loans were approved per month on average, which can be observed in the Figure 5 (Bank of Slovenia, 2019). Despite the slight increase in the volume of new loans in 2020, the CRE market has been less active than the RRE market since 2016. This is due to lower demand from companies for bank resources. Additionally, this market segment was generally less affected by the Covid-19 pandemic (Bank of Slovenia, 2021a; Bank of Slovenia, 2021b; Bank of Slovenia, 2022b). As depicted in Figure

4, the amount of NFC loans for CRE is relatively modest. However, it experienced an increase in 2022, reaching 4.1% by December, although still lower than the level at the beginning of 2011. At the end of 2022, a majority of NFC loans for CRE (62.3%) had a maturity period of up to five years and nearly all of them carried a variable interest rate. These loans are predominantly secured by CRE, with an average loan-to-value (LTV) ratio of around 50% as of December 2022. Nevertheless, it is worth noting that approximately 45% of the loan value had an LTV above 80% (Bank of Slovenia, 2023).

Figure 4: Stock of loans to NFC for CRE
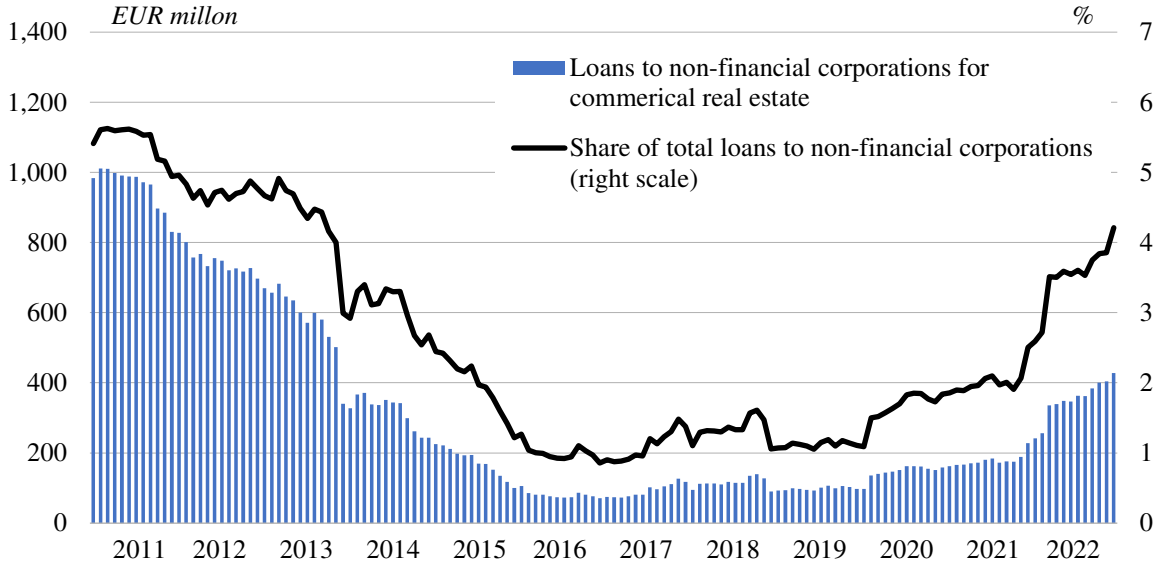
Source: Bank of Slovenia (2023).

Figure 5: New loans for NFCs for CRE, and their share of total loans to NFCs
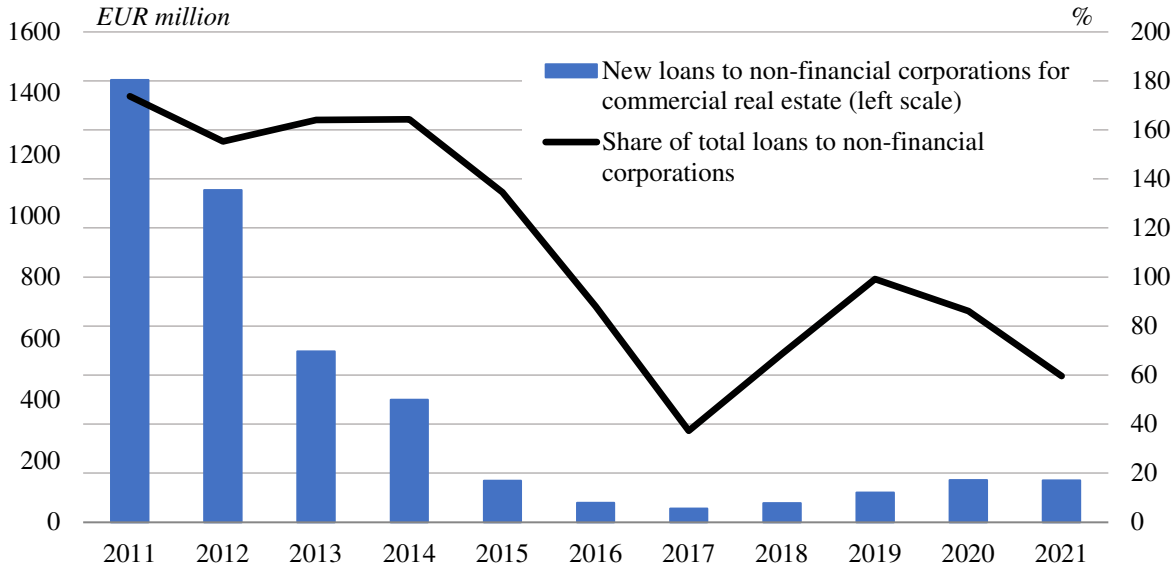
Source: Bank of Slovenia (2022a).

1.4   Approaches to calculating fundamental value and price misalignment

One of the most common challenges in the real estate market is the price misalignment, which refers to the mismatch between the market price of a property and its intrinsic value. The latter is the price that should be aligned with the market value, considering all the relevant factors. For residential and commercial properties, determining the correct fundamental price can be a challenging endeavour. Most frequently method used in the literature is the valuation of the fundamental prices, based on different economic fundamentals of supply and demand. The obtained valuation is then compared with the market value of the property. If the latter are lower than the fundamental ones, the market is undervalued and vice versa. However, as there are many factors that can influence prices, it can be difficult to determine whether the current price of a property deviates from the fundamental price, which would indicate a mispricing. The study of price misalignment in real estate, including the determination of fundamental price, is a crucial area of research with significant implications for buyers, sellers, and the broader economy. The problem is that fundamental prices cannot be observed directly and researchers therefore use different methods to estimate them.

One of the approaches widely used in the literature is the net present value methodology, which forms the basis for the valuation of residential and commercial property and decision-making in real estate investment. This model calculates net cash flows from properties (rental income), discounted at a fixed rate and then compares them to the market price of the property (Geltner & Mei, 1995). There is also a user cost approach, which calculates all the costs that property owners have to factor in, when determining the market rent if they choose to rent out their property instead of using it or occupying it themselves (World Bank Group, 2010). Principally this method compares continuing property ownership costs to market rentals, where for the user cost of housing the factors are typically maintenance expenses, interest costs, property tax payments, opportunity costs of the deployed capital, risk premium and prospects of future changes in house prices. When homeownership costs are equal to rental costs, the real estate market is said to be in equilibrium (Himmelberg et al, 2005).

Nevertheless, econometric-based approaches are mostly used in the academic literature to estimate fundamental prices. The following section will discuss the most commonly used approaches and present examples of empirical studies in which they have been applied.

The econometric approaches applied to RRE, used in related literature can be generally divided into several groups. First and, according to the authors knowledge, probably the largest strand of literature applies the multivariate time series models, such as vector autoregression (VAR) model (Igan & Loungani, 2012) and vector error correction model (VECM), which allow us to analyse both the long-run and short-run relationship between cointegrated variables (Gattini & Hiebert, 2010; Chen, Gan, Hu & Cohen, 2012). Note, these models are often applied in forecasting exercises. Second strand of literature uses modelling approaches applied for panel datasets, for example Kajuth, Knetsch and Pinkwart (2013)

applied stock-flow model of the housing market. Some authors have used non-linear modelling techniques to test whether there are non-linear relationships in the data that explain the behaviour of the data better than their linear counterparts. For example, they applied state space models (Kizys & Pierdzioch, 2009) and multivariate structural time series models (Runstler & Vlekke, 2018). Lastly, Dreger and Kholodilin (2011) proposed an early warning system which is based on a signalling strategy, a logit model, and a probit model, where they demonstrated that the latter two models allow for far more accurate predictions of housing bubbles and that this could make them helpful for forecasting.

All methods for estimating fundamental prices carry a significant degree of uncertainty, but findings can be more reliable when multiple distinct indicators align. This is why several authors in the literature have employed a variety of measures for this purpose. For instance, ECB (2011a) published a misalignment indicator for residential property that utilized four different metrics, including the house price-to-rent ratio, the house price-to-income ratio, a demand equation approach and an asset pricing approach. Also, Kulikauskas (2016) tried to evaluate house price misalignments and employed a combination of statistical indicators, such as the price-to-rent ratio, price-to-income ratio, and univariate Hodrick-Prescott filter, along with estimates from an equilibrium equation. Investigation revealed that the imbalances in the Baltic RRE markets, which led to the 2008-2009 crisis, could have been detected in real-time, as early as 2005, using the proposed framework.

There has also been done some research using multiple indicator approach, which weights and aggregates the numerous variables into a single indicator in order to represent both the supply and demand sides of the real estate market. To find risks and imbalances in the Swiss housing market UBS (2012) developed a method that entails computing the "UBS Swiss Real Estate Bubble Index" since 2011. The index is composed of six sub-indices, namely the ratio of house prices-to-rent, house prices-to-household income, house prices-to-inflation, mortgage debt-to-income, construction activity to GDP and loan applications for rental properties to total loan applications. Similar misalignment indices were created by Schneider (2013) based on seven sub-indicators that represented the Austrian housing market's underlying fundamentals, including investor and household viewpoints as well as elements that affect the entire financial system. The article concludes that at the time, Vienna signalled a rising level of overvaluation, the driver being the relative real estate price (compared to rentals, consumer prices, and construction costs), which was only slightly offset by rising home ownership affordability. Despite increase in prices, the indicator for Austria as a whole indicated a sustained undervaluation. In a similar manner Lenarčič and Damjanović (2015) applied this methodology to the Slovenian market and concluded that Slovenian RRE prices were undervalued at the time. In Malta, prices also followed a similar trend, but by the end of 2015 they were mostly in equilibrium (Micallef, 2016). For the German market Hertrich (2019) determined that at the beginning of 2018 the market was overvalued, where interest rate risk and an advanced stage of the housing cycle were the primary drivers, but this have been somewhat mitigated by a reasonably strong capacity to service loans.

The literature review thus far has revealed a significant amount of research has been conducted on RRE prices and misalignment with fundamentals, but CRE has also long been of interest to researchers and practitioners in the field, particularly in recent years, with an increase in studies on the topic of CRE price misalignment with fundamentals. The following section will describe key findings from various studies that have looked at that topic, where some have examined a whole market and some the specific type of a commercial property.

Starting with the report where ECB (2011b) performed an analysis presenting a set of indicators that can be used to detect possible misalignments in the value of CRE markets. It focused on euro area countries and used two sets of fundamental indicators, namely some macroeconomic variables (GDP, private consumption, employment) and some factors that have an impact on the future income (rents, initial yields). According to the report, in 2007, CRE markets in multiple euro area countries were deemed to be overvalued. However, since then, this overvaluation has substantially decreased. In 2011, the indicators revealed that the market was not misaligned overall, and the adjustments made to correct the overvaluation in 2007 were consistent across all five indicators. The report also suggests that indicators have a number of restrictions, but this approach can help provide a more comprehensive view of the market and its misalignment. It also demonstrates the need for long time periods of the data, at least a complete CRE cycle, for the analysis to give an unbiased result as possible.

Later, Hlaváček, Novotný and Rusnák (2014) developed an error-correction model that they applied to few central European countries. With the model they showed the reliance of the prices of office property on macroeconomic factors (such as GDP, inflation, interest rates), demographic (population increase and size) and structural factors. The study reveals that the maturity of the loan market, as well as supply and demand parameters have an impact on office prices. More specifically it turned out that GDP, effect of consumer prices and supply factors are statistically significant, but the maturity of the credit market has a smaller impact. The analysis also showed that property prices were overvalued during the period from 2006 to 2008 and before that they show undervaluation. In 2013, it was observed that office property appeared to be undervalued in countries experiencing relatively high GDP growth rates. On the other hand, in other countries, prices were observed to be near or slightly below their equilibrium levels. Similarly, Coffinet and Kintzler (2019) tried to evaluate office prices in France. They used vector error-correction model that explains office price dynamics considering several macroeconomic variables (GDP and interest rate) and historical data on office supply, stock and rent. Their main finding was that office prices are positively correlated with GDP and rent, but negatively correlated with interest rates, the latter having a particularly weak influence. The analysis showed that the office market in France was only somewhat overvalued and close to fair value towards the end of 2017.

The misalignment of commercial property prices was also examined by Hejlová, Hlaváek, and Vakova (2020), who created a semi-structural model and assumed that CRE market consists of three separate but interlinked segments (rental, investment and construction). With the inclusion of the three segments in the model they tried to capture market's structure

for commercial property. The research was done on industrial property and offices for five central and eastern European (CEE) countries and Germany. They conducted cross-country and cross-property panel calculations and concluded that investors tend to focus more on certain property types than on specific countries. Most of the countries showed overvaluation for most property types as of the middle of 2019, while price dynamics within each country are largely correlated across property types, but with different degrees of overvaluation.

Some research has been also conducted that takes a broader perspective on commercial property prices and the factors driving them. For example, Hagen and Hansen (2018) made an analysis on office prices in 58 cities in Europe. They decomposed prices of CRE into yields and rents and showed how each of the two influence or signals the up- or downturn of the market. They concluded that while the rent component was primarily responsible for the price peaks before 2003, dropping yields can be used to explain a large portion of the rises that followed. Davis and Zhu (2011) studied another question regarding CRE, namely the association between commercial prices and credit. They did an analysis on 17 countries, using panel error-correction model with the following variables: CRE prices, credit to the private sector, GDP, private investment and short interest rate (all variables were expressed in real terms). They concluded that credit has a beneficial impact on CRE prices in the short term but has an unfavourable impact in the long term. Additionally, they observed that GDP has an impact on both commercial property prices and bank credit, where GDP has a positive impact on prices and they have favourable effect on credit. This is suggesting a significant impact for external shocks in the relationship between property prices and credit.

The literature on price misalignment in the real estate market has primarily focused on residential property. However, the importance of CRE and its implications for financial stability have led to increased research on misalignment of prices in this area. In terms of methodology, it has been noted that a greater variety of methods have been developed and applied specifically to the RRE market, but some of methods have been utilized in research on the CRE market as well. One of the techniques developed by UBS (2012) and Schiller (2013) is multiple indicator approach that has been applied to various housing markets but has not yet been applied to the case of the commercial property. This master thesis aims to fill this gap by using this approach to investigate price misalignment in the Slovenian CRE market.

2 DATA AND METHODOLOGY

2.1 Sub-indicators

This section presents the nine fundamental indicators that are considered to have the greatest influence on the behaviour of the Slovenian CRE market and, as such, are included in the construction of the overall misalignment index. The section will provide a comprehensive explanation of the process involved in collecting data for each sub-indicator. Additionally,

it will delve into the methodology used to construct each indicator and discuss the potential effects it may have on the aggregated index. Overall, the sub-indicators can be categorized into three distinct groups, each addressing a different perspective. Specifically, the price-to-PPI ratio, price-to-GOS ratio, price-to-hypothetical borrowing volume ratio, and FDI-to-GDP ratio are considered to represent the demand-side perspective, while the price-to-rent, price-to-construction costs ratio, investments in other buildings-to-GDP ratio, and inverse of construction value reflect factors influencing the supply-side. Lastly, the loan-to-GOS ratio provides crucial information from the system perspective. The data used for all these sub-indicators is at quarterly frequency, covering the period from 2005Q1 to 2022Q4. To address the issue of volatility within individual datasets, a smoothing technique, specifically the moving average method, was applied. This approach involves calculating the average value of a specific number of consecutive data points within the dataset. By replacing each data point with its corresponding moving average, fluctuations and short-term variations were mitigated, resulting in a smoother and clearer representation of the overall trend.

Analysing CRE data has many limitations due to the fragmented and opaque nature of the market. Official data on CRE prices and rents are often not available in many countries, and private company data may only cover larger cities, which might not be representative of the entire market. Additionally, capital values can lag actual market developments, as they are based on valuations made for annual reports, which can be delayed by a short period. Therefore, it is important to approach developments in commercial property markets with caution when relying on this type of data (ECB, 2008). For Slovenia, there were some similar data issues, and alternative methods and sources had to be used to construct some indicators. The data collection process for each sub-indicator is described in detail. Nevertheless, the data used in this thesis is deemed sufficient to allow a general discussion of major developments in the CRE market in Slovenia.

Firstly, four sub-indicators that present demand side of the CRE market will be described. These indicators portray the perspective of business or other organizations that are looking to lease or purchase space for their operations. Subsequently, the discussion will proceed with the presentation of sub-indicators that capture the developments of the supply side. These sub-indicators display the perspective of property owners and developers, who are responsible for building, renovating, and managing commercial properties. Developers often construct new commercial properties in response to market demand, while property owners can decide to sell or lease their properties based on market conditions. Additionally, institutional investors such as pension funds and REITs also play a role in the supply side of the market by building, acquiring, and managing CRE as part of their investment portfolios. They may also invest in new developments or partner with developers to construct new properties. This section will be concluded with the inclusion of the loan-to-GOS sub-indicator, which provides the system perspective.

2.1.1   Price-to-PPI ratio

Real commercial property prices were derived by deflating the nominal CRE price index with the producer price index (PPI), following the equation 1. They capture the demand side perspective; they most clearly summarize CRE market developments in Slovenia and are presented in the Figure 6. In the period leading up to the GFC, the real price of commercial property in Slovenia exhibited a consistent upward trend, reaching its peak in the fourth quarter of 2007. However, the onset of the GFC and the subsequent cooling of global real estate markets brought about a pivotal moment in the valuations of Slovenian CRE. During the following period, the index measuring the real price of Slovenian CRE experienced a significant decline, losing more than a third of its value before reaching its lowest point by the end of 2014. Since then, there has been a gradual recovery in the price of CRE, with nominal values almost reaching pre-crisis levels in the second half of 2022. However, it is important to note that this price increases, did not account for the PPI index and inflation-adjusted valuations have actually resulted in a stagnation. By the end of 2022, real price of Slovenian CRE had are 5% above the bottom point.

Figure 6: Price-to-PPI ratio
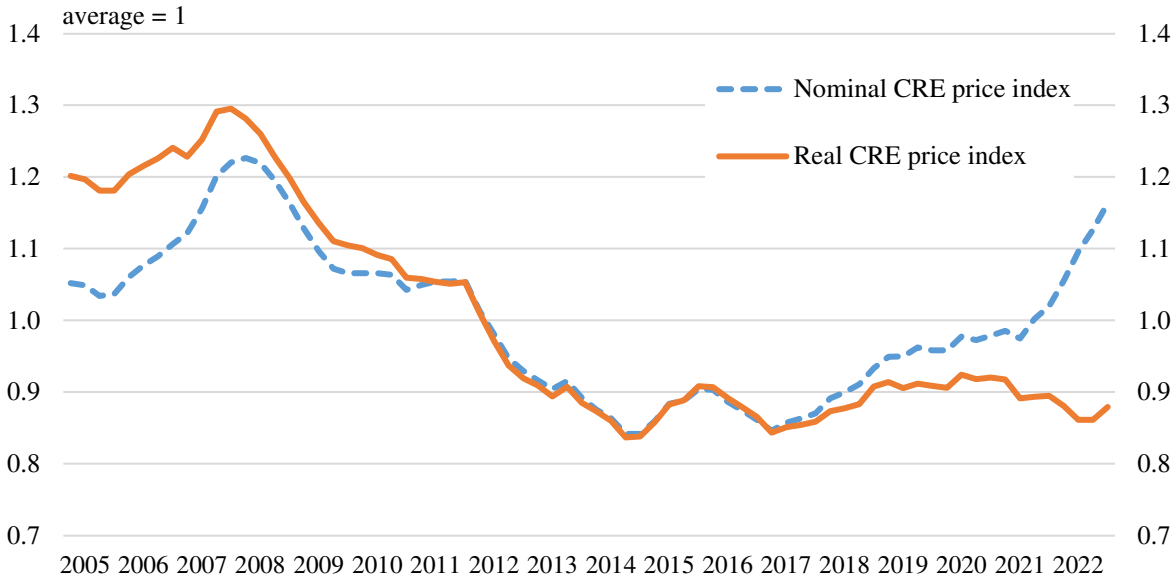
Source: Own work.

For commercial property prices, the official commercial property price index produced and published by the SORS for the period from 2008 to 2022 was used. The unit of observation is a CRE from one of the two groups of properties, namely "offices" and "retail", where the latter, as already discussed, incudes retail spaces, restaurants and services real estates. For the construction of the index, the selling (transaction) price reached on the date of conclusion of the sales contract is observed. The base period is 2015 and the calculation follows the hedonic method, which uses regression analysis of the physical and locational characteristics of the sold properties that affect the sale price. The most influential feature is the usable area

of the property and the second one is belonging of a property to a value range, where ranges are defined by SMA. Due to the unavailability of CRE price data prior to 2008 at SORS, the construction of the index for the period spanning from 2005 to 2008 was necessary. This was done by using growth rates of the average advertised prices in Ljubljana, for each group, obtained from the Nepremičnine.net real estate advertisement database. Furthermore, to enhance the clarity of the index, a smoothing technique was employed.

The price-to-PPI ratio indicator was developed in two steps. Firstly, separated price indexes were generated for the two groups of commercial properties, namely retail and offices. Each index was then weighted using the average number of transactions. Data for this process was obtained from SORS, consisting of quarterly transaction data spanning from 2008 to 2022, where the average weight of total transactions was calculated for each group. Secondly, different producer price indexes were utilized to deflate the CRE price index for each group. Specifically, the service PPI was applied to deflate the CRE price index for retail, while the original PPI was used to deflate the CRE price index for offices:

$$Price-to-PPI\ ratio_t = \frac{\overset{CRE}{price\ index-RETAIL_t}}{PPI-services_t} * w_R + \frac{\overset{CRE}{price\ index-OFFICES_t}}{PPI_t} * w_O \quad (1)$$

As part of the robustness check, three additional variations of the price-to-PPI ratio were constructed and compared alongside the original version as can be seen in the Figure 7. The first variation involved a simplified approach, where the entire commercial property price index was used without separating it into two groups, and it was deflated by the original PPI. In the second variation, both groups were deflated using the same producer price index. The last version followed the main procedure but incorporated a difference in weighting. Instead of using average weights that remained constant throughout all periods, different weights were assigned to each quarter. For the missing data of the number of transactions for the quarters spanning from 2005Q1 to 2007Q4, the weight from 2008Q1 was applied.

Figure 7: Alternative versions of price-to-PPI ratio
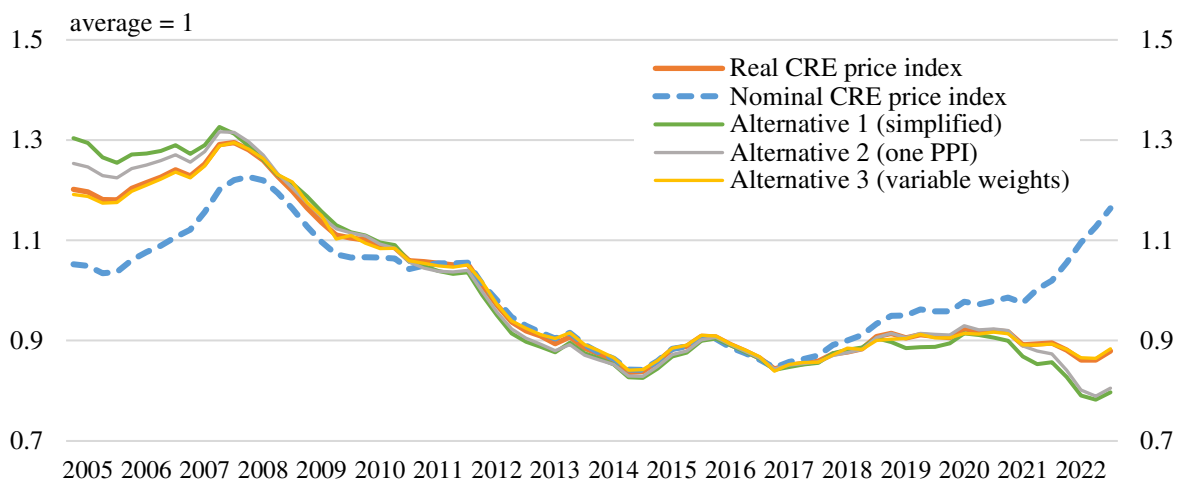
Source: Own work.

The results of the robustness check indicate that all variations of the indicator are consistent with each other, suggesting that the indicator is robust. It can observed that the smallest difference exists between the original and the last version of indicator, where the only difference are the weights used. Specifically, in original case, the weights remain fixed, while in the other, they vary from period to period. Based on this observation, it can be concluded that it is possible to simplify the indicator by using the average weight for each property type, for all observations.

2.1.2   Price-to-GOS ratio

Another way to assess the demand is by looking at affordability of commercial property ownership. This can be done by examining the relationship between property prices and value added or profits of enterprises. For the analysis of companies in the sector, a commonly used measure is earnings before interest, taxes, depreciation and amortization (EBITDA). However, due to the availability of data, which is limited to yearly frequency, a proxy measure of gross operating surplus (GOS) was utilized. The first part of the indicator uses the same index as constructed for the previous indicator, but in nominal terms and the GOS index is published by the SORS. The latter is defined as the income generated by a particular activity (in production process), before considering (added or subtracted) interest, rent or costs, paid or received by the unit. This is the part of the income representing the remuneration for the capital used in the production process and is the basis for calculating the profit margin indicators of the performance of NFC (Celcer, 2022). This sub-indicator is calculated in the following way:

$$Price-to-GOS\ ratio_t = \frac{CRE\ price\ index_t}{GOS\ index_t} \qquad (2)$$

The chart in Figure 8 illustrates movement of price-to-GOS ratio. Throughout the observed period, the ratio decreased by approximately 60%, which suggests that it was becoming more and more affordable for companies to purchase property, with the profits of the companies increasing at higher level than the nominal prices of CRE. There were some intermittent increases, the most significant of which occurred in 2009, with an increase of around 10%. This was after the GFC, when the affordability of CRE decreased, implying that business earnings were increasing at a slower rate than the CRE prices. During this time, both CRE prices and GOS decreased, but the latter decreased to a greater degree, leading to an increase in the entire indicator. Subsequently, there was a notable shift in the affordability of CRE, as prices experienced a decline while profits remained stagnant. This led to increased affordability in the market. Starting around 2016, a significant change occurred where greater affordability was driven by the accelerated growth of profits surpassing the growth rate of CRE prices. However, it is important to be careful when interpreting these findings, as the use of GOS as a proxy for company profits may not adequately capture the true profitability of the sector. Nonetheless, these observations provide valuable insights into the

relationship between CRE prices and financial performance of companies operating within the sector.

Figure 8: Price-to-GOS ratio
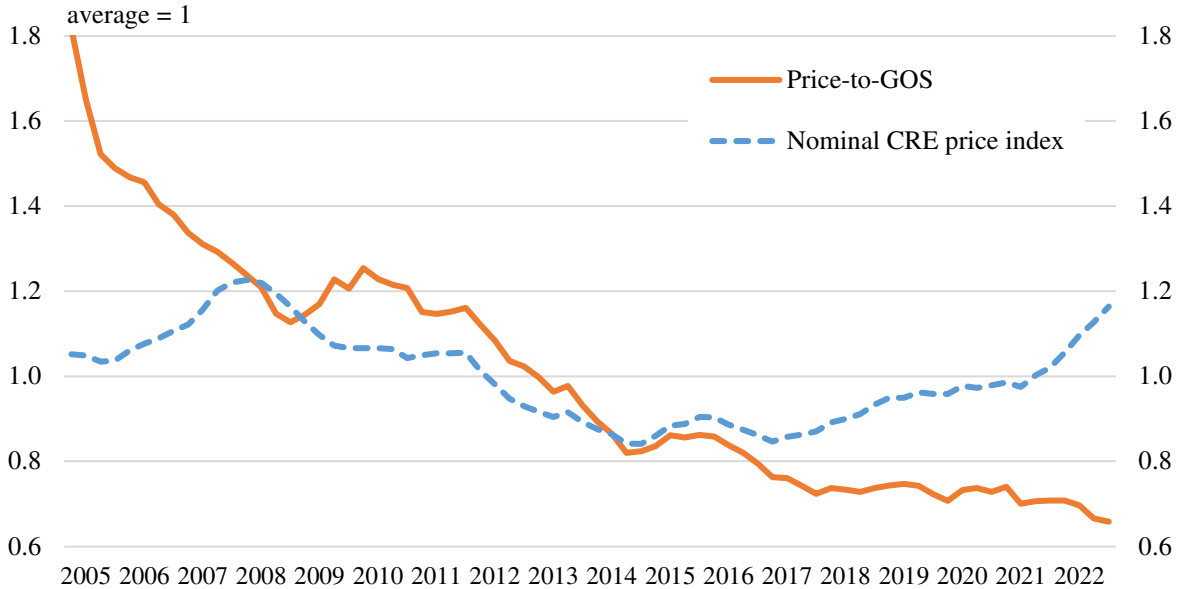
Source: Own work.

2.1.3 Price-to-hypothetical borrowing volume ratio

An additional measure that captures affordability, while considering both profits of the companies and interest rates, is the ratio of "hypothetical borrowing volume" to commercial property prices. Interest rates have a crucial impact on the maximum affordable mortgage payment that can be made based on profits that the company has, particularly in the context of significant purchases like CRE. To address this, Schneider (2013) introduced a hypothetical borrowing volume (K), which factors in both profits of the companies, presenting an income level, and interest rates. It is defined as:

$$K_t = \frac{c * Y_t [\frac{1 - R_t^{T+1}}{1 - R_t}]}{R_t^T} \tag{3}$$

The assumption made here, is that there will be a fixed ($c * Y_t$) percentage of operating profits of the companies that is accessible for mortgage repayments of the loan with repayment period of 20 years ($T = 20$). In the equation, c represents a constant, which tells what share of the income will be used, and Y_t is a GOS in time t. R_t stands for bank interest rates for loans to NFC with an original maturity of over one and up to five years, in Slovenia, in time t, that were obtained from Statistical Data Warehouse of the ECB. In the composite indicator the inverted affordability (($K/CRE\ prices)^{-1}$) is included to make it reliable to other sub-indicators and observe the extent to which CRE prices deviate from what

companies can afford in terms of both profits and borrowing volume. Similar to the previous sub-indicator, the analysis in this section also relies on the CRE prices index in nominal terms and GOS index.

In the Figure 9 it can observed that price-to-hypothetical borrowing volume ratio has decreased during the observed period by 67%, which is even more than the price-to-GOS ratio. This can be mostly attributed to increasing hypothetical borrowing volume, which is indicating that commercial properties were becoming more and more affordable. However, there were also a couple of increases observed during specified period. The initial modest growth happened in 2006, whereas more substantial increases were observed from late 2009 until the end of 2011. These notable increments were interspersed with occasional decreases, resulting in an overall rise of only 1% in the overall ratio. During this period, prices remained relatively stable and the hypothetical borrowing volume slightly decreased, due to continuous rise of interest rates. The most recent increase occurred in the 2022, specifically from the second to fourth quarter, where the ratio increased for 31%. This increase can be attributed to two factors: the rise in prices and a simultaneous decrease in the hypothetical borrowing volume. The latter was primarily driven by a significant upturn in interest rates.

Figure 9: Price-to-hypothetical borrowing volume ratio
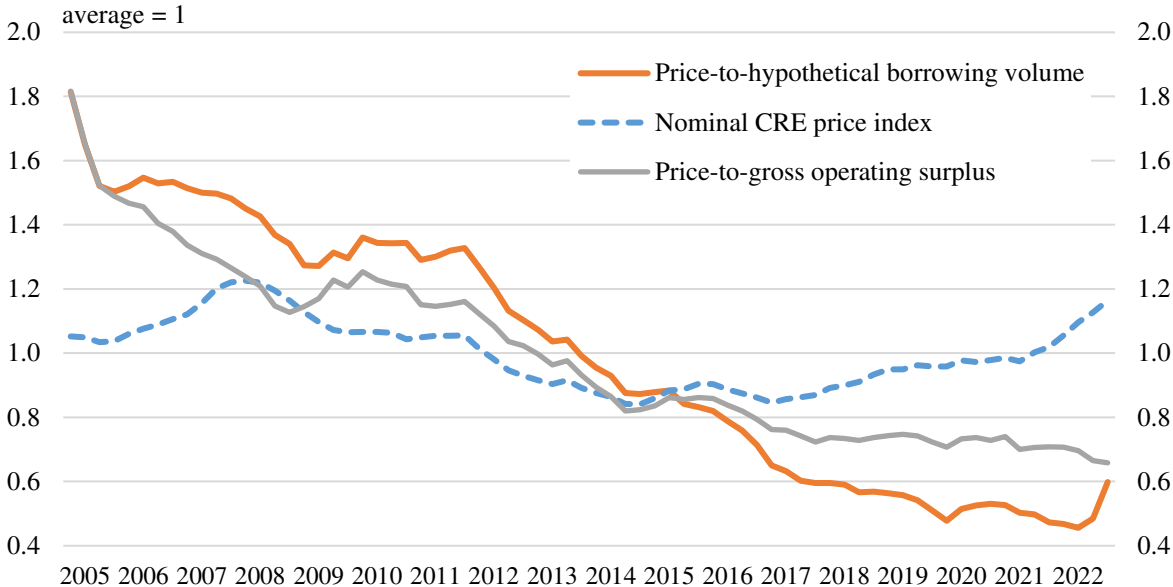
However, it can be observed that this indicator follows the same dynamic as price-to-GOS ratio. The differences that can be seen are that affordability indicator offered by Schneider (2013) better capture some peaks and drops, whereas the price-to-GOS ratio is more steadily decreasing. The divergence in the dynamics of the two indicators can be attributed to the inclusion of financing conditions in the second indicator. While the price-to-GOS ratio focuses solely on the correlation between prices and firms' profits, the hypothetical borrowing volume indicator considers the influence of interest rates, which also holds

significant importance in the investment decision-making process. Their impact becomes particularly evident in the post-2015 period, characterized by a highly accommodative monetary policy. The relaxed lending conditions during this period were an important driver behind the improved affordability of CRE, as indicated by the disparity between the hypothetical borrowing volume indicator and the price-to-GOS indicator, which does not consider financing conditions.
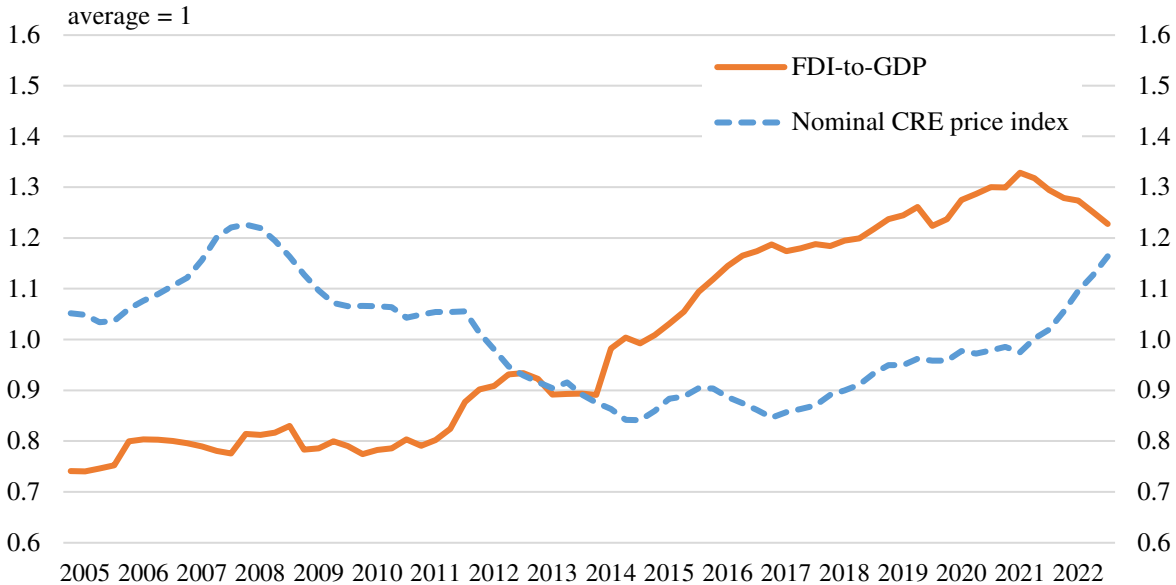
2.1.4 FDI-to-GDP ratio

The sub-indicator, which measures the ratio of foreign direct investments (FDI) to the GDP, is included in the analysis and it also covers the demand perspective of the CRE market. As pointed out by Belke and Keil (2018), the CRE market is often shaped by factors beyond local supply and demand, such as international corporations and franchises. FDI helps to build strong and long-lasting connections between different economies and therefore, examining the FDI-to-GDP ratio helps to provide a comprehensive view of the underlying dynamics of the CRE market. This ratio measures the amount of capital invested from other countries relative to the overall economy. The OECD (2023) defines FDI flows as the amount of money that crosses borders for direct investments within a certain time frame. These investments include buying stocks, reinvestment of earnings and borrowing between companies. For this sub-indicator only inward flows are included, which represent how much foreign investors have increased their investments in businesses located in Slovenia, minus any decreases in their investments (OECD, 2023).

The increase of FDI inflows can lead to two outcomes. Firstly, it may indicate a rise in demand for new or existing properties from foreign sources. However, this may ultimately result in an increased supply, although it might not be in the same location due to land availability constraints and at the same time, due to long construction lags, which are typical for CRE. Nevertheless, given that the supply response can be slow, a surge in commercial property demand may temporarily push up property prices until the higher prices encourage an increase in construction activity (Gauder, Houssard, & Orsmond, 2014). Worth mentioning study is also by Olszewski and Humanicki (2018), conducted on several CEE countries, where they find a strong correlation between FDI inflows and the construction of office space. Their findings indicate that in some countries, office construction follows FDI inflows, while in others, the two occur simultaneously. According to Amondi's (2016), an increase in FDI inflow causes a surge in demand from multinational businesses for residential and commercial properties, attracting both international and local investors. This increased demand causes a rise in mortgage finance and real estate investment, which has an effect on property price growth in the host country. To attract more FDI inflows, governments invest in infrastructure like transportation networks and social facilities, leading to the growth of satellite towns. As businesses move to these areas, the demand for commercial buildings increases, providing an opportunity for the real estate industry to profit and contribute to rising investment and property prices.

As a desirable form of investment, FDI promotes economic growth by encouraging the accumulation of physical capital and facilitating the transfer of knowledge and technology. FDI plays a significant role in driving economic growth, as investment is the dynamic component of GDP (Encinas-Ferrer & Villegas-Zermeño, 2015). As such, it is assumed that both FDI and GDP move in the same direction. However, FDI serves as a leading indicator that reflects the future growth potential of specific sectors or industries, making it more vulnerable to price fluctuations. Knowing that, the increase of FDI-to-GDP ratio would suggest that foreign investments in Slovenia increased more than its GDP. An initial increase in FDI is likely to result in higher demand for CRE, which may lead to a temporary price push until the supply aligns with the increased demand. Consequently, a higher FDI-to-GDP ratio is expected to have a positive impact on the misalignment between market prices and fundamental prices of CRE in the short term. In the Figure 10 it can be observed, that during the observed period, FDI in Slovenia has shown a steady increase relative to GDP. However, in recent years, there has been a slight decline in its share. Several factors have influenced this dynamic. Firstly, the post-pandemic period has witnessed robust economic growth in Slovenia. Concurrently, however, increasing geopolitical tensions and the swift tightening of monetary policies globally have cooled down international investment activity. As a result, the growth of FDI to Slovenia has moderated. Overall, as the Slovenian economy has expanded at a faster pace than FDI, the proportion of FDI naturally decreased.

Figure 10: FDI-to-GDP ratio

Source: Own work.

To compute the FDI-to-GDP ratio indicator, the first step involved acquiring the FDI inward quarter-end stocks[2] from the Bank of Slovenia database for the periods starting from 2009Q1

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[2] The data used in this indicator was calculated using the new BPM6 methodology, which follows the directional principle adopted by the Bank of Slovenia since 2014. Due to changes in the categories considered,

onwards. For the periods before that, only few end-year stocks were available at this database, because of that an alternative approach was employed to construct the remaining quarterly series. Yearly FDI inward flows were obtained from the OECD database for the periods ranging from 2005Q1 to 2008Q4. To approximate the flows for each quarter, these yearly flows were divided equally into four parts. Since the original data was denominated in US dollars, it was necessary to convert it to Euros. This conversion was accomplished by utilizing exchange rates obtained from the Yahoo Finance website for each respective period. To determine the quarter-end stock, the quarterly flows were applied to the last available stock. For instance, the flow for 2008Q4 was subtracted from the quarter-end stock in the same quarter to derive the quarter-end stock for 2008Q3. To obtain the FDI-to-GDP ratio, the inward FDI flows stock for each quarter was related to the GDP for the same quarter. The GDP data was obtained from SORS and the indicator was calculated in a following way:

$$FDI-to-GDP\ ratio_t\ = \frac{Inward\ FDI_t}{GDP_t} \tag{4}$$

2.1.5 Price-to-rent ratio

The CRE market analysis needs to also consider the supply side perspective, where one of the crucial parameters is the price-to-rent ratio, which compares the costs of owning a property to renting it. Higher values of the price-to-rent ratio indicate that buying a property is more beneficial than renting it. In long term, the ratio should be stationary as rising property prices make renting a more appealing option, leading to reduced demand for property ownership, which induce the fall in prices or a catch-up of rental rates. Here the data gathering was the most challenging, due to the lack of institutions that monitor and publish rents for CRE. This is a problem not only in Slovenia but also in other countries, as the ECB (2008) noted that data on CRE rents are not officially available for most countries. The same is true for in Slovenia, which is why the approximate CRE rent index had to be constructed different sources and by applying different methods.

To construct this indicator, the CRE price index remained the same as in previous indicators, denominated in nominal terms, while the CRE rent index was created using the following methodology. For the initial period until 2011, advertised rents of commercial premises per square meter in Ljubljana, categorized into offices, retail premises, and restaurants, were obtained from Slonep.net. To derive the average price for each quarter, these three types were weighted by the average number of leases concluded between 2016 and 2019, sourced from real estate market reports published by the SMA. For the period spanning from 2011 to 2015, the data was constructed as follows: firstly, data from 2005 to 2011 was utilized, and a regression was performed, regressing rents against nominal prices. The resulting coefficients, along with the prices for each quarter, were then used to construct the series for

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the stocks calculated according to the new methodology have significantly changed. To illustrate, inward FDI stock at the end of 2013 amounted to EUR 8,926 million according to the new methodology, compared to EUR 10,729 million calculated using the previous methodology.

the missing periods[3]. As for the data after 2015, real estate market reports published by the SMA were employed, specifically utilizing the average monthly rents for offices and retail premises in Ljubljana. These rents were weighted by the size of the sample for each type of premises. Consequently, this approach yielded the rent index covering the entire observed period. Price-to-rent ratio was calculated in the following way:

$$Price-to-rent\ ratio_t = \frac{CRE\ price\ index_t}{CRE\ rent\ index_t} \tag{5}$$

From the Figure 11 it can be observed that in Slovenia CRE prices rose at faster level than the rents in the periods before GFC, namely the peak was in fourth quarter of 2007, where the ratio, from the beginning of the observed period, increased for around 9%. This indicates that at that time, there was the most significant overshooting of the real estate prices in comparison to the rental market. After that, the ratio experienced a decreasing trend for some period, reflecting the adjustments of the house prices after the crisis. The lowest value was reached in the third quarter of 2014. During this period, the overall ratio was predominantly influenced by the trend of CRE prices, while the rental rates experienced a minor decrease and their impact was relatively minimal. From the biggest peak until the biggest drop in 2014, the ratio decreased for almost 27%. Since 2014 the ratio was increasing with some drops in between, but is still on the rise, with even higher value than during GFC. From the lowest point to the fourth quarter of 2022, it is almost 40% higher. Furthermore, during this period, as seen before, the primary determinant of the ratio was the behaviour of CRE prices, as rental rates remained relatively stable.

Figure 11: Price-to-rent ratio
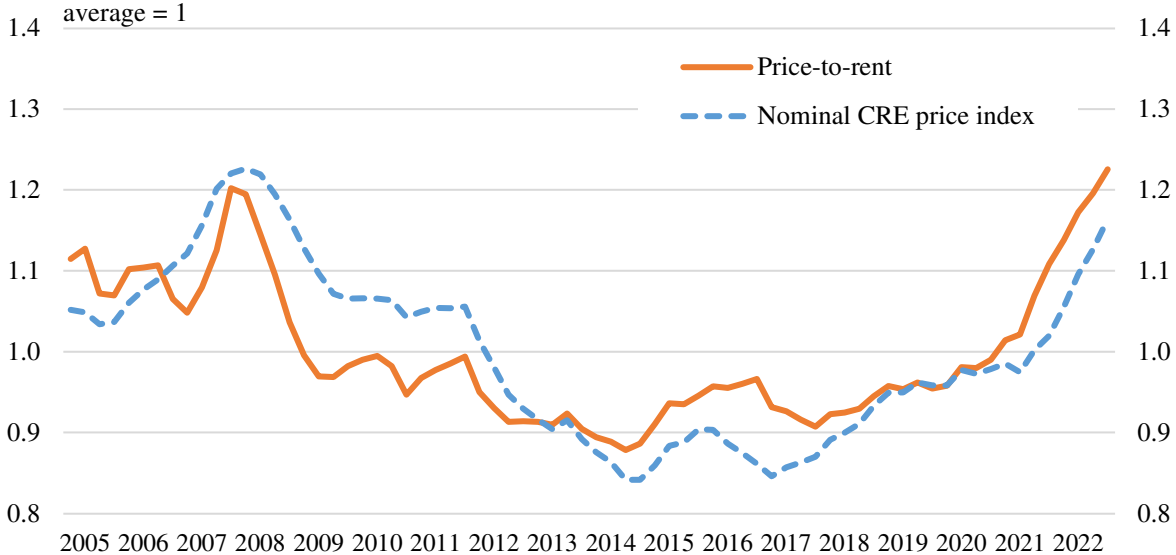
Source: Own work.

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[3] Detailed results were not included in the thesis due to limited space. For access to these results, please contact the author directly.

Overall, the recent development suggests a growing appeal for renting, as the ratio between CRE prices and rents reaches unprecedented levels. However, it should be noted that the CRE rental market presents distinct constraints compared to the residential rental market, which may impact the decision to rent. For example, an apartment is typically easier to trade and sell compared to a specialized factory designed for a specific company or industry.

2.1.6   Price-to-construction costs ratio (Tobin's Q)

The construction costs are crucial factor that impacts the supply side of the CRE market. Consequently, a sub-indicator capturing the relationship between CRE prices and construction costs was included. The price index used in this indicator remained the same as previous indicators, denoted in nominal terms. To approximate construction costs, three indexes were obtained, and their average was calculated. The first component of the ratio employed the construction cost index for new dwellings under construction, obtained from the SORS. This index is derived as a weighted average of two components, namely the construction material costs and labour costs. The second component utilized the cumulative price differential index for residential construction. Meanwhile, the third component relied on the cumulative price difference index for civil engineering constructions, both of which were generated by the Chamber of Construction and Building Materials Industry of Slovenia (CCBMIS). Price-to-construction costs ratio is calculated in the following way:

$$Price-to-construction\ costs\ ratio_t = \frac{CRE\ price\ index_t}{Construction\ costs\ index_t} \qquad (6)$$

This sub-indicator is similar to Tobin's Q or company's performance, which is widely used in finance as an indicator for future investment opportunities. It measures company's market value against the cost of replacing its assets (Fu, Singhal & Parkash, 2016). For the price-to-construction costs ratio, if a value of more than 1 is reached, it means that the prices of the properties are too high compared to the costs of constructing them. This can be seen as an over-valuation of the properties, similar to an over-valuation of a company's stock in the context of Tobin's Q. In the Figure 12 it can be observed, that in the period before the GFC, the ratio has increased, because the CRE prices increased much faster than construction costs, with the ratio's highest value of 1.54 in fourth quarter of 2007. From that point on it decreased by more than 42%, until reaching the lowest level in second quarter of 2022, namely 0.84. This was mainly due to the high increases of construction costs in that period. After that, the ratio has risen for three subsequent quarters, because prices again started to surpass the increase of construction costs. Form the 2014Q1 onwards the ratio is below the level of 1, which means that the costs of constructing the properties were higher than the actual prices of those properties. This sub-indicator is indicating that in the periods around the GFC, when the ratio was above one, the prices were overvalued compared to the costs of constructing them, but from 2014Q1 onward, they are under-valued.

Figure 12: Price-to-construction costs ratio
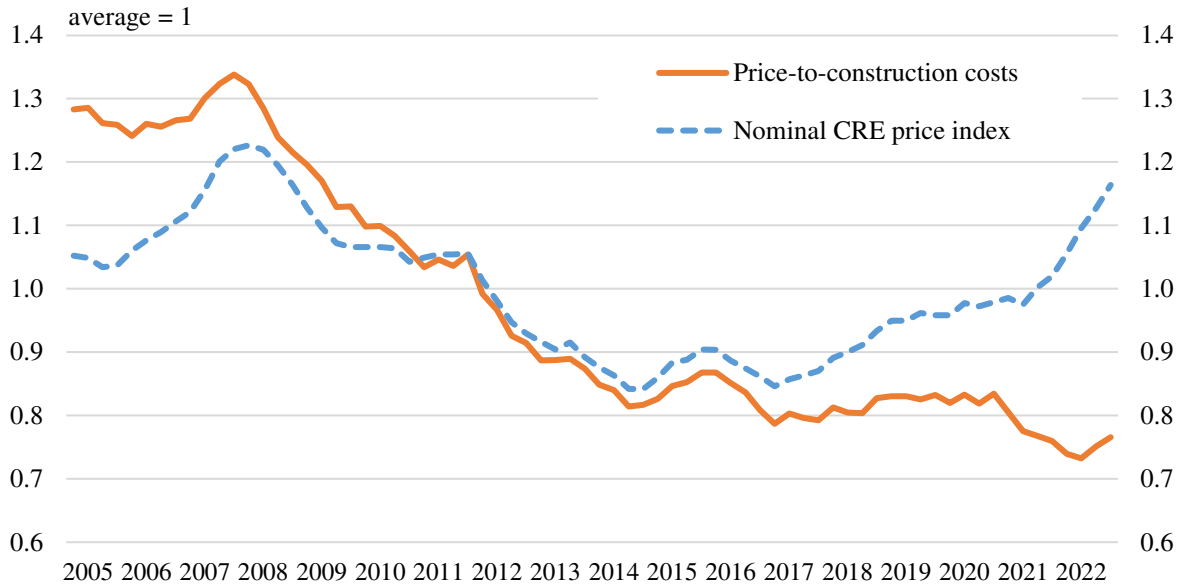
Source: Own work.

2.1.7   Investments in other buildings-to-GDP ratio

The next sub-indicator that also captures the supply side of the CRE market is ratio between investments in other buildings and GDP. This indicator measures the amount of capital invested in supporting property development relative to the overall economy. While investments in other buildings tend to move in the same direction as the economy, they are more prone to market and sector vulnerabilities and price fluctuations. A high ratio of investments in other buildings-to-GDP can indicate an overheating of commercial property market and can be a sign of a positive misalignment. Thus, this ratio can help predict both the upswing and downturn phases in the CRE market.

The indicator is plotted in Figure 13 and it clearly shows a high increase until the burst at the end of 2008 and the beginning of 2009, where ratio was the highest, specifically 11.5% of GDP. After that the investments in other buildings-to-GDP ratio was decreasing with a slight increase in 2014, but then reaching the lowest level of 4.8% of GDP, in the fourth quarter of 2016. These low values reflect the construction sector breakdown in Slovenia after the burst in the market. Since then, the ratio again has started to increase and by the fourth quarter of 2022, it had reached 7.09% of GDP.

To construct the indicator the data for investment in other buildings and GDP was obtained from SORS. Specifically, current, seasonally adjusted prices were used. The ratio was then calculated by comparing the relevant data points, in the following way:

$$Investments\ to\ other\ buildings - to - GDP_t = \frac{Invesments\ in\ other\ buildings_t}{GDP_t} \quad (7)$$

Figure 13: Investments in other buildings-to-GDP ratio
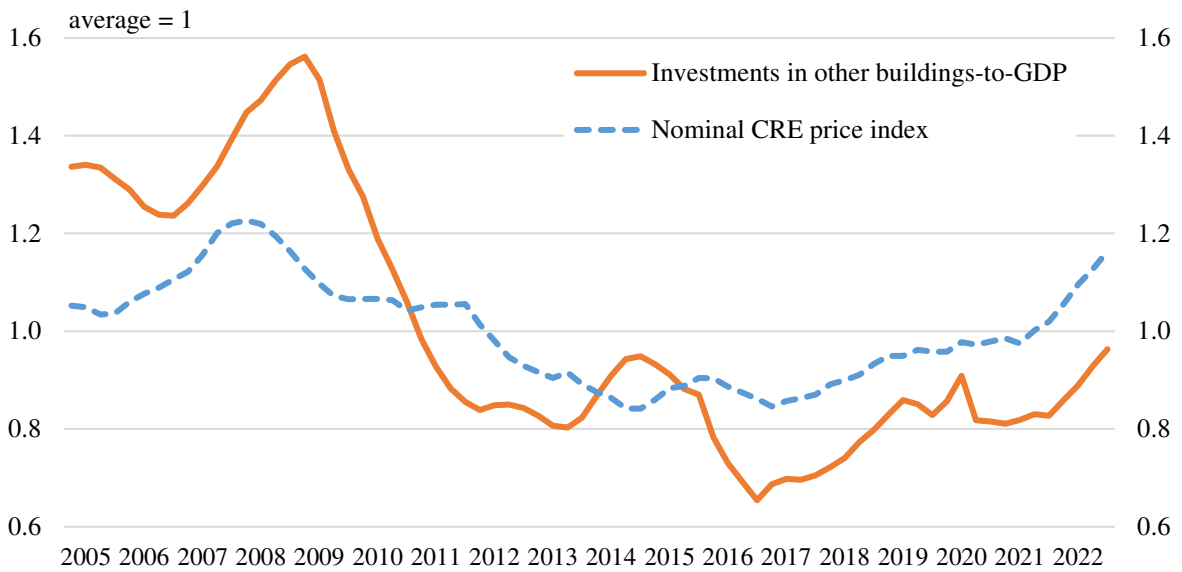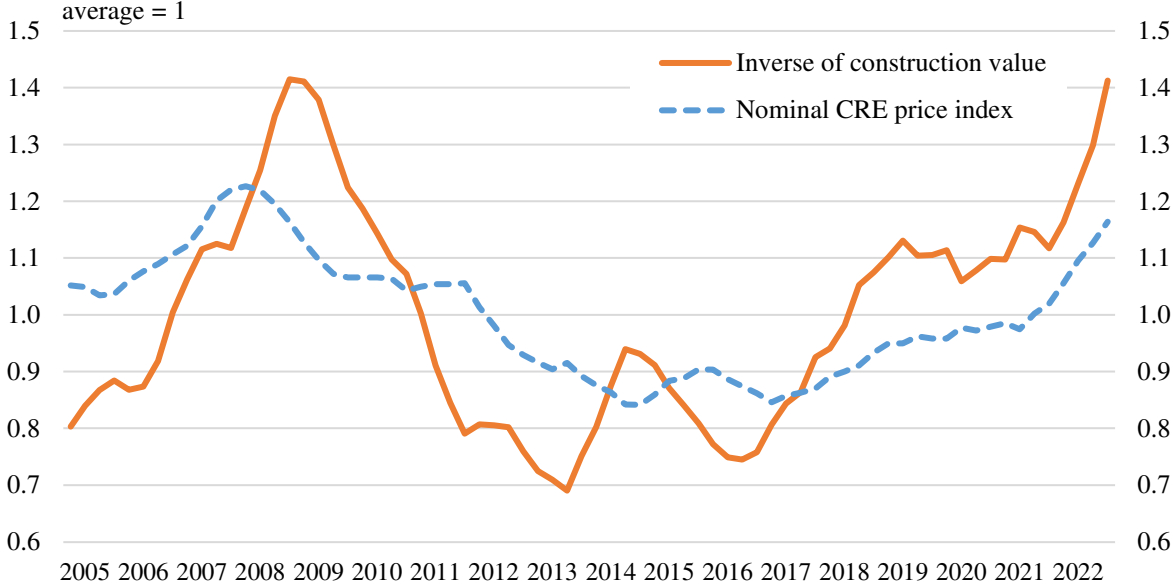

Source: Own work.

2.1.8 Inverse of construction value

In analysing the supply side of the CRE market, it is essential to also examine construction activity. One indicator included is the inverse of construction value, which calculates the ratio of nominal value of construction work to nominal CRE prices. A high value of this indicator indicates that the increase in construction put in place is greater than the increase in actual property prices. This suggests that there is oversupply of commercial properties and the market may overvalue properties and fail to account for the actual level of demand, leading to a future correction in property prices. Conversely, a low value of the indicator implies that property prices are rising faster than construction work, indicating a tight supply of CRE, with developers unable to meet demand. This may result in a shortage of commercial properties relative to demand, leading to the future increase in property prices to achieve balance.

As can be observed from the Figure 14 this ratio was increasing in the periods before GFC, until reaching the highest value in the fourth quarter of 2008, where there was the highest value of construction put in place, but the prices already started to fall. This means that at that time the CRE prices were overvalued leading to the oversupply of CRE. From the peak onward the prices started to adjust, and the inverse of construction value shows a falling trend. There were some increases in between, the biggest in 2014, but the market took a turn only in the end of 2016, when ratio again started to rise for longer period. Since then, it has increased by 86%, reaching the almost the same level as in the peak of GFC in fourth quarter of 2022. The recent trend in this indicator provides additional evidence suggesting a potential overheating of the Slovenian CRE market, as the supply, as represented by the value of

construction put in place, is growing at a faster pace than the prices. However, it is crucial to acknowledge that this is not a standalone indicator but rather as an integral component within a broader puzzle. For example, one explanation for today's strong activity could also be partly justified by the lack of construction during the crisis years. Consequently, any interpretations derived from this indicator should be approached with caution.

Figure 14: Inverse of construction value

Source: Own work.

To construct the inverse construction value indicator, the CRE price index in nominal terms was used, the same one as in the other indicators, and the nominal value of construction put in place, which was obtained from SORS. The ratio is calculated in the following way:

$$Inverse\ construction\ value_t = \frac{Nominal\ value\ of\ construction\ put\ in\ place\ (index)\ _t}{CRE\ price\ index_t} \quad (8)$$

2.1.9 Loan-to-GOS ratio

From a system perspective loan-to-GOS ratio was incorporated, which is somehow also related to affordability, as the indicator measures the relationship between the income of a businesses and the amount of loans granted to them in Slovenia. Since the loans to business for CRE were not available for such a long time period, all loans given to business were used. This ratio provides insight into a business's capacity to repay their credit obligations. The increase in this ratio places businesses in a more vulnerable position to meet their repayment obligations, thereby reducing their flexibility in the event of a deteriorating macroeconomic outlook. This, in turn, raises banks' exposure to systemic risk. On the other hand, a low value of the index indicates that there is room to stimulate lending activity and promote construction, thereby increasing the supply of CRE.

Schneider (2013) in his paper included similar indicator, defined as a loan bearing capacity, where hypothetical borrowing volume is related to the aggregate amount of actual new loans given to them. Hypothetical borrowing volume is defined the same as in one of the previous indicators. In the aggregated index, he included the inverted loan bearing capacity. For the purpose of this thesis, the version following Schneider's approach (loans given to business relative to the hypothetical borrowing volume) was also construction and the two were compared, as seen in the Figure 15. Both indicators are exhibiting similar long-term dynamics, with the difference in the highest peak, where loan-to-GOS ratio is steeper. With the aim of evaluating the misalignment of CRE prices, the latter indicator was chosen, as it provides a clearer depiction of the pronounced peak after 2008.

Now looking at the sub-indicator displayed in Figure 15, it can be observed that loan-to-GOS ratio was falling at the beginning of the observed period and started to increase in the first quarter of 2007. It was increasing until reaching its peak in the third quarter of 2009. Between 2006 and the end of 2009, this indicator almost doubled, due to the increase of loans granted to companies and from 2008 to 2010 the 17% decrease of profits further intensified the rise of the indicator. After the onset of the economic and financial crisis the ratio has dropped sharply and it still decreasing. This is indicating that new borrowing is decreasing in proportion to loan serving capacity, whereas the profits of the companies are steadily increasing.

*Figure 15: Loan-to-GOS ratio*
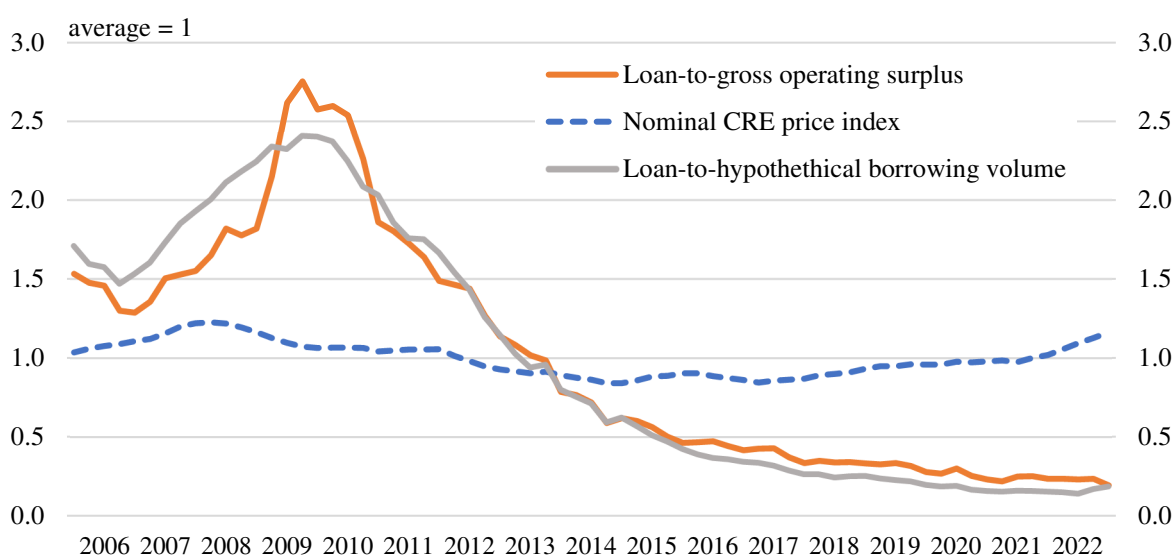
Source: Own work.

The data for loans given to business was provided by Bank of Slovenia and the GOS, which is a proxy of profits of companies, was obtained at SORS. The latter was already used and explained in one of the previous sections. Loan-to-income ratio is calculated in the following way:

$$Loan - to - GOS\ ratio_t = \frac{Loans\ given\ to\ business_t}{GOS_t} \qquad (9)$$

2.2   The multiple indicator method

To construct the overall misalignment measure, the multiple indicator method was applied, which involves using a number of sub-indicators to capture supply, demand and system perspective. This approach can provide a comprehensive assessment of the market and effectively identify potential imbalances and risks. The sub-indicators were presented as time series variables and initially, each value was expressed as a deviation from the mean value of its corresponding sub-indicator, regardless of the presence of any long-term trends in the data. To uncover any cyclic changes in these variables, it was necessary to remove the long-term trends from the data. To achieve this, the data was detrended, and the residuals were identified as cyclic variations. The resulting output represents the detrended sub-indicators, expressed as a percentage deviation from their respective historical averages, which are then combined to create the aggregated misalignment indicator. These detrended series for all nine sub-indicators are presented in Figure 16.

Figure 16: Detrended series of all sub-indicators
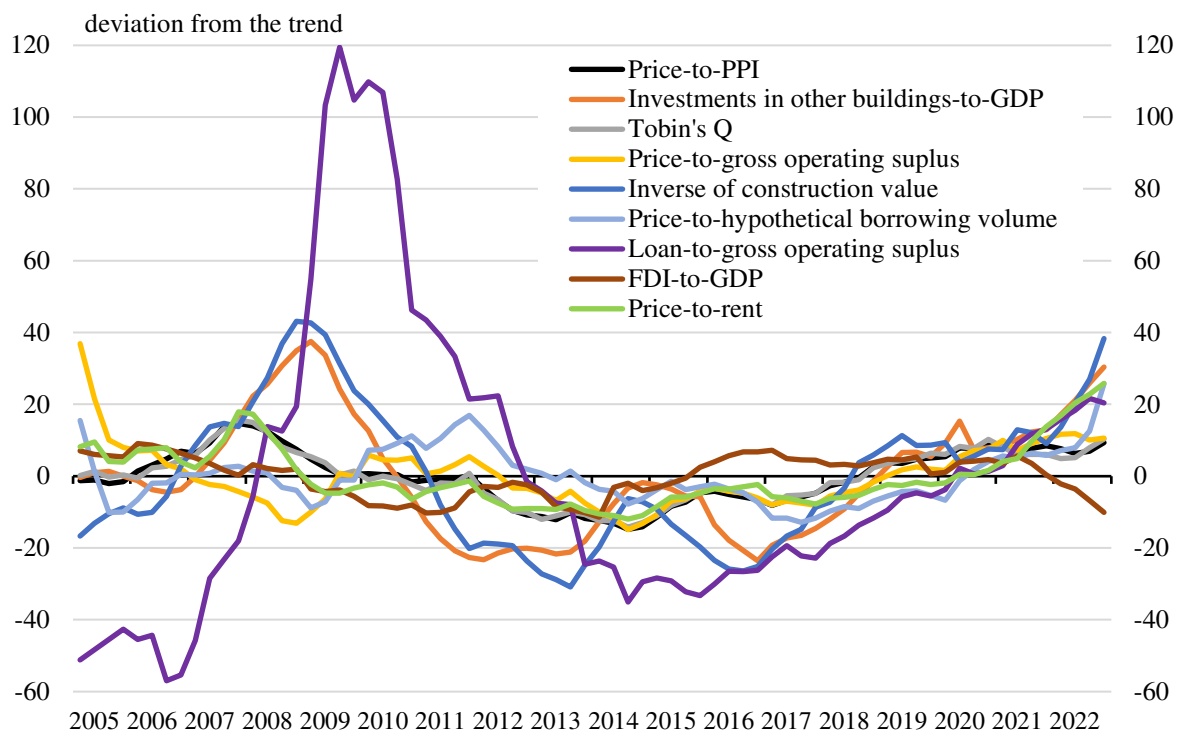
Source: Own work.

Following UBS (2012) and Schneider's (2013) method, first the weighting factor for each indicator was determined. This was done by using the principal component analysis (PCA), which is a multivariate technique that employs advanced mathematical approach to reduce the dimensionality of the dataset by converting a set of correlated variables into a smaller set

of orthogonal variables. The purpose of PCA is to extract meaningful information from data sets and represent it using a new set of uncorrelated (orthogonal) variables. This is done by computing new variables, called principal components (PCs), that are obtained as linear combinations of the original variables. The first PC has the maximum possible variance and explains the largest part of the dataset. The second component is computed under the constraint of being orthogonal to the first component and having the highest possible variance. The remaining PCs are calculated in a similar manner. The degree of association between a component and a variable is measured using the correlation coefficient, which is known as factor loading and it estimates the information shared by the two (Abdi & Williams, 2010).

For a more comprehensive understanding of PCA and its derivations, refer to the work by Abdi and Williams (2010). Here, a brief overview will be provided. Consider an n x m matrix X, which is subjected to PCA analysis. In this context, n represents the number of observations and m represents the number of variables. It is assumed that the columns of X are centered, meaning that the mean of each column is zero, and additionally, when the variables are measured in different units, it is common practice to standardize them. The matrix X can be expressed as a singular value composition (SVD) [4] as follows:

$$X = P\Delta Q^T \tag{10}$$

In the given equation, P is the $n \times k$ matrix, representing the left singular vectors, Q as the $m \times k$ matrix representing the right singular vectors, and Δ as the diagonal matrix consisting of the singular values [5]. The PCs are derived from the SVD of the data table X. The matrix $n \times k$ of factor scores, denoted as F, can be obtained in the following way:

$$F = P\Delta \tag{11}$$

$$F = P\Delta Q^T Q = XQ \tag{12}$$

The matrix Q provides the coefficients necessary for calculating the linear combinations used in determining the factor scores. Additionally, this matrix can be understood as a projection matrix, as the product of X and Q yields the projections of the observations onto the principal components.

Returning back to the dataset and applying PCA, each of nine sub-indicators can be expressed through a linear combination of orthogonal (uncorrelated) factors:

$$x_{i,t} = \alpha_{i,1}PC_{1,t} + \alpha_{i,2}PC_{2,t} + \cdots + \alpha_{i,j}PC_{j,t} + \varepsilon_i \tag{13}$$

---

[4] The SVD is an extension of the eigen-decomposition. It involves decomposing a rectangular matrix into three distinct matrices: two orthogonal matrices and one diagonal matrix. Further details and in-depth information on this topic can be found in the research conducted by Abdi and Williams (2010).

[5] The squared matrix Δ^2 is equivalent to the diagonal matrix Δ, which consists of the (nonzero) eigenvalues derived from the matrices $X^T X$ and XX^T.

where $\alpha_{i,j}$ represents a factor loading of variable i and factor j and $PC_{j,t}$ is a principal component factor.

Table 1 displays the estimated PCs, namely their standard deviations, proportion of variance explained and cumulative proportion of variance explained. Each PC represents a certain percentage of the total variation in the dataset. Specifically, PC1 explains approximately 49% of the total variance, PC2 explains 22% of the total variance, and so on. The cumulative proportion of variance is presented in the last row, indicating that the first three PCs account for 88% of the total variance among all indicators.

Table 1: Estimated principal components

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
Standard deviation	2.101	1.415	1.230	0.682	0.570	0.352	0.333	0.191	0.095
Proportion of variance	0.491	0.222	0.168	0.051	0.036	0.014	0.012	0.004	0.001
Cumulative proportion	0.491	0.713	0.881	0.932	0.969	0.983	0.995	0.999	1.000

Source: Own work.

The percentage of variance that each principal component explains is also presented in the Figure 17 where the largest portion is explained by the first PC.

Figure 17: Scree plot
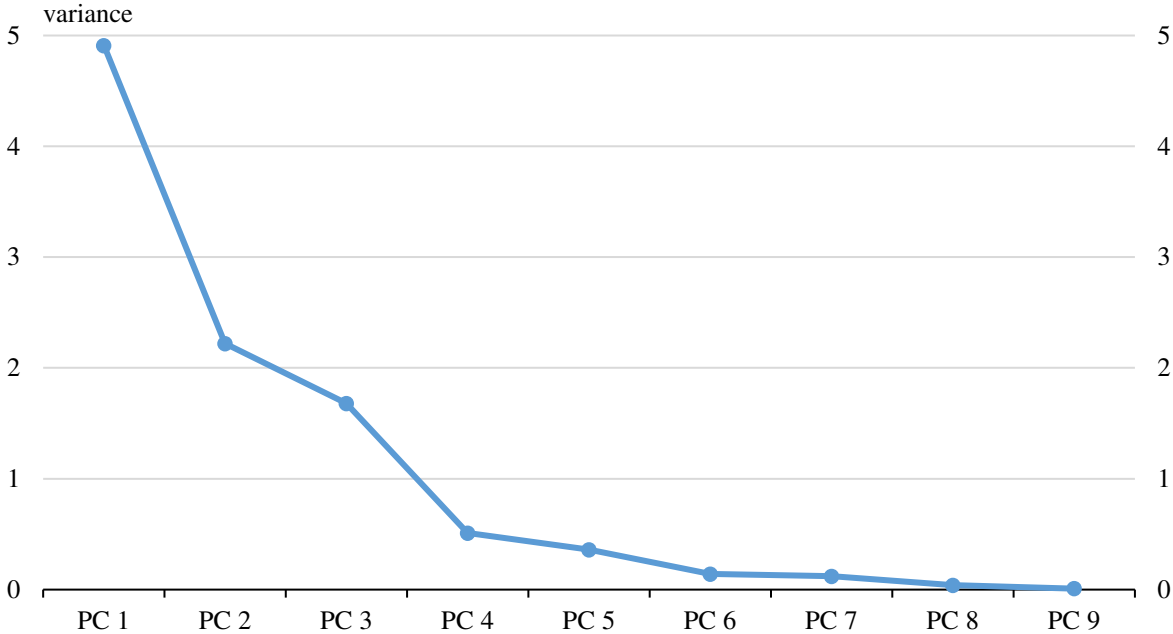
Source: Own work.

The overall misalignment indicator can be computed as a weighted sum of all sub-indicators:

$$MI_t = \sum_i^I w_i x_{i,t} \qquad (14)$$

where w_i is the weight for variable i and it is calculated from the pre-weight v_i. The sum of all pre-weights is normalized to 1 and each is calculated in the following way:

$$v_i = \alpha_{i,j}^2 \varphi_j \qquad (15)$$

where squared factor loading $\alpha_{i,j}$ of variable i on factor j is multiplied with explained fraction of the dataset variance φ_j by factor j. The latter is defined as:

$$\varphi_j = \frac{\sigma_j^2}{\sum_{j=1}^J \sigma_j^2} \qquad (16)$$

where factor j represents the factor on which variable i has the highest loading:

$$j = \text{argmax}\left(abs(\alpha_{i,j}^2)\right). \qquad (17)$$

Table 2 shows the sub-indicators weights, with minimal deviations observed among them.

Table 2: Sub-indicator weights

Indicator	%
Demand	
Price-to-PPI ratio	13.69
Price-to-GOS ratio	8.71
Price-to-hypothetical borrowing volume ratio	7.04
FDI-to-GDP ratio	13.57
Supply	
Price-to-rent ratio	10.94
Price-to-construction costs ratio (Tobin's Q)	13.52
Investments in other buildings-to-GDP ratio	11.23
Inverse of construction value	11.13
System	
Loan-to-GOS ratio	10.18

Source: Own work.

3   RESULTS

This section will present the obtained results and discuss their implications. It will begin by showcasing the aggregate misalignment indicator of CRE prices based on historical averages of the nine sub-indicators, highlighting the pattern of over- and under-valuation during the observed period. It will provide comprehensive information about the factors that contribute to the misalignment in each timeframe, as well as explain the observed shifts and address the driving forces behind them. Additionally, in the subsequent part of this section the validation and robustness checks will be looked at, which aimed to assess the stability and reliability of the misalignment indicator and its sub-indicators. These checks include sensitivity analysis of sub-indicators, examination of different versions of the price indicator, and the robustness of the index to different ratios. The section will conclude with a comparison of the results to other measures and a comparison with residential property prices in Slovenia.

3.1   Misalignment indicator and contribution of sub-indicators

The obtained aggregate misalignment indicator of CRE prices, based on the nine sub-indicators, is shown in Figure 18. The findings revealed a clear pattern of over-valuation during the 2008 boom cycle, driven by several indicators. The peak was reached in the third quarter of 2009, when CRE prices were overvalued by 17%. In the initial phase of the boom cycle, the (inverse of) construction value and the investments in other buildings relative to GDP played a significant role, with each factor contributing approximately two to four percentage points during the period from the end of 2007 to beginning of 2010. The overvaluation of the construction sector was mainly driven by a surge in construction activity, leading to an oversupply of properties, which lowered the fundamental value and increased the over-valuation, since the nominal prices did not decline as much. Similarly, the considerable contribution of investments in other buildings to GDP ratio was influenced by a substantial increase in such investments, which were growing twice as fast as the overall GDP, on a quarterly basis, during that period, which implies overheating.

However, as the GFC progressed, the factors contributing to the overvaluation shifted. From the beginning of 2009, the misalignment became primarily driven by the loan-to-GOS ratio, which implies deteriorating access to credit. Both factors were driving this development – while profits declined, loans kept growing. It is worth noting that in the pre-crisis period, this indicator was the main driver of undervaluation, but as indicator started pointing to the overvaluation, it soon became the strongest contributor overall overvaluation in the subsequent period, in the peak contributing 12 percentage points, which accounted for 70% of the overvaluation. Careful reader may observe that the CRE market appears to be overvalued for a significant portion of the crisis period, which raises the question of why this phenomenon is observed, considering that market valuations of CRE decreased during that time. The model offers a relatively straightforward explanation for this observation.

While the market valuation experienced a decline, the fundamental value of CRE appears to have declined even further, resulting in an increased level of overvaluation despite the apparent decrease in the market value of CRE.

As the crisis persisted, the misalignment gradually started to diminish and by the second quarter of 2011, the market had reached equilibrium. This can be attributed to decrease in construction activity and decreasing trend in investments in other buildings, as displayed by the dynamics of the inverse of construction value and the investments in other buildings-to-GDP indicators, respectively. These two indicators that drove overvaluation during the 2008 period were now contributing to the undervaluation. On the other hand, loan-to-GOS ratio, price-to-hypothetical borrowing volume, and price-to-GOS ratio were still suggesting overvaluation. Among the overvalued indicators, the loan-to-GOS ratio had still accounted for the largest part. Consequently, this resulted in an overall absence of mispricing in CRE prices (see Figure 16).

However, from this point onward, the period of undervaluation began. At its lowest point, in the final months of 2013, the CRE was undervalued by almost 14%. During this period, several indicators played a significant role in driving the undervaluation. Specifically, the inverse of construction value and the investments in other buildings-to-GDP ratio accounted for three and two percentage points, respectively, to the undervaluation. This was due to decrease in investments and construction work put in place, while GDP had increased. Furthermore, all other indicators also indicated undervaluation, which was not observed previously. However, it can be noticed that the banking system-wide indicator (loan-to-GOS ratio) lagged behind the other indices. It indicated undervaluation only at the end of 2012, and after remained a prominent contributor, accounting for more than 2 percentage points of the overall undervaluation in the lowest point. This was primarily influenced by a low lending activity, coupled with strong GOS growth, which made this indicator one of the main contributors for CRE's undervaluation.

Following the lowest point, the overall index gradually increased until 2015, when it indicated an approximately 9% undervaluation of CRE market prices. However, it experienced a slight drop afterwards. During this period and leading up to the point of equilibrium, there were notable changes in the contributions of sub-indicators to the overall undervaluation. Firstly, the negative contribution of the loan-to-GOS ratio to the overall undervaluation increased steadily, reaching its peak in 2014Q3, where it accounted for almost one third of the undervaluation. This can be attributed to the previously mentioned trend of declining new loans granted to businesses and the concurrent increase in profits, which was further intensified during this period. One reason why this indicator accounted for a significant portion of the overall index at this time, was also that many other indicators had relatively smaller contributions in 2015, compared to previous periods. One noteworthy difference was observed in the contributions of the investments in other buildings-to-GDP ratio. This indicator experienced a minor peak during that time, shown in smaller contribution to under-valuation at the beginning of 2015, as investments increased faster

than GDP. Furthermore, after the third quarter of 2015, first signs of market revival emerged, as some indicators started showing signs of overvaluation. Specifically, the FDI was growing at a faster pace than GDP during that specific period, thereby indicating an overvalued state.

Subsequently, there was a significant increase in the misalignment indicator, surpassing the equilibrium level in the beginning of 2019. However, the equilibrium was achieved in a different way than in 2011. During this period, there were fewer deviations among the indicators, with all sub-indicators contributing smaller percentages. From that point onward, the misalignment showed a consistent upward trend of overvaluation in CRE prices. By the fourth quarter of 2022, it reached a value of only one percentage point lower than in the peak observed in 2008. However, the dynamics differed from the GFC period, as various indicators played a significant role in driving the overvaluation. At the beginning of the period following equilibrium, the contribution of majority indicators showed positive misalignment, with the exception of the loan-to-GOS, price-to-hypothetical borrowing value, and price-to-rent ratio, which continued to indicate undervaluation. However, later on, also these indicators turned and displayed a positive misalignment, with all the sub-components contributing positively. Overall, this increase is indicating that CRE prices were and continue to be overvalued for more reasons, with comparable contributions from different indicators.

Figure 18: Misalignment indicator and the contributions of sub-indicators

Source: Own work.

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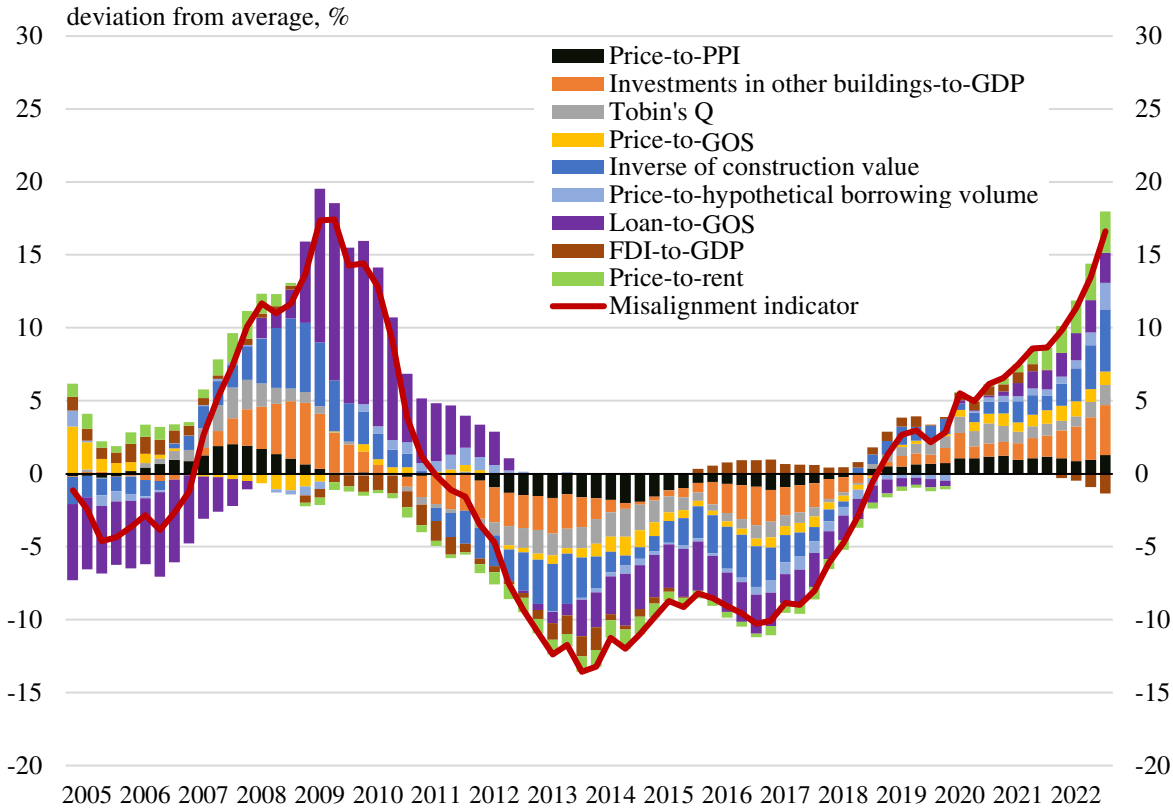
At the time of writing, the misalignment indicator indicates more than 16% overvaluation of CRE prices. The primary contributors to this overvaluation are the inverse of construction value and the investments in other buildings relative to GDP ratio, accounting for four and three percentage points, respectively. This is due to increase of real construction value and investments. These indicators are exhibiting similar behaviour to the boom period observed in 2008. However, the loan-to-GOS ratio does not have a dominant impact this time, due to the decrease in the amount of new loans granted to businesses. One indicator that particularly stands out is the price-to-rent ratio, which has the highest contribution through all the observed periods, specifically almost three percentage points. This is attributed to the substantial increase in nominal CRE prices, while rents remained relatively stable.

3.2   Validation and robustness checks

To assess the accuracy and reliability of the results, validation and robustness checks were performed. These checks aimed to evaluate the stability and consistency of the misalignment indicator, ensuring its ability to provide meaningful insights for all relevant sources.

As previously detailed in the section outlining the methodology for constructing the CRE price-to-PPI ratio and the creation of its three alternative versions, it was concluded that they exhibit consistency with one another. In this section, the results of incorporating different versions of the real price indicator, to formulate the overall misalignment index, will be presented. Given that prices appear as a part of few other sub-indicators, verifying the robustness of the diverse price construction indices, is critical to ensure the validity of the entire index. When prices are included in any other sub-indicator in nominal terms, they are constructed according to the methodology applied to the corresponding version of the ratio, without considering the adjustment for inflation. Furthermore, it has already been established that CRE prices are not directly attainable and, thus, different components needed to be used to create the indicator, which raises concerns regarding the validity of the constructed price index, the selection of an appropriate deflator and the robustness of the aggregated indicator. In Figure 19, four misalignment indices are shown, each using a different variation of the CRE price index. The visual inspection indicates that the overall indicator follows the same pattern regardless of the CRE price version used, supporting the robustness of the findings. The contributions of each of the nine sub-indicators, for different versions of the misalignment indicator, can be found in Appendix 2.

Another question that emerged during the research is related to the loan-to-GOS ratio. Specifically, certain authors (Schneider, 2013; Lenarčič & Damjanović, 2015) employed the concept of loan-bearing capacity, which compares the amounts of loans to a hypothetical borrowing volume instead of considering income or profits. In one of the previous sections, it was concluded that this sub-indicator displays a consistent trend irrespective of the ratio used. However, an additional analysis was conducted to examine the overall index's stability when either of the two ratios are employed.

Figure 19: Alternative versions of misalignment indicator based on different price-to-PPI
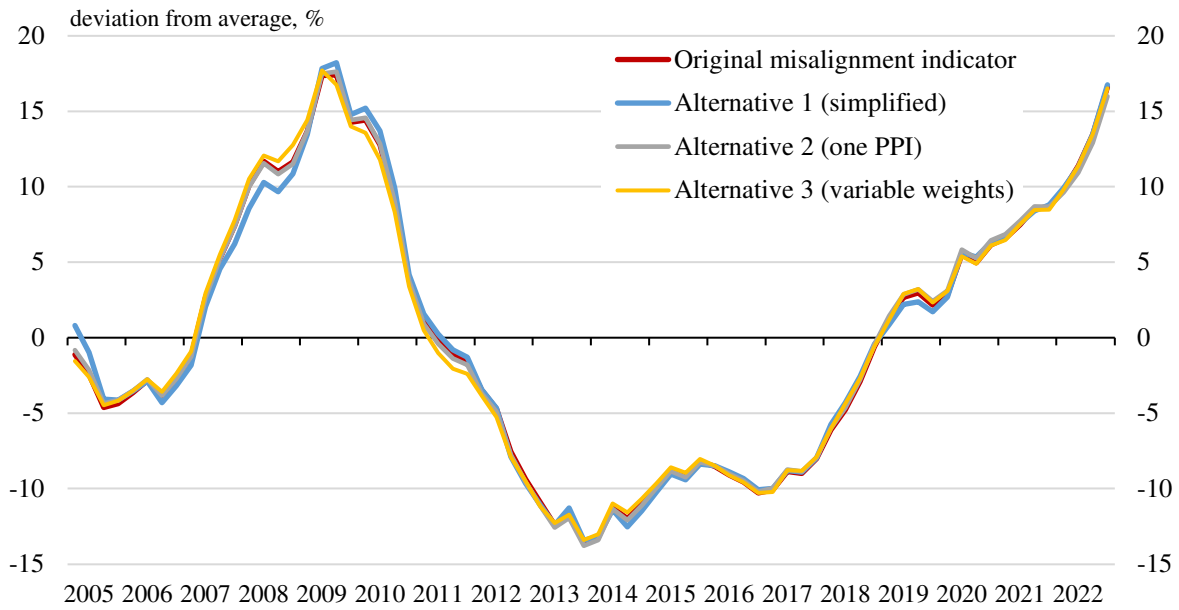
Source: Own work.

Figure 20 represents the original misalignment indicator, which is based on the loan-to-GOS ratio, and the alternative misalignment indicator, who utilizes the loan-to-hypothetical borrowing volume ratio instead, while keeping other factors unchanged. The results indicate the robustness of the findings, as both indices demonstrate a similar trend.

Figure 20: Alternative version of misalignment indicator based on different loan-to-GOS ratio
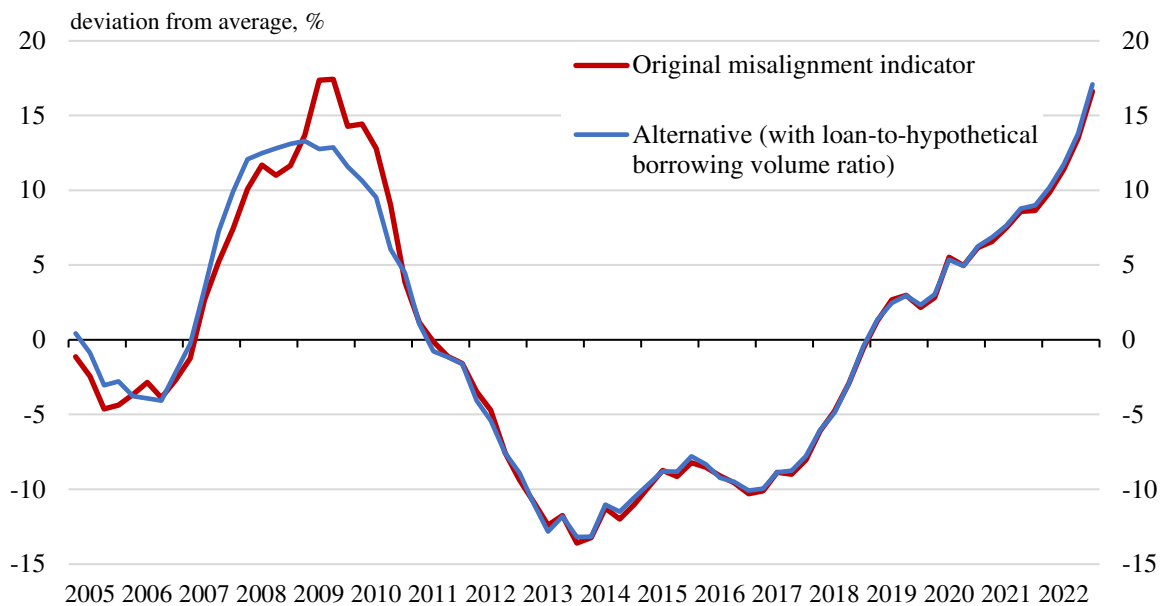
Source: Own work.

As also evident from the individual indicators, the second one displays a noticeably smaller peak during the 2008s period, with a correspondingly smaller contribution to the overall index at that time. The decision to include the loan-to-GOS ratio was primarily driven by its ability to clearly depict the peak during that specific period. In other time periods, the differences between the two indicators are negligible, as are the inconsistencies in the contributions of other sub-indicators, which can be found in Appendix 3.

In order to evaluate the overall impact of all sub-indicators on the misalignment index, an examination was carried out to assess the effects of excluding specific sub-indicators with minimal contributions to the overall index. Initially, the analysis involved excluding the price-to-hypothetical borrowing volume sub-indicator, which had the smallest weight in the construction of overall index (see Table 2). Subsequently, the price-to-GOS ratio, with the second smallest weight, was also excluded. Lastly, the analysis involved excluding the loan-to-GOS ratio, which had the third smallest weight. These variations are denoted based on the number of remaining sub-indicators, for example alternative 8 represents the exclusion of one sub-indicator, namely the price-to-hypothetical borrowing volume ratio, where other eight remaining unchained. Alternative 7 includes sub-indicators from previous alternative, with the additional exclusion of one indicator and so on.

Figure 21 displays all three variations along with the original misalignment indicator. It can be concluded that all variations exhibit similar dynamics, where alternative 8 and alternative 7 the most closely align with the original indicator. This indicates that the price-to-hypothetical borrowing volume ratio and price-to-GOS ratio do not significantly influence the overall trend, instead, they follow the patterns set by other sub-indicators. However, a distinction is observed at the beginning of the observed period, where alternative 7 displays a higher degree of undervaluation compared to the other three variations. This can be attributed to the exclusion of the price-to-GOS ratio, which previously contributed positively to the misalignment (refer to Appendix 4, Figure 6). As a result, the exclusion of this sub-indicator amplifies the impact of the loan-to-GOS ratio, emphasizing the undervaluation. The last alternative deviates the most from the original misalignment indicator, as the loan-to-GOS ratio, despite having the third smallest weight in the index construction (refer to Table 2), contributes significantly to the overall misalignment, particularly in the first half of the observed period. Consequently, excluding this sub-indicator introduces some deviations in the trend.

However, the overall trend and contributions of sub-components remain consistent across the alternatives, indicating the robustness of the indicator. Nonetheless, the inclusion of all sub-indicators ensures a more robust and comprehensive assessment of the misalignment, providing a better overall understanding, since each sub-indicator may capture different aspects of the phenomenon being analysed. The contributions of each sub-indicator for different variations can be found in Appendix 4.

Figure 21: Alternative versions of misalignment indicator with the exclusion of some sub-indicators
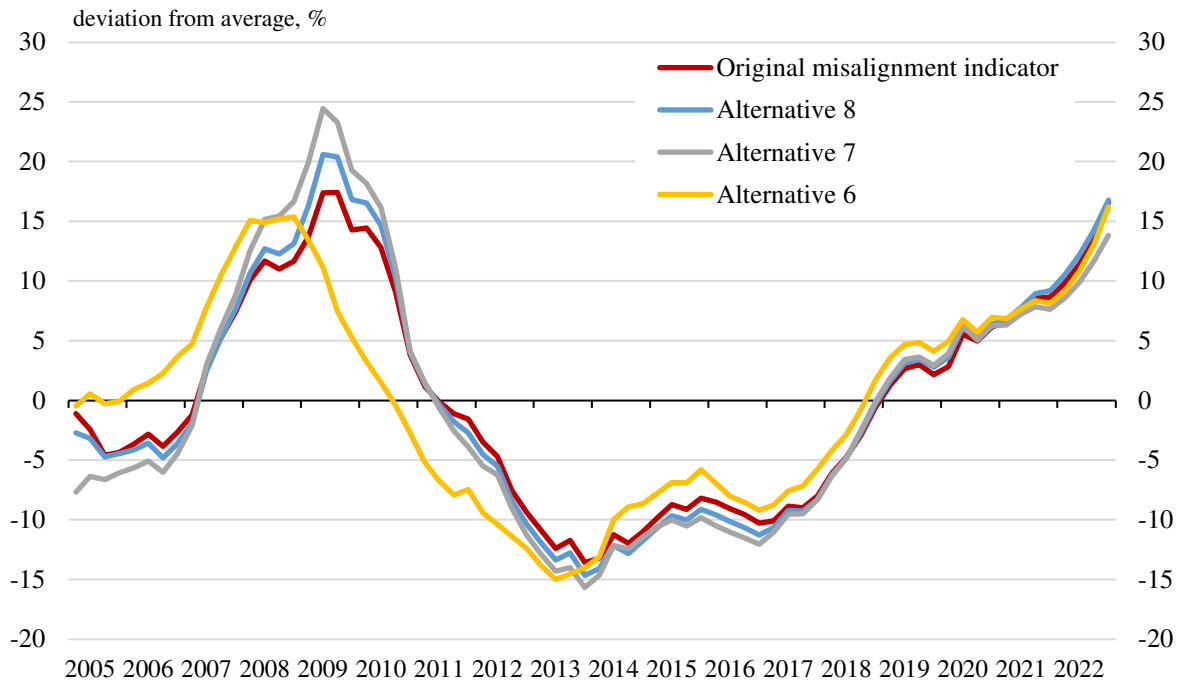

Source: Own work.

The validation process includes a crucial step of comparing the results with other relevant measures to confirm their validity. In one of the previous sections, several studies addressing the misalignment of CRE prices have been discussed. This section aims to present the key findings related to misalignment movements from each study in order to compare them with the results obtained for Slovenia. It should be noted that the time spans covered in these studies differ from the present analysis, primarily focusing on past periods without inclusion of recent years. Nonetheless, examining their findings for overlapping periods holds value as it provides perspective on the consistency of misalignment patterns in Slovenia compared to other countries. Such consistency would indicate the robustness of the obtained results.

One of the studies was conducted by ECB (2011b), where they utilized five fundamental indicators to evaluate misalignments in the value of CRE markets in several European countries. Their findings are shown in Figure 22. They concluded that in 2007, CRE prices in most of the countries were overvalued. In contrast, the findings for Slovenia indicate that the highest misalignment occurred later, specifically peaking in the third quarter of 2009. The ECB's (2011b) findings also reveal adjustments in the misalignment indicator in 2011. The indicators showed that, overall, the market was not misaligned at the time, with some countries showing negative values and others showing positive values. In the case for Slovenia, the misalignment indicator also showed equilibrium in 2011, demonstrating alignment with the average misalignment observed in the euro area.
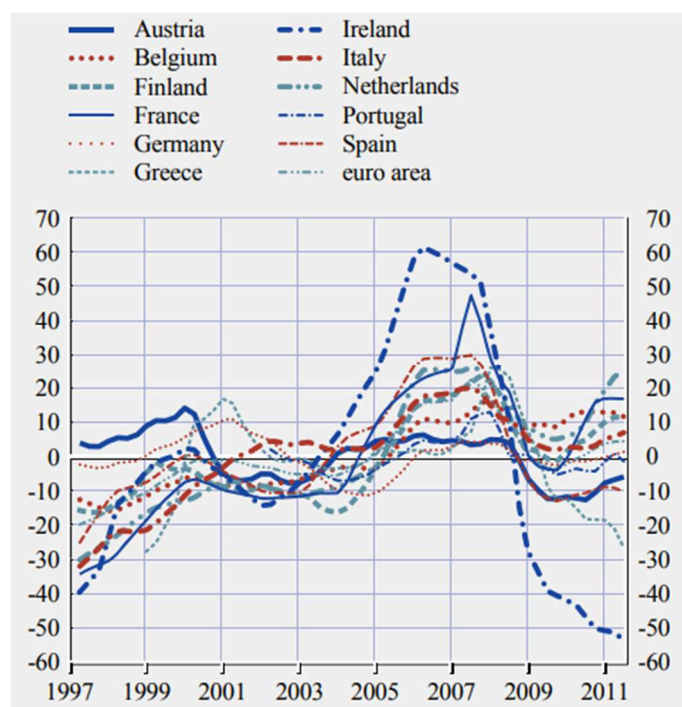
Source: ECB (2011b).

Hlaváček et al. (2014) conducted an evaluation of office property price misalignment in several central European countries. Figure 23 illustrates their findings, showing that during the period from 2002 to 2005, most of the observed countries exhibited undervaluation. From 2006 to 2008, office property prices were found to be overvalued in all countries, followed by a decrease from 2009 to 2011. In 2013, the study observed that office property appeared to be undervalued in some countries, while in other countries, prices were near or slightly below their equilibrium levels. These findings align well with the findings for the Slovenian CRE market. Once again, it is evident that the peak of overvaluation in Slovenia occurred later than in the countries examined by Hlaváček et al. (2014). In 2013, Slovenian CRE prices experienced the highest undervaluation, which is consistent with some of the other countries analysed in the study.

Similarly, the assessment conducted by Coffinet and Kintzler (2019) aimed to evaluate the pricing of office spaces in France. The outcomes of their analysis can be observed in Figure 24. The office market in France demonstrated an overvaluation from 2005 to 2009, followed by a slight undervaluation. Towards the end of the observation period, particularly in the fourth quarter of 2017, they were slightly above equilibrium and close to fair value. These findings draw parallels with the results obtained for Slovenia, albeit with a lag of a few years. Specifically, at the end of 2017, Slovenia still experienced an undervaluation of CRE prices. However, the undervaluation had already been decreasing at that time and reached an equilibrium value one year later.

Figure 23: Office price "gaps"
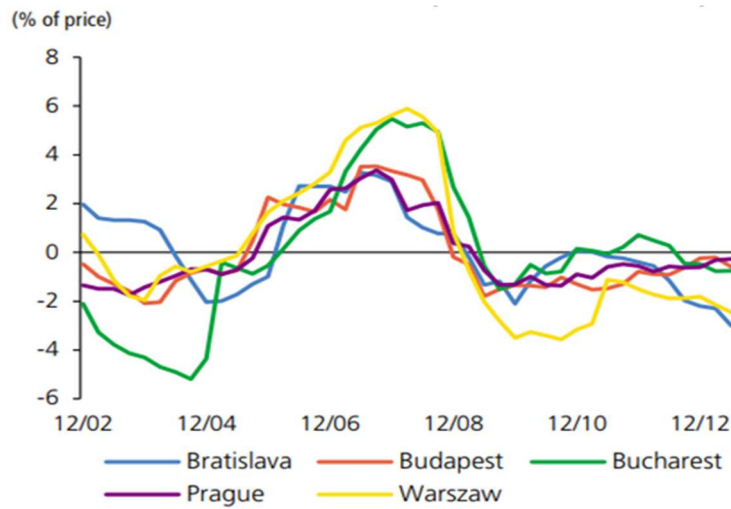
Source: Hlaváček, Novotný, and Rusnák (2014).

Figure 24: Misalignment of office prices in France
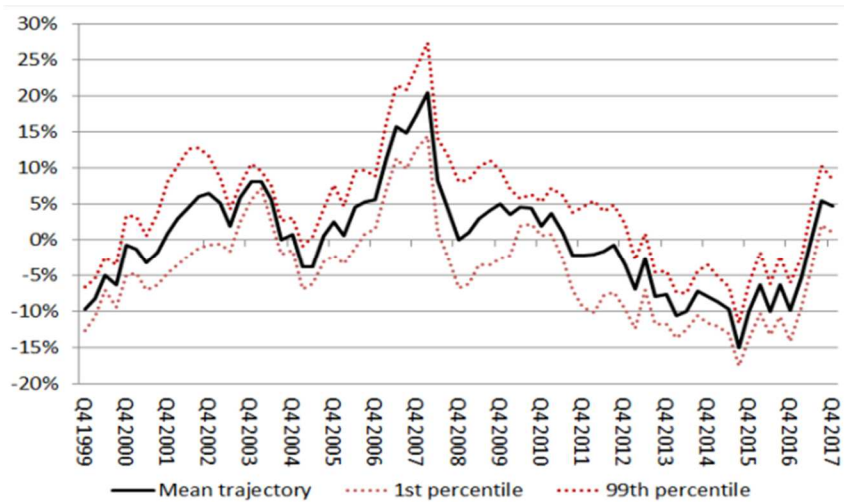
Source: Coffinet and Kintzler (2019).

The misalignment of CRE prices was also examined by Hejlová et al. (2020). Their study focused on industrial properties and offices across five CEE countries, as well as Germany. Results from the misalignment estimation of the Cross-Country Panel, depicted in Figure 25, will be presented. When considering the misalignment of office prices, a notable similarity in trends among the countries can be observed, consistent with previous studies. Among the studies discussed, this particular research stands out as the most recent investigation of office prices. Consequently, it provides valuable insights into the recent peak of overvaluation, indicated by the findings for Slovenia. According to their paper, a significant number of countries displayed overvaluation in mid-2019, which aligns with the

findings for Slovenia. At that time, Slovenia also exhibited overvaluation, which continued to intensify subsequently.

In light of the collective evidence from the studies presented above, it can be concluded that the results of this analysis are robust and are alignment with other findings. This consistency is evident in the shared patterns observed regarding the timing of misalignment. However, it is crucial to acknowledge that variations do exist, coming from the distinct economic contexts of each country as well as the divergent methodological approaches employed in the studies. Nevertheless, these differences do not detract from the overall similarity in the observed trends and robustness of results presented in the thesis.

*Figure 25: Property price misalignment (in %)*
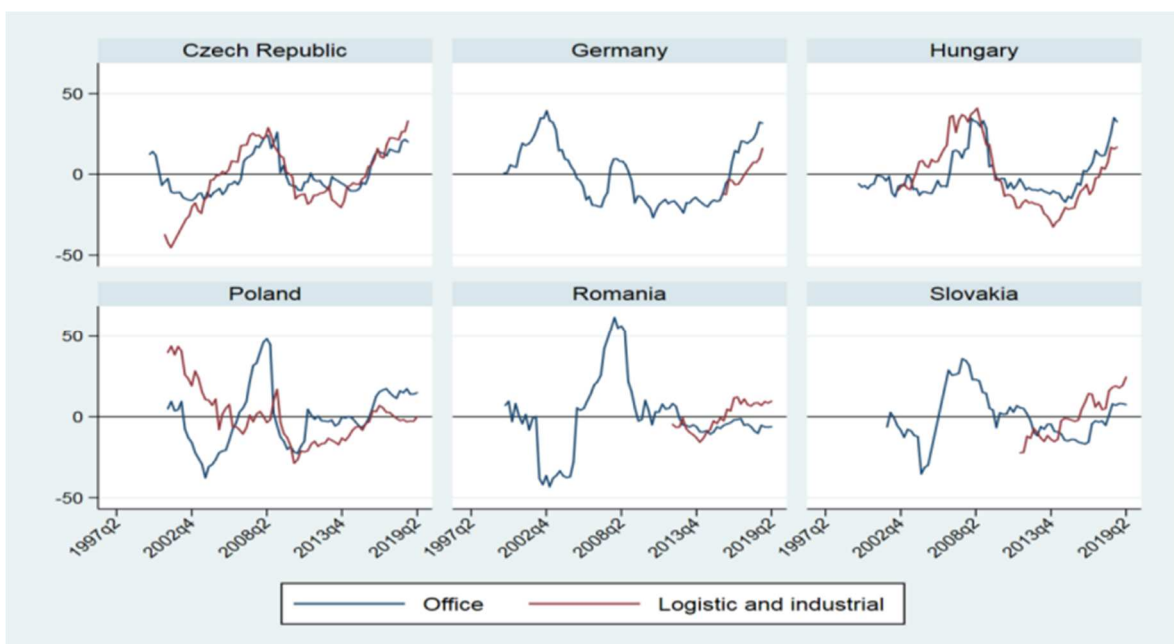
Source: Hejlová, Hlaváek, and Vakova (2020).

Lastly, a comparison was conducted between the results obtained for CRE prices and RRE prices in Slovenia, aiming to examine the interplay between the two sectors. For the sake of consistency, the findings will be presented alongside the research conducted by Lenarčič and Damjanović (2015), who utilized the same methodology to analyse residential prices in Slovenia. Figure 26 displays the misalignment indicator and its components, which are similar to those used in the analysis of CRE prices but specifically applied to the RRE market. The misalignment indicator for housing prices reveals a peak in overvalued prices at the end of 2007, with an estimated overvaluation of 35%. The lending capacity indicator and the ratio of residential real estate investment to GDP were found to have the highest contributions to this peak in overvaluation. These findings align with the trends observed in the CRE market, where overvaluation was also evident during that period but had not yet reached its peak. It is noteworthy that the sub-indicators contributing to overvaluation share some similarities between the two sectors. In the initial phase of the peak, overpricing in the

CRE sector was primarily driven by investments in other buildings-to-GDP ratio. In the later phase, the loan-to-GOS ratio, which corresponds to the lending capacity indicator in the RRE context, played a dominant role. However, there are notable differences, such as the magnitude of overvaluation, with the RRE sector appearing to be significantly more overvalued at that time. Additionally, the contributions of sub-indicators in the RRE sector were more evenly distributed compared to the CRE sector, where the loan-to-GOS ratio dominated.

Furthermore, it is worth noting that both the CRE and RRE sectors achieved equilibrium in 2011 and thereafter exhibiting a negative misalignment. In terms of undervaluation, RRE prices reached their lowest point in 2014, with housing prices showing even greater undervaluation compared to the CRE sector. Subsequently, RRE prices experienced a correction, reaching equilibrium by the end of 2018, coinciding with the equilibrium state of the CRE sector. Following this period, both sectors once again experienced overvaluation in prices. In the case of RRE, the leading contributor to this overvaluation was the lending capacity indicator, while in the CRE sector, more sub-indicators made relatively equal contributions. At the latest observation point, specifically at the end of 2021, the misalignment index for RRE prices indicated an overvaluation of approximately 15%. On the other hand, the CRE sector exhibited an 8% overvaluation at that time, which had subsequently increased to 15% by the end of 2022. In conclusion, the analysis of CRE price misalignment in Slovenia aligns with the findings of Lenarčič and Damjanović (2015) regarding housing prices. This similarity is significant as both analyses focus on the Slovenian market, employ the same methodology, and demonstrate similar movements between the two sectors.

Figure 26: Misalignment indicator of RRE and its sub-components

Source: Bank of Slovenia (2022a).

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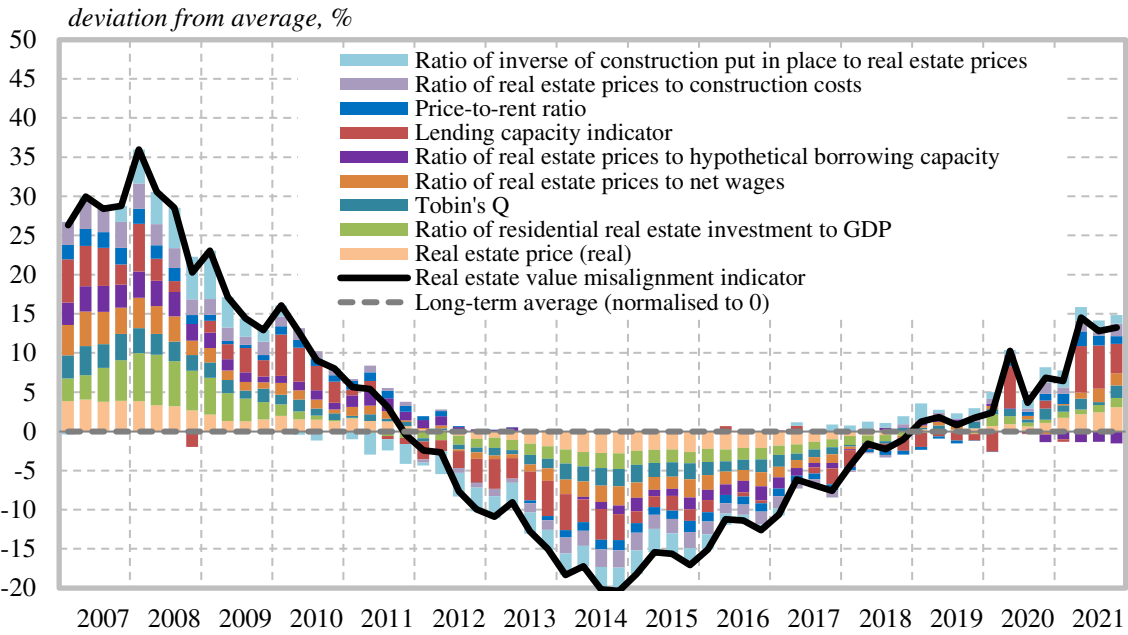
In order to further evaluate the validity and reliability of the findings, a sensitivity analysis was conducted. This analysis aimed to provide an additional assessment of the misalignment indicator by employing statistical filtering technique. Specifically, the Hodrick-Prescott (HP) filter was utilized to decompose the cycle of real CRE prices. While the HP filter is widely employed and it is easy to be interpreted, it is important to acknowledge its limitations. Nonetheless, undertaking this sensitivity analysis contributes to enhancing the overall value, robustness, and applicability of the misalignment indicator for CRE prices in Slovenia.

The methodology employed follows approach used by Micallef (2016) in analysing residential property prices in Malta. However, one of the limitations associated with the HP filter technique is known as the end-point bias, which arises from the fact that the final data point in a series can disproportionately impact the trend estimation at the end. While this bias may not be significant when solely examining the characteristics of the cycle, it is advisable to exclude the trend values at the end of the series to mitigate this issue (Bruchez, 2003). In an effort to address this concern, an autoregressive integrated moving average (ARIMA) (2,1,1) model was employed to extend the time series from 2023 to 2030, where the Akaike information criteria (AIC) was used to select the optimal model specification. By extending the series, the point of interest is no longer solely focused on the final data point, which helps lessen the problem to a certain extent. However, it is important to recognize that the usefulness of this approach is limited, and caution should still be exercised when interpreting the latter part of the series.

The HP filter was defined by Hodrick and Prescott (1997), where y_t represents a time series and it is defined as the sum of a growth component g_t and a cyclical component c_t, where $t = 1, \ldots, T$:

$$y_t = g_t + c_t \tag{15}$$

The smoothness of the $\{g_t\}$ path is quantified by the sum of the squares of its second difference. Meanwhile, the c_t components represent deviations from the growth component, with the underlying assumption that their average approaches zero over long time period. Based on these premises, the following minimization problem arises as a means of determining the growth components:

$$\min_{\{g_t\}_{t=-1}^T} \left\{ \sum_{t=1}^T c_t^2 + \lambda \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\} \tag{16}$$

The parameter λ represents a positive value that serves as a penalty for variability in the growth component series. A larger value of λ leads to a smoother solution series. However, one of the challenges associated with the HP filter is also selecting an appropriate smoothing parameter, as it significantly influences the outcomes. In this thesis, the first variation of the HP filter, referred to as HP filter 1, adopts a λ of 400,000, aligning with the guidance provided by the European Systemic Risk Board (ESRB) regarding the computation of the

counter-cyclical capital buffer using the credit-to-GDP ratio. The second measure, referred to as HP filter 2, follows the approach proposed by Goodhart and Hofmann (2008)[6], who employed a λ value of 100,000.

Figure 27 illustrates both versions of the HP filter alongside the original misalignment indicator, offering a visual depiction of their application and outcomes. It is evident that both measures yield a similar interpretation of the cycle in CRE prices. Similar to the misalignment index, the statistical filter also indicates an overvaluation of CRE prices from 2006 to 2011, albeit with the peaks occurring slightly earlier than indicated by the overall index. Subsequently, both measures point to an undervaluation in CRE prices from 2012 to 2019, followed by a recovery thereafter. The main discrepancy arises in the recent periods, where the misalignment indicator shows a consistent increase, while the HP filter demonstrates a pattern of increasing overvaluation until the end of 2020, followed by a decrease. This observation can be attributed to the end-point bias commonly observed in the HP filter. Similarly, Hejlová et al. (2020) discovered that towards the end of their sample period, the HP filter suggested an equilibrium level, while for certain countries their model indicated deviations from the equilibrium. Nonetheless, the objective of this sensitivity analysis is to assess the robustness of the results. Given the comparable dynamics observed in most periods, it can be implied that the findings remain robust, thereby validating the analysis.

Figure 27: Sensitivity analysis
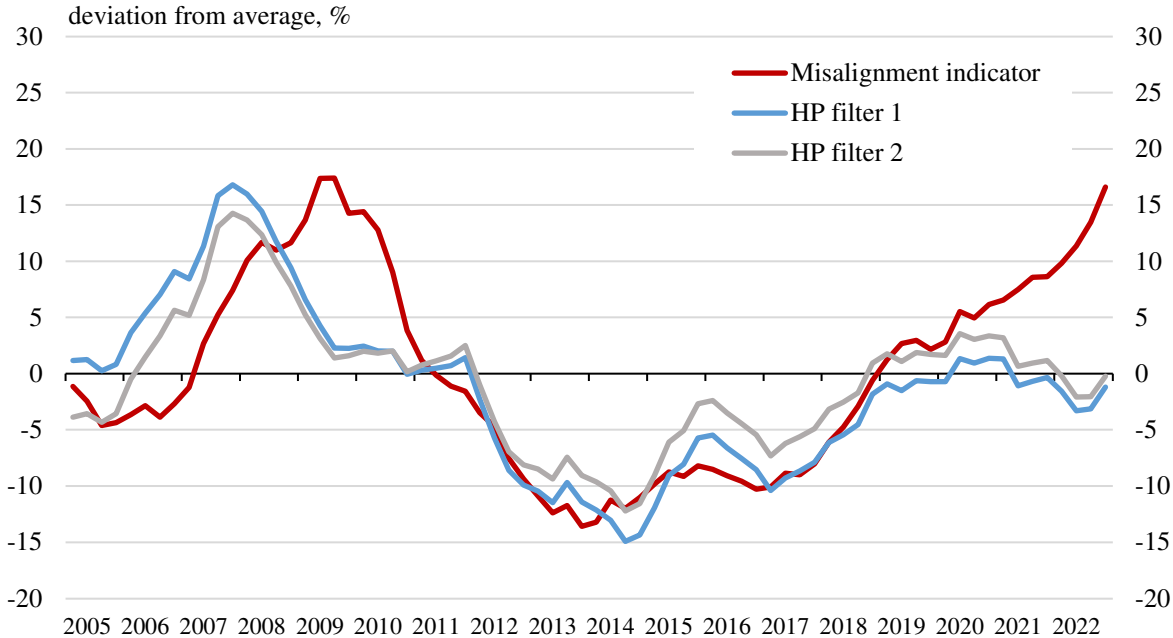
Source: Own work.

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[6] See also European Commission (2012).

CONCLUSION

The lessons learned from recent economic shocks have underscored the critical importance of timely intervention during periods of crises. However, effectively addressing the challenges that arise during such times necessitates the availability of appropriate detection tools. Given the significant role played by the CRE market in driving economic growth, employment, and infrastructure development, it becomes vital to carefully monitor its dynamics. Historically, the focus of research has primarily cantered on the RRE market, while the CRE market has received relatively less attention. Nevertheless, in recent years, there has been a noticeable shift in this trend, and the work presented in this thesis contributes to the expanding body of literature in this field.

The central objective of this research is to develop an indicator capable of measuring the misalignment between fundamental and market prices within the CRE market. This indicator serves the purpose of accurately quantifying and closely monitoring the developments in the CRE market, thereby enabling relevant stakeholders to make informed decisions and implement appropriate policies. By analysing various factors and employing advanced statistical and analytical techniques, the developed indicator provides a comprehensive assessment of the extent to which market prices deviate from their underlying fundamentals. This valuable tool facilitates early detection of potential market imbalances, allowing for timely interventions and proactive measures to mitigate risks and enhance the stability of the CRE market. The methodology used in this thesis can be easily applied to different countries and markets, making it highly useful and adding significant value. As a result, it also creates additional opportunities for further research and work to be undertaken.

The constructed indicator, comprising nine sub-indicators, reveals the dynamic behaviour of the Slovenian CRE market. Following the dissipation of overvaluation during the GFC, the market initially reached equilibrium and subsequently experienced undervaluation. However, in recent years characterized by robust economic activity, the market has rebounded, re-entering the territory of overvaluation. At present, the indicator signals an overvaluation of 16 percent in the Slovenian CRE market. This level of overvaluation has been surpassed only by the period preceding the full impact of the GFC on the Slovenian economy.

This study serves as a valuable foundation for future research on the misalignment of CRE prices. However, acknowledging the limitations serves as a reminder of the need to be careful when interpreting the analysis findings and highlights the importance of considering these factors when evaluating CRE price misalignment. Moving forward, several avenues can be pursued to enhance the study's scope and reliability. Firstly, in order to address the limitation of a short time series data in studying CRE price misalignment, it is recommended to collect and extend the existing data. Acquiring data from additional sources, including non-publicly available data, would greatly enhance the accuracy and reliability of the indices used in the analysis. By incorporating a longer time series, it becomes possible to capture

the complex dynamics and trends within the CRE market more effectively. Secondly, for proxy indicators that may be affected by data limitations, alternative methodologies should be explored to construct sub-indicators that can provide more robust insights. This could involve considering different data sources or employing alternative calculation methods to enhance the comprehensiveness of the analysis. Furthermore, it is advisable to validate the findings by applying alternative methodologies on Slovenian CRE market, such as those employed by other researchers. Comparing the results obtained through different approaches would contribute to strengthening the overall validity and reliability of the analysis.

In summary, the application of this indicator enables policymakers, investors, and industry professionals to gain critical insights into the health and stability of the CRE market and empowers them to make informed decisions, promoting decision-making based on reliable information and supporting the development of a robust and sustainable real estate sector.

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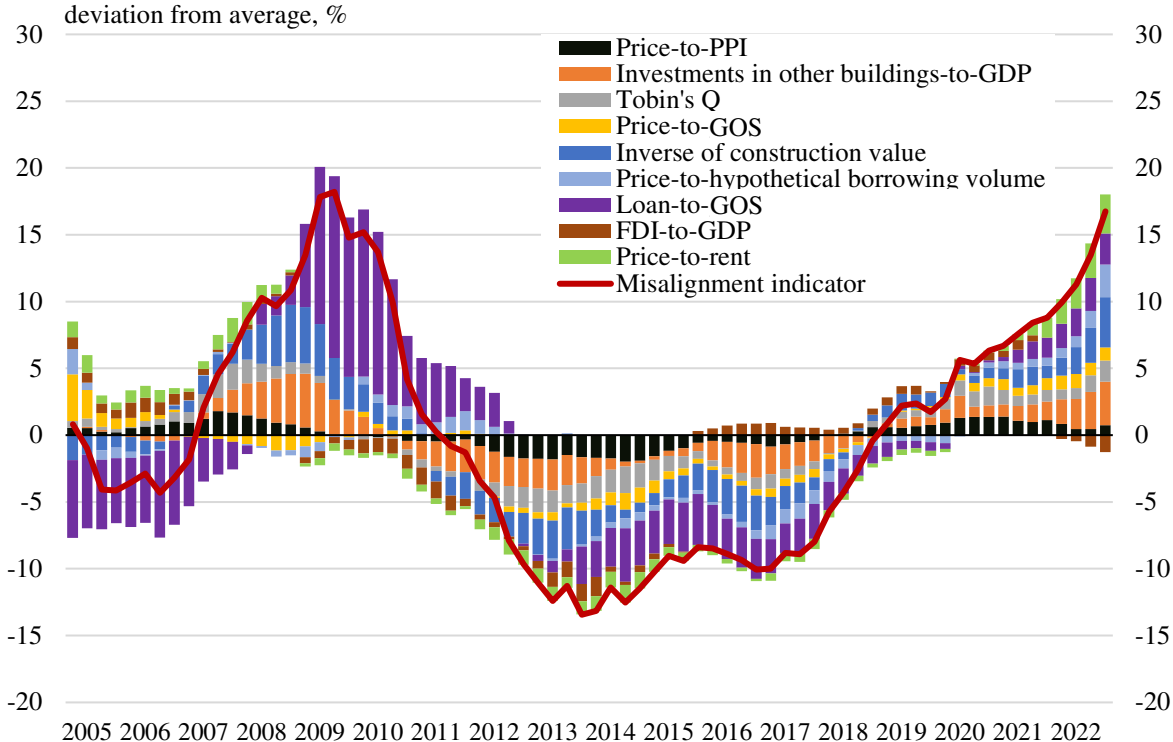
APPENDICES

Appendix 1: Povzetek (Summary in Slovene language)

Izbruh pandemije virusa Covid-19, energetska kriza, ki je sledila začetku ruske agresije na Ukrajino in visoka inflacija, so le nekateri izmed šokov, ki so v zadnjih letih vplivali na dogajanje na nepremičninskih trgih. Ker slednje pomembno vpliva, tako na gospodarsko aktivnost, kot tudi finančno stabilnost, je razvoj orodij, ki lahko v realnem času zaznajo odmik od ravnotežja, ključen za pravočasno oblikovanje ukrepov, ki preprečujejo nestabilnost. To je tudi namen te magistrske naloge. Rezultati predstavljajo pomemben mejnik v razvoju modelske infrastrukture, ki preučuje dogajanje na slovenskem trgu poslovnih nepremičnin. S pomočjo devetih kazalnikov, ki predstavljajo različne dejavnike tega trga, je bil razvit indikator, ki med letoma 2005 in 2022 ocenjuje razliko med notranjo in tržno vrednostjo slovenskih poslovnih nepremičnin. Sestavljen kazalnik razkriva, da so bile slovenske poslovne nepremičnine v času finančne krize, leta 2009, rekordno precenjene. Tržno vrednotenje se je, ob vztrajanju negotovosti poslovnega okolja, zatem sprva začelo približevati ravnotežju, z letom 2011 pa prevesilo v območje podcenjenosti in dno doseglo konec leta 2013, ko je bila tržna cena za 13,6 odstotka nižja od notranje. Kljub gospodarskemu okrevanju je trg v območju podcenjenosti vztrajal vse do leta 2019. Danes so tržne cene slovenskih poslovnih nepremičnin za 16,6 odstotka višje od njihove notranje vrednosti. Čeprav se je precenjenost od začetka epidemije močno povišala, je ta še vedno manjša kot leta 2009, ko je bila tržna cena za 17,4 odstotka višja od notranje.

Appendix 2: Alternative versions of misalignment indicator based on different price-to-PPI ratio
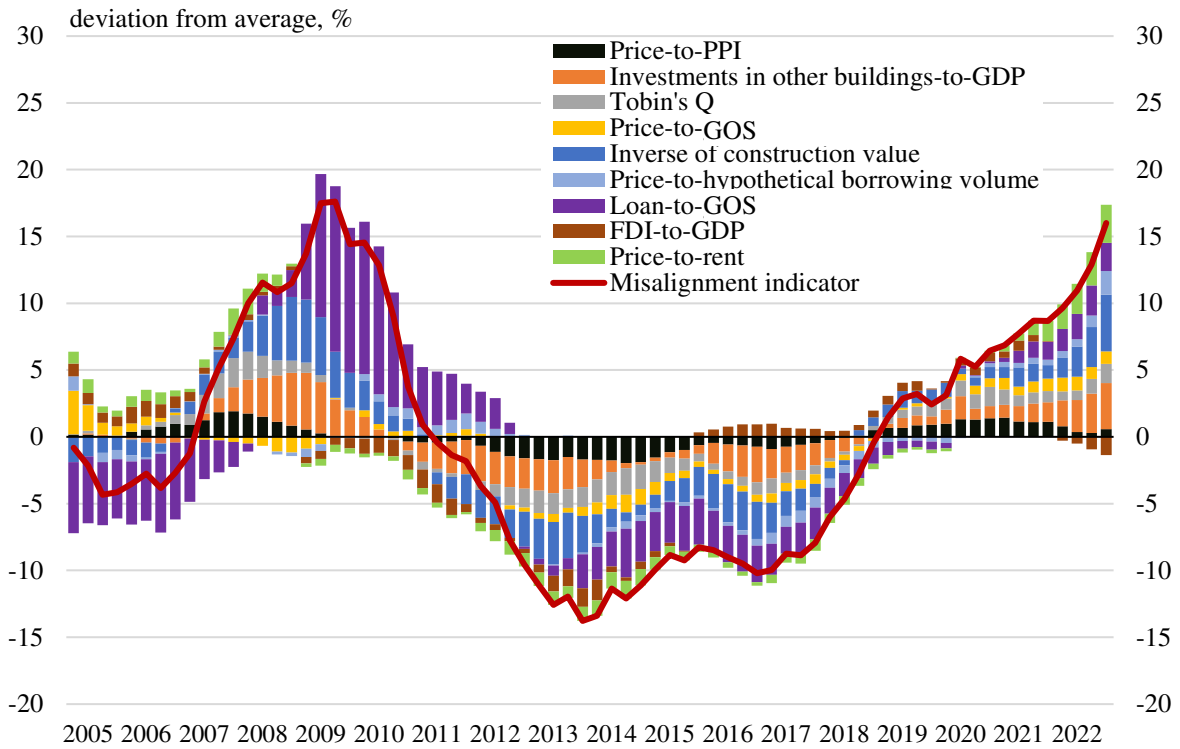
The figures display the misalignment indicator for three different alternatives. Each alternative utilizes a distinct price-to-PPI ratio. As one of the sub-indicators varies across the alternatives, the contribution of this indicator, as well as others, also differs in each version. These visuals showcase the contributions of all sub-indicators for each alternative version.
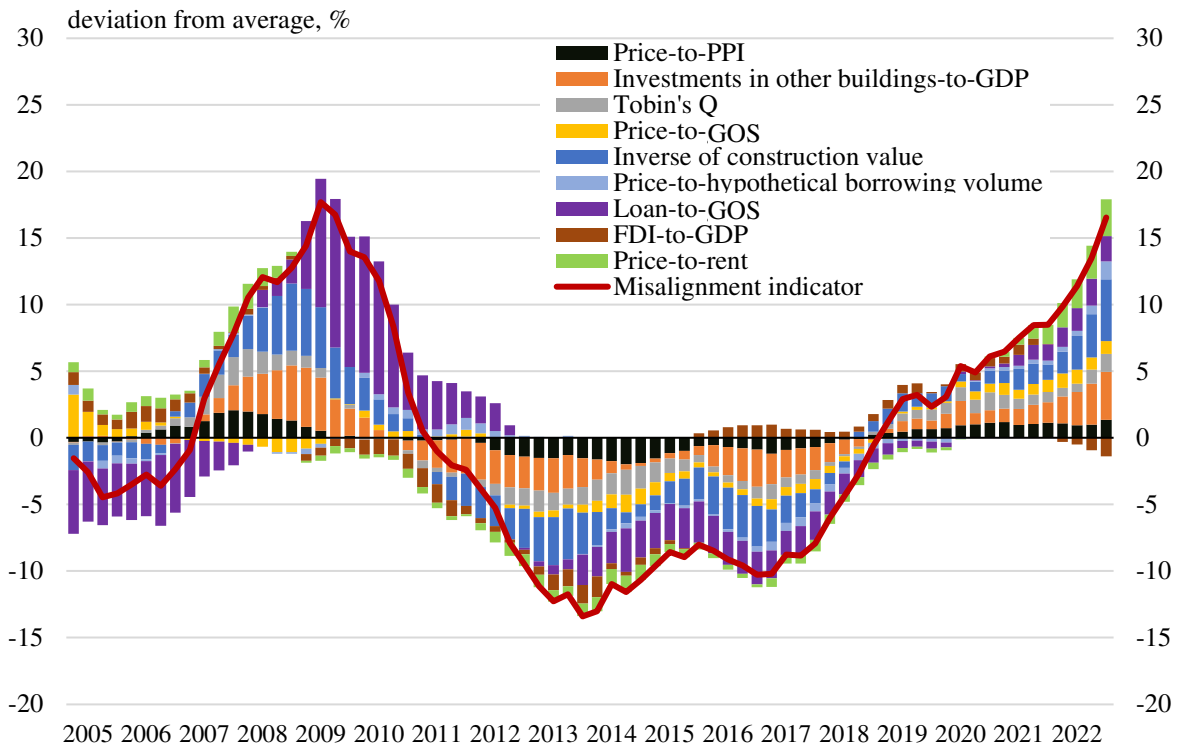
Figure 1: Alternative 1 (simplified)

Source: Own work.

Figure 2: Alternative 2 (one PPI)

Source: Own work.

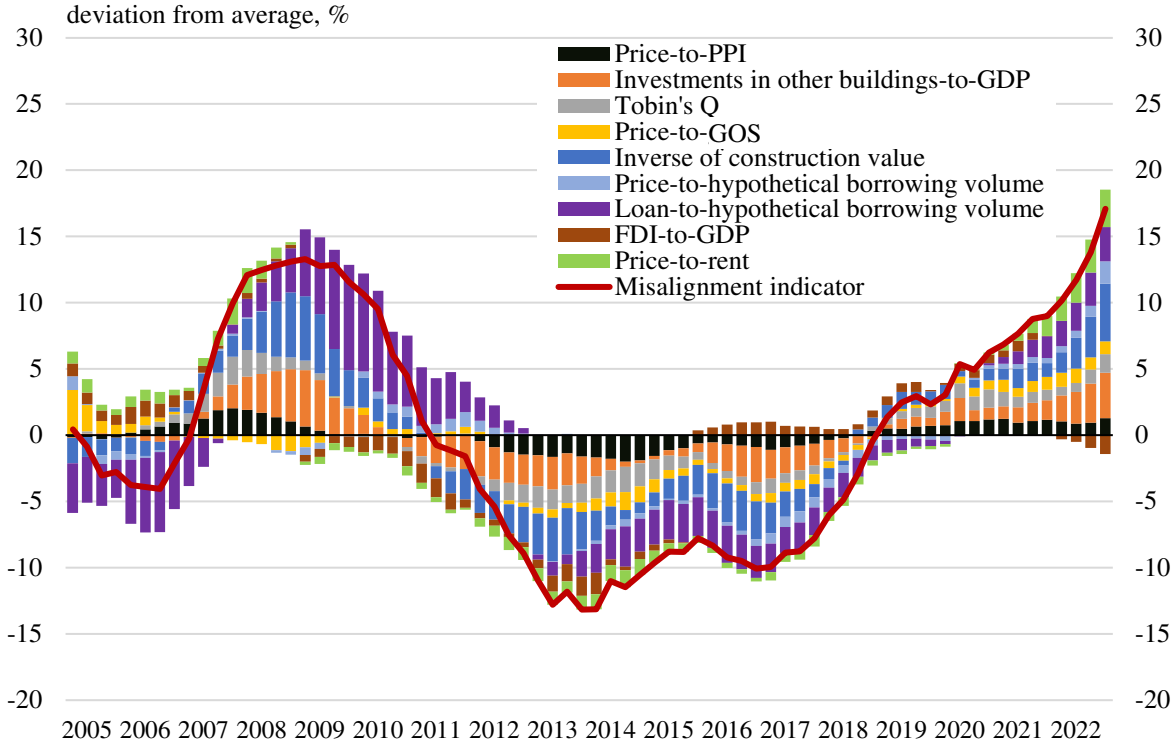## Figure 3: Alternative 3 (variable weights)

Source: Own work.

Appendix 3: Misalignment indicator with loan-to-hypothetical borrowing volume ratio and contribution of each sub-component

The figure illustrates an alternative version of the misalignment indicator that incorporates the loan-to-hypothetical borrowing volume ratio instead of the loan-to-GOS ratio. This substitution not only affects the overall indicator value but also alters the contributions of all the sub-indices, as evident from the figure.
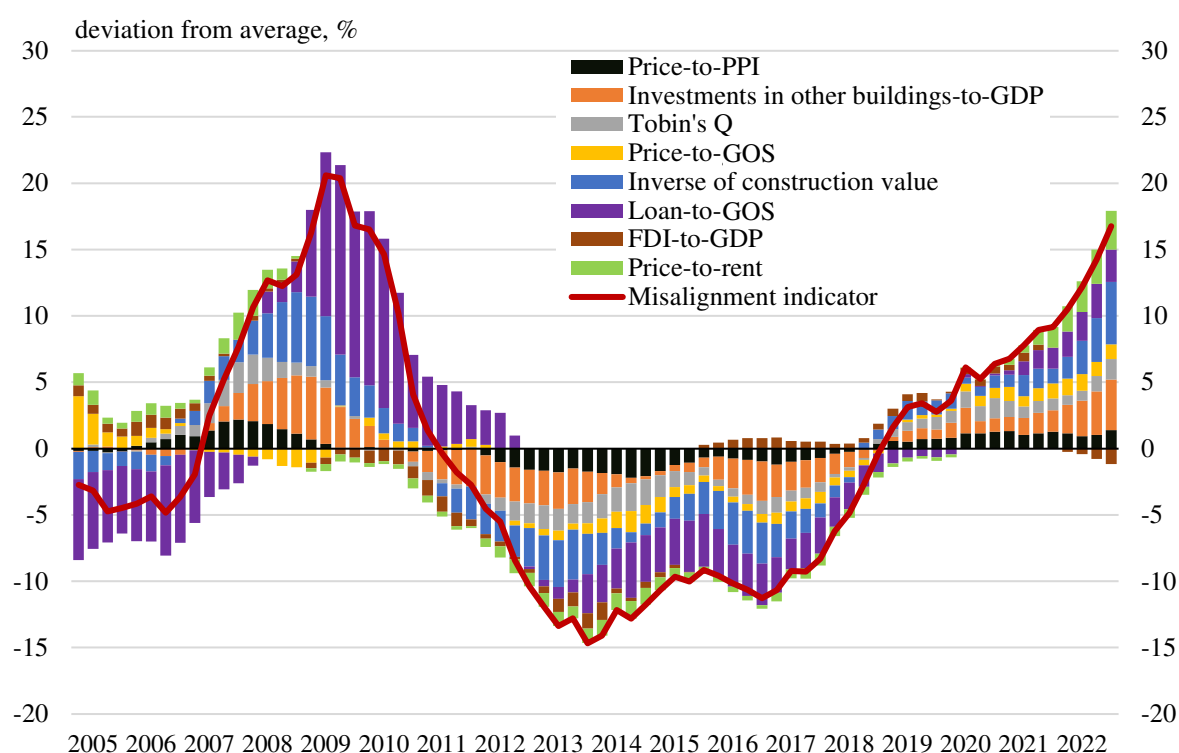
Figure 4:

deviation from average, %

Legend:
- Price-to-PPI
- Investments in other buildings-to-GDP
- Tobin's Q
- Price-to-GOS
- Inverse of construction value
- Price-to-hypothetical borrowing volume
- Loan-to-hypothetical borrowing volume
- FDI-to-GDP
- Price-to-rent
- Misalignment indicator

Source: Own work.

Appendix 4: Misalignment indicator with the exclusion of some sub-indicators and contribution of each sub-component

The figures illustrate three alternative versions of the misalignment indicator, each employing a unique set of sub-indicators. Firstly, the misalignment indicator was calculated by excluding the price-to-hypothetical borrowing volume ratio, and in Figure 5 contributions of each remaining component is presented. Turning to Figure 6, it presents a modified misalignment indicator that excludes an additional sub-indicator, namely the price-to-GOS ratio. Once again, the contributions of the remaining sub-components are displayed. Lastly, Figure 7 showcases a configuration where three sub-indicators are excluded: the two mentioned previously, along with the loan-to-GOS ratio. Similarly, to the earlier figures, it also exhibits the contributions of the remaining sub-indicators.

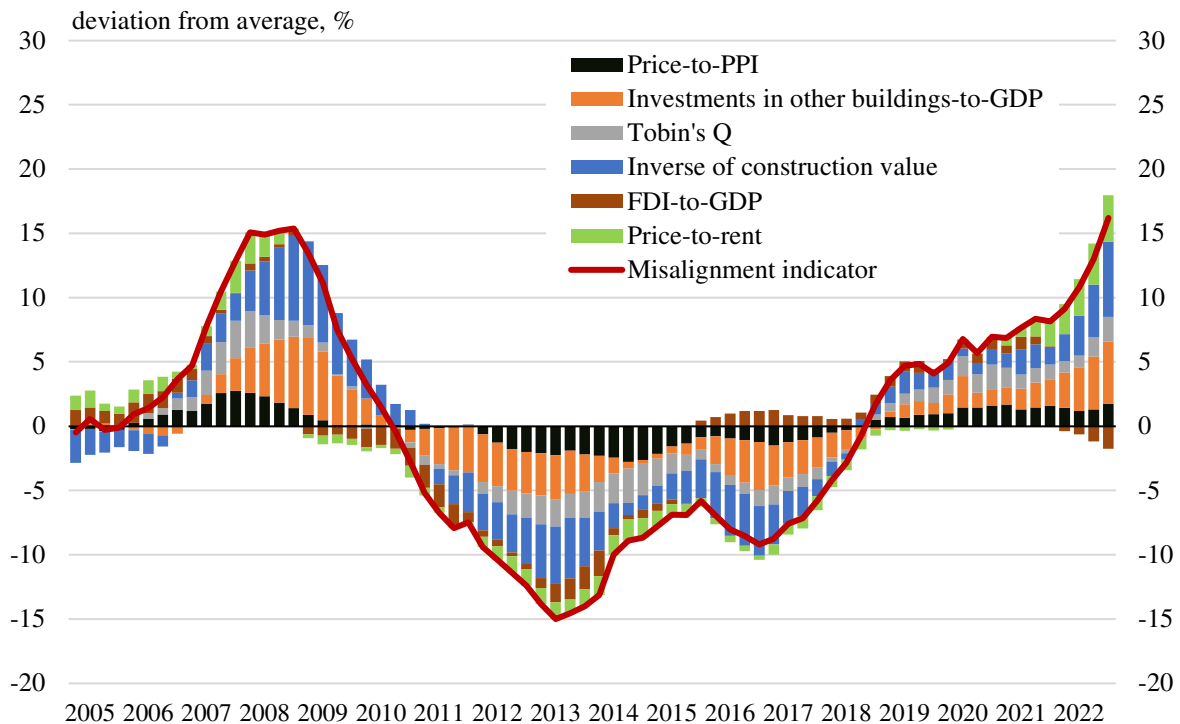*Figure 5: without price-to-hypothetical borrowing volume ratio*

Source: Own work.

Figure 6: without price-to-hypothetical borrowing volume ratio and price-to-GOS ratio
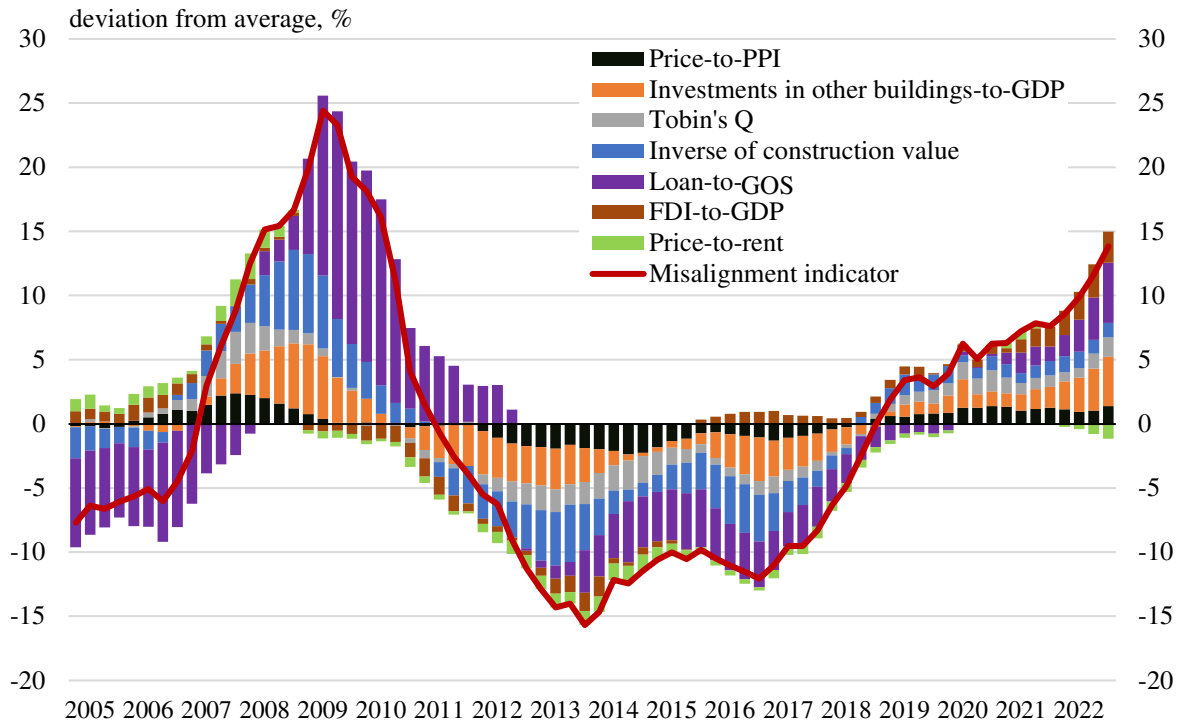
Source: Own work.

Figure 7: without price-to-hypothetical borrowing volume ratio, price-to-GOS ratio and loan-to-GOS ratio

Source: Own work.