Charles University

Faculty of Social Sciences
Institute of Economic Studies

MASTER'S THESIS

A forecast of Commercial Real Estate Development and Investment Volumes in the Czech Republic

Author: **Bc. Thanh Tu Nguyen**

Supervisor: **Tomáš Jandík, M.A., M.Sc.**

Academic Year: **2017/2018**

Declaration of Authorship

The author hereby declares that he/she compiled this thesis independently; using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, July 31st, 2018

Signature

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I dedicate this thesis to my beloved and greatest supporter, Jiří Pařízek, who has always been by my side and cheered me up along the way. I thank his family for their warm welcome and kindness whenever I miss my family back in Vietnam. Finally, I become the person I am today thanks to my inspiring and loving parents, who are now a quarter of the Earth away, whom I forever cherish.

Abstract

This thesis attempts to forecast investment volumes of the commercial real estate market in the Czech Republic in the medium-term from 2017 to 2020, using both qualitative methods and econometric models. Fundamental analysis and chart analysis are employed while judgemental forecasts by market experts are collected. In order to find evidence of historical and upcoming commercial asset price bubbles, a state-of-the-art peak-tagging technique and chart analysis for the graph of commercial real estate capital value index are used before integrating with market specialists' opinions. Neither CRE bubble nor signal for future major downturn has been found since 2000 despite the occurrence of minor overpricing periods. ARIMA and several VAR models with endogenous and exogenous variables are run to find the best quantitative forecasts. Final forecasted investment volume for the upcoming years is found by integrating experts' opinion and results from the chosen model.

JEL Classification	R33
Keywords	commercial real estate, investment, investment volumes, prime yields, office properties, shopping centres, industrial properties, Czech Republic

Author's e-mail	88176426@fsv.cuni.cz
Supervisor's e-mail	tomas.jandik@reicofunds.cz

Abstrakt

Tato diplomová práce předpovídá objem investic na trhu komerčních nemovitostí v České republice ve střednědobém horizontu 2017-2020 pomocí kvantitativních metod a ekonomických modelů. Při fundamentální analýze a analýze grafů byly zároveň shromážděny odborné předpovědi účastníků trhu. Pro hledání existence historických a budoucích bublin na trhu komerčních nemovitostí jsou nejprve použity nejmodernější metody hledání vrcholů a analýza grafů, stanoven index kapitálové hodnoty komerčních nemovitostí, a výsledky dále propojeny s názory expertů. Přes výskyt krátkých období přeceněných nemovitostí nebyla od roku 2000 nalezena na trhu komerčních nemovitosti ani bublina ani signál pro výrazný budoucí pokles trhu. Nejlepší kvantitativní předpovědi jsou hledány modely typu ARIMA a několika VAR modely s endogenními a exogenními proměnnými. Závěrečná předpověď investičních objemů pro následující roky je stanovena na základě výsledků testů a názorů expertů.

Klasifikace	R33
Klíčová slova	komerční nemovitosti, investice, investiční objemy, výnosy z prémiových nemovitostí, kancelářské budovy, nákupní střediska, logistické haly, Česká republika

E-mail autora	88176426@fsv.cuni.cz
E-mail vedoucího práce	tomas.jandik@reicofunds.cz

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Acronyms

AIC	**Akaike Information Criterion**
ARTN	**Association for Real Estate Market Development** (in Czech "Asociace pro rozvoj trhu nemovitostí")
BIC	**Bayesian Information Criterion**
CE	**Central Europe**
CEE	**Central and Eastern Europe**
CRE	**Commercial real estate** (or in its plural form "commercial real estates" depending on the context)
CZ	**the Czech Republic**
C&W	**Cushman & Wakefield**
ECB	**European Central Bank**
EUR	**Euro currency. In this paper, any amount of money quoted are in EUR if not stated otherwise.**
EWS	**Early Warning System,** referring to a research reviewed in this paper
FAVAR	**Factor-Augmented Vector AutoRegression**
JLL	**Jones Lang LaSalle**
LHS	**Left hand side**
PRIBOR	**Prague interbank offered rate**
Q	**Quarter**
q/q or q-o-q	**quarter on quarter**
RHS	**Right hand side**
RE	**Real estate** (or in its plural form "real estates" depending on the context)
REITs	**Real estate investment trusts**
VAR	**Vector AutoRegressive or Vector AutoRegression**

Master's Thesis Proposal

Author:	Bc. Thanh Tu Nguyen
Supervisor:	Tomáš Jandík, M.A., M.Sc.
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Proposed Topic:

Forecasting Commercial Real Estate Development and Investment Volumes in the Czech Republic

Motivation:

More than 5 years have passed since the deepest hit of the latest large-scale crises; and many economies worldwide, including the Czech Republic, have reversed the downturn. It is reported that the performance of the Czech real estate market recently surpassed their pre-crisis level. Particularly in the commercial real estate (hereinafter as *"CRE"*) segment, whose development generally trails closely to the macroeconomic situation (Brueggeman et al., 1989), the Czech market outperformed most of the CEE countries in the last 3 years. Indeed, investment volume has been increasing with positive growth rate, while prime yields' hardening trend is yet to stop and vacancy rates have dropped despite increasing supply. The EU's quantitative easing and other measures might contribute significantly to this, as borrowing rate is now at record low level.

Nonetheless, with the evidence of business cycle theory and the exposure to deflation risk in the Czech Republic, this fast growth spurs questions among scholars and experts: will the trend continue in the next some years or has it reached the local highest peak - are there any signs of future decline?

Due to the long-term nature and enormous amount of capital involved in each transaction, Brooks and Tsolacos (2010) recommended that both model-based approach and qualitative methods should be used in market projections to achieve high accuracy. In fact, there are numerous articles and research papers by private firms and other organisations employ judgemental and chartism forecast to predict the upcoming performance of the CRE market in the Czech Republic. In the absence of model-based research, this paper will be one of the first to address the topic combining both methods for the case of this country.

Hypotheses:

1. Hypothesis #1: The commercial RE market in Czech did not experience any price bubble, similar to the Czech housing market.
2. Hypothesis #2: The RE investment volume depends significantly on national macroeconomic factors, with negative correlation with (1) the change of 10-year government bond yields and (2) unemployment rate. Positive correlations are expected regarding (1) the change in interest rate spread, (2) logarithm of change in prime yield (specific to each CRE subsector) and (3) industrial production, (4) consumer spending, (5) GDP growth, (6) and inflation.
3. Hypothesis #3: In the next 3 years, the promising trend and positive growth will prevail according to both quantitative and model-based analyses.

Methodology:

Suggested by many researchers and evidence from UK market practice, particularly Brooks et al. (2010) a combination of judgemental method and model-based approach is recommended to perform any forecast regarding real estate due to is complexity and dependence on qualitative factors. All things considered, I will employ both qualitative and quantitative forecasting approach, and then perform forecast tests.

1. Qualitative method:
   - Chartism:
     - Pairwise historical movement graph
     - CRE investment market, even though comprises of mainly existing properties, also depend on the construction market. Construction of such large-scaled properties requires several years to complete and usually require financing and other decision-making in advance.
     - Consumer demand, investor mix, business cycle detection, macro-economic performance, trend analysis, building permits issued
     - Analysing and drawing information from the graph of the historical CRE investments in Czech and the CRECVI index (Commercial Real Estate Capital Value Index, developed by the research department of a leading agency Cushman & Wakefield Czech Republic). This index in its raw form are based on nominal values and not adjusted to varying risk-free rate, therefore I would like to solve this drawback.
   - Analysing other qualitative factors which are specific for Czech market: investors' sentiments toward investing in Czech over the years, current standpoint of Czech CRE market, long-term fundamental potential and current constraints in terms of planning permit issuance.
   - Judgemental: Summarizing market experts' forecasts and opinions, along with their explanations, based on official announcements such as periodical research papers, press releases, relevant publishing media. *"Market experts"* are the largest consultancy corporations, investors, banks and developers who are closely related to the Czech CRE market. I will assess briefly the possibility of these views being somehow biased, since most of them are businesspeople that prefer publishing positive views to spur their activities and boost the market as a matter of fact.

2. Quantitative method, or model-based approach:
   - At least one of the following two successful models will be calibrated:
     - An augmented random effect regression: this model identifies determinants of International Commercial Real Estate investment with a panel data of 47 countries around the world from 2004-2009 (Lieser et al., 2011). The working paper is very comprehensive with 66 data series proxied by 6 latent key drivers. Besides that, 22 main indicators for country-based time series estimator were pointed out, based on which I have a clear direction of how to choose relevant variables for the case of the Czech Republic. Interpretations on the results of "within" estimator will be particularly focused since they imply correlations within a country over time. 80% of data required are available for the Czech Republic in annual terms, which are assumed to be of enough amounts for calibration.
     - The Early Warning System prototype: written by a number of researchers at *Steering and Advisory Committees of the Shaping the Future of Real Estate*.

Even though the study is thorough with accurate result, most of the data types are typical for the USA which might not be available for the Czech Republic. After applying historical numbers for the case of Czech to each model, necessary tests will be run and then future estimated values will be used to calibrate.

- My model: VAR model is chosen due to its suitability for forecasting purpose. This method requires less information about explanatory variables when compared to structural models having simultaneous equations; and in fact the economic-political-social factors are dynamically interrelated. Impulse response, as a result of VAR, will be analysed and interpreted.
  - Stability issue: Detect stationary problem by unit root tests. To avoid this problem, differences or percentage changes are used. According to several literatures, annual changes (p=4, i.e. lag of 4 quarters) are proved to be suitable and better than first differences.
  - Lag length selection: either based on literature review or by statistical testing (where we set a null hypothesis, for example H0: p=4 and test it against the alternative H1 : p > 4; then asymptotic likelihood test will be construct and repeated until the optimal lag length is found).
  - Choice of variables: this is the most challenging part of VAR, 22 variables suggested by Lieser and Groh will be scrutinised to finalise the selection of variable set, with much consideration regarding the Czech market. The following are probably the most essential variables: changes in government 10Y bond yields, interest rate spread, logarithm of change in prime yield (specific to each CRE subsector), consumer spending, GDP growth, inflation, industrial production, and unemployment rate.
  - Ordering of variables: from the most exogenous variables to the most vulnerable variables.
- Prognosis analysis: using simple trend line analysis. In particular, data up to Q2 2016 (the start date of research) will be used for the models; then the trend line will be applied to find the future values; finally real data collected till Q1 2017 (the end date of research) will be used to cross-check the findings.
- Forecast tests: Loss function will be used. It measures the magnitude of forecast error which is resulted by subtracting actual values to forecast values. If necessary, revision of VAR model will be done.

Conclusion: sum up the results found from a number of aforementioned methods and draw suitable conclusion based on forecast tests.

Expected Contribution:

With a lack of academic papers performing model-based forecast on CRE investment market for the Czech Republic, this thesis aims at using econometric framework to address this topic from a different angle. Using key correlations between the CRE investments and macroeconomic indicators suggested by a number of literatures, along with assessing the interdependence of the developer market, the occupier market and the investment market, the forecast from this paper is expected to be more precise in terms of the magnitude of the CRE institutional investment volume in the near future, considering the performance of CEE property market as a whole.

Outline:

1. Introduction and Motivation
2. Thesis Objectives and Methodology

3. Theoretical Foundation (Literature review, main terms and definitions, the relations between CRE market and macroeconomic performance, forecasting techniques and the most recent findings)
4. Quantitative / charting forecasts (Supply, demand, investors, historical development of CRE investment)
5. Model-based forecasts (calibration of successful models, my VAR model, interpretations)
6. Forecast tests
7. Conclusion: comments on the findings and implications for future research

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Author **Supervisor**

1 Introduction

Nearly 10 years have passed since the deepest hit of the global financial crisis and the European debt crisis. Many economies worldwide including the Czech Republic have reversed the downturn. The real estate market performance of the country recently surpassed pre-crisis levels. Particularly in the commercial real estate (CRE) sector, the Czech market outperformed most of the CEE countries in the last few years in many aspects. Indeed, Czech CRE investment volume has been increasing with positive growth rate, while prime yields' hardening trend is yet to stop in some sectors and vacancy rates have dropped significantly despite an increasing supply. The EU's continuous quantitative easing, which led to a record low borrowing rate, is believed to contribute considerably to this. However, with the evidence of business cycle theory and the exposure to deflation risk in the Czech Republic between 2013 and 2016, this fast growth spurs questions among scholars and experts: will the upward trend in the property sector continue in the next few years, or has it reached the (local) highest peak - are there any signs of future decline?

Looking from a broader perspective, there have been several warnings regarding the end of the current global real estate cycle: in middle of December 2016 the U.S. Federal Reserve decided to raise its key interest rate for the second time in the last decade; enormous property value growth overtook the pre-crisis level in some locations, and international investor's appetite towards real estates has gradually dropping. Some fundamental indicators and property prices started to move in opposite directions across this country. Retail apocalypse phenomenon across North America have raised the red flag around the world about the effect of e-commerce. Buehler and Rodrigues de Almeida (Understanding the Commercial Real Estate Investment Ecosystem – An Early Warning System Prototype, 2016) stated: "The most destructive cycles were those in which asset price leverage and credits were intertwined, causing the greatest systemic effects. Asset pricing dynamics impact economies from the local to the global level."

On the other hand, numerous real estate specialists expressed their disagreement with the fear, assuring that the market is continuing its strong momentum with very favourable conditions for business to expand and no sign of bubble. For the CEE market in particular, investors' confidence has been strong, since many investors have considered it as a good alternative for assets in countries with growing uncertainty such

as the UK, evidenced by the fact that properties in this region attracts more attention after the Brexit vote.

Various researches have been implemented regularly to measure the current market sentiment and to forecast trends, mainly on rental levels, yields and vacancy rates. One of the most essential indicators of CRE market performance is the investment volume, which draws attentions of every market player. Forecasts for this indicator in CZ are nonetheless based mainly on speculations, experts' opinions or chartists' analyses. More thorough works are only performed in mature markets with rich time-series data such as the U.S. and the UK.

This thesis attempts to tackle the current disadvantages: the lack of model-based forecasts and the lack of long-term consistent data. Besides finding the direction of the movements, absolute amounts are also estimated to the extent that available data allow.

This paper comprises of seven parts. Section 2 describes the thesis objectives and detailed methodology. Theoretical background, including key definitions, forecasting methodologies and suggestions from literature reviews are in Section 3. Description and analyses of CRE market in the Czech Republic are in Section 4, including comments on proxies for CRE performance and pricing. Forecasts using qualitative approach are focused in Section 5, in which experts' opinion and official announcements of leading CRE companies are considered for reference. Detection of commercial real estate bubbles is also carried out in this part. After that, Section 6 concentrates on quantitative forecasts based on the author's own empirical models. The best model is chosen to produce model-based forecasts which are then integrated with judgemental forecast in Section 7. Finally, conclusion of the thesis is drawn in Section 8, along with overall outcome, final remarks as well as recommendations for future studies.

2 Objectives, Methodology, Hypotheses

2.1 Objectives

The aim of this paper is to forecast both direction and magnitude of the Czech commercial real estate investments in the medium term, annually up to 2020. As many CRE indicators are at a record high level, the paper also attempts to investigate potential turning points of the CRE capital market by identifying historical asset price bubbles and detect upcoming downturn signal. A generalised verifiable methodology is expected to be found for similar forecasts in the future and further for other CEE nations.

2.2 Hypotheses

Three key hypotheses of this thesis are as follow:

- Hypothesis #1: If the housing market in the Czech Republic experienced any asset price bubble in the past (i.e. from 2000 to date), the commercial real estate market would undergo the same situation.
- Hypothesis #2: The Czech CRE investment volumes have negative correlation with the change in price levels and the change in unemployment rates. Positive correlation is expected with regards to the change in ten-year government bond yields, the change in portfolio capital value index, the change in interest rate spread and the change in consumer spending.
- Hypothesis #3: From 2017 to 2020, positive growth in Czech CRE investment volume will prevail according to both quantitative and model-based analyses.

2.3 Methodology

Following suggestions of many researchers and previous forecast reports done in developed CRE markets, this paper is a mixed method research, in which both qualitative and quantitative measures are employed independently, followed by an integration process to obtain final outcome. As property values are at all-time high raising concerns about the emergence of a real estate bubble, a peak tagging process is carried out to identify cycle peaks and detect potential upcoming downturns. Detailed

explanation and reasonings for the selected methods can be found in sections 3.3 and 3.5.

2.3.1 Qualitative methods

Two major qualitative methods in real estate studies are chartism and judgemental forecasts, according to Brooks and Tsolacos (2010).

Forecast using charting techniques in a broader context are characterised by finding patterns from graphs of historical levels to project future trends. It is a commonplace method of technical analysts in security markets and is proved to be relatively useful where the market is highly volatile and cyclical. Similarly, charting is also widely utilised by real estate specialists, however with a careful consideration of some niche market knowledge and often non-disclosed information. Charting analyses in this context are considered as a qualitative method by Brooks and Tsolacos (2010) albeit being based on numerical data, because subjective speculation and human intervention in the forecasting process are common practices in real property sector. It differs from the pure time series analyses which utilise techniques such as moving average and linear prediction.

Using fundamental analysis and chart analysis, this thesis studies prime yields, prime rents, global and regional trends, market cycle detection, and recent macroeconomic performance. Additionally, the Czech CRECVI index (Commercial Real Estate Capital Value Index) is examined and compared to the NCREIF of the U.S. and the IPD index of the UK.

This paper also attempts to calibrate the successful Early Warning System published recently to detect the probability of potential downturn. Damage periods can be found, while market cycle peak can be identified. Although the lack of suitable data prevents the calibration of the econometric model suggested in the research (the third stage), market specialists' opinions are used instead to draw final conclusions.

It is undoubtedly indispensable to discuss other qualitative factors specific for the Czech market as well: investors' sentiments toward investing in this country over the years, current position of this market in comparison with neighbour CEE countries in particular and with European market in general, long-term potentials, expansion prospect, and current constraints in terms of legal aspect and planning permit issuance.

Judgemental forecasts are suggested to be of enormous significance (Brooks and Tsolacos, 2010). The following information is collected for reference: market experts'

forecasts and opinions, along with their justifications, based on official announcements such as periodical research papers, press releases and informal interviews. The potential bias underlying these views is briefly assessed, as one may question the conflict of interest borne by individuals who are directly involved in the capital market and benefitted from the positive messages conveyed in their press release.

2.3.2 Quantitative methods (model-based approach)

A number of models are established to forecast the Czech investment volumes, namely an ARIMA model and a VAR model.

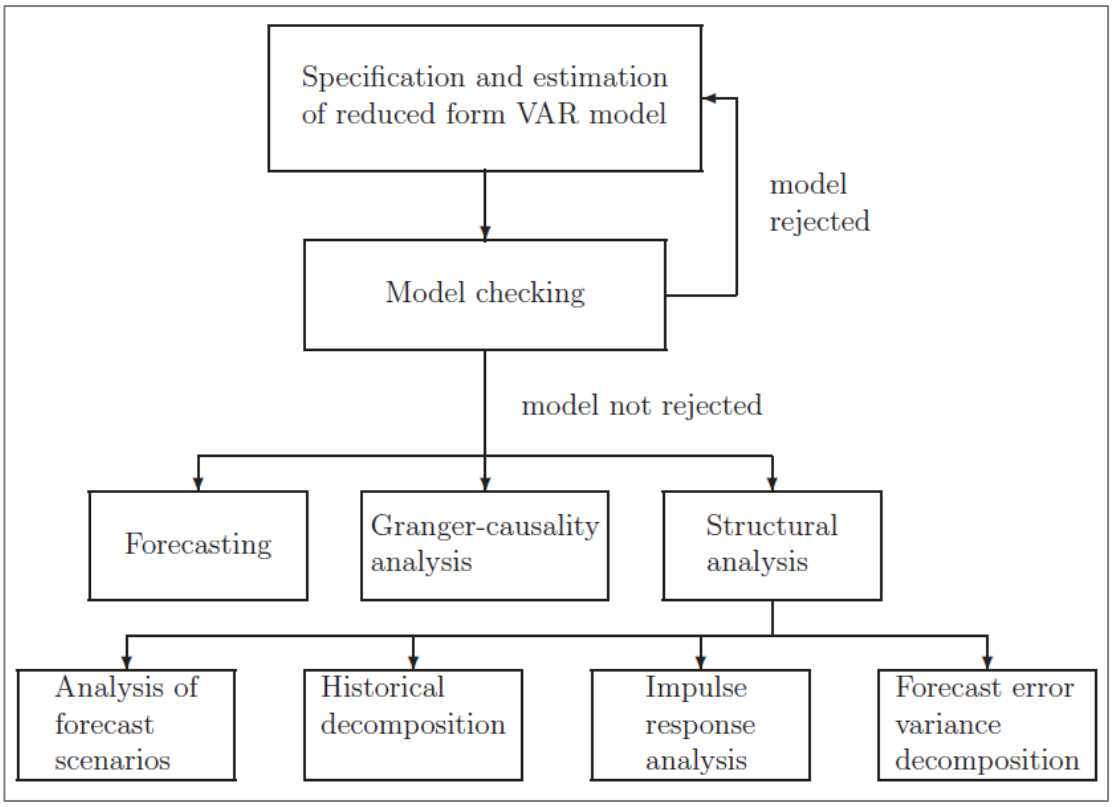
Autoregressive integrated moving average (**ARIMA) model** as a preliminary simple approach is to be carried out first. It examines interaction of the investment data with its lag values, which then enables out-of-sample prediction in a relatively straightforward way. Assumptions for disturbance terms of ARIMA are similar to other structural models, namely (1) being independent identically distributed random variables having normal distribution, zero mean and constant variance. For short-term data, univariate models or very simple multivariate models are able to produce lower errors than those by models with more than two variables according to Hyndman (Hyndman, 2014).

OLS (Ordinary least squares) model is used to test the second hypothesis regarding the direction of correlation between the macroeconomic/financial variables and the investment volumes.

Vector autoregressive (VAR) model is selected as the main model-based forecasting methodology in this paper due to its suitability for forecasting purposes and the fact that VAR model also provides insights about interaction between the investments and different market factors. VAR model is a generalization of an autoregressive model for a set of time series by allowing more than one evolving variables. Every endogenous variable has its own equation describing its evolution based on its lag values and the lags of the remaining variables. This method requires less information about explanatory variables and less strict conditions when compared to structural models with simultaneous equations. It takes into account the fact that different factors are dynamically interlinked. On top of that, it is an empirically verified tool for general forecasting as well as for models analysing shocks in monetary policies. Impulse response, as a result of VAR, will then be analysed and interpreted, which is an advantage in comparison with ARIMA models.

This paper follows the VAR analysis process by Luetkepohl (2011), which is illustrated in the diagram Figure 1:

Figure 1: A typical process of VAR analysis



Source: Luetkepohl, 2011.

As explained by Luetkepohl (2011), first and foremost, the reduced form model is estimated then checked against model deficiencies, which can be removed by amending the original model until all conditions are fulfilled. The author confirmed that as long as the model is found adequate, subsequent step such as forecasting, Granger-causality analysis and structural analysis can be carried out. Certain tests are then needed to help remove any model deficiencies. A few problems are commonly found in VAR analysis:

- Non-stationarity: non-stationarity of time series data can be detected by unit root tests. To tackle this problem, a certain level of adjustments such as differences and trend/cycle removal are helpful.

- Seasonality: this issue can be detected by periodogram and spectrum or F-test for seasonality. Gretl's X-12-ARIMA package is able to provide reliable F-test results and to generate seasonally-adjusted series in case seasonality is present.

- Lag length: lag length can be selected using statistical testing. The test is based on a null hypothesis, for instance H_0: p = 1, against its alternative, say H_1: p > 1; then asymptotic likelihood test is constructed and repeated until the optimal lag length is found. Alternatively, lag length can be chosen correspondingly to the characteristic and nature of the data under investigation.

- Choice of possible variables is the most challenging preparation step of VAR. 22 variables suggested by Lieser and Groh (2011) and other relevant factors will be checked to finalise the selection of variable set, with much consideration regarding the Czech market. The most essential variables besides lag values of investment volume variable are found to be: (1) private consumer spending, (2) inflation rate (3) unemployment rate, (4) interest rate spread, (5) 10-year government bond yields, and (6) portfolio CRECVI index. The number of variables applied in VAR models is ensured to be no more than the maximum recommended amount to avoid overfitting problem. The variables are then ordered from the most exogenous variables to the most endogenous variables.

There have been some attempts to use more advanced forecasting models such as factor-augmented VAR (FAVAR) and Bayesian VAR (BVAR). However, FAVAR was proven to be ineffective when applied on Czech economic data (Borys and Horvath, 2009), whereas BVAR is not necessary in this thesis since the chosen models will be designed to avoid the overfitting problem that BVAR aims to solve.

Best models among the above are then run to extract in-sample forecast points. These series are examined by OLS model to find the best-fitted one suitable for forecasting purpose.

2.3.3 Integration of different forecasts

Forecast estimates of chosen model are integrated with judgemental forecasts and other findings from fundamental analysis using the result combination methods suggested by Brooks et. al. (2010).

3 Theoretical Foundation

This section serves as the paving stone to the forecast techniques and chosen variables in this thesis. Literatures focusing on asset bubbles in CZ are also summarised and reviewed in order to assist the identification of historical and upcoming real estate bubbles in the country. Key terminologies in the commercial real estate sector present in this paper are also briefly defined.

3.1 Key definitions and overview

3.1.1 Key definitions

Commercial real estate refers to properties which are constructed and used for profit-making purposes, as opposed to residential real estate and properties for non-commercial public uses. The term "commercial real estate" mostly refers to three main categories, retail, office and industrial buildings, if not otherwise stated. Other types include hotels, healthcare buildings, leisure/cultural facilities and other specialised real estates. Large multifamily housing buildings might be classified as CRE in case its main purpose is to generate profit. In this paper, the term CRE refers only to the three main types, partially because the dataset collected for this paper contains only transactions of these categories.

Institutional real estates are high-quality and large-scaled commercial properties built or held for investment purposes. They are managed by professionals or a third-party company with substantial expertise on behalf of institutional investors as opposed to the case of owner-occupied properties. It is estimated by PwC that that total value of institutional-grade properties worldwide was USD 29 trillion in 2012, growing to USD 45.3 trillion in 2020 and USD 69 trillion in 2030 (PwC, 2016).

Institutional investments in this context are investments of institutional real estates.

The term ***investment volume*** in commercial real estate refers to the sum of concluded prices of all institutional transactions within a period, oftentimes a quarter or a year. It must be distinguished from the definition in other contexts, such as the security market, in which investment volume indicates the number of shares traded daily.

Downturns in dynamics of asset price are large decreases in CRE values (Steering and Advisory Committees of the Shaping the Future of Real Estate, 2016).

A ***commercial real estate bubble*** is broadly defined *"as an environment in which both actions (e.g. appraisals, valuations, and transactions) and perceptions (e.g. discounted cash flow projections) and actual prices become "detached" from market supply/demand fundamentals. Prices rise so sharply and at such a sustained rate that a sudden collapse is likely",* as explained by Steering and Advisory Committees of the Shaping the Future of Real Estate (2016) based on Financial Times's lexicon. This definition is in line with previous papers of researchers such as Stiglitz (1990), Case et. al. (2004) and Zemcik (2011). It is important to identify the start of the downturn, the so-called "peak", as coined by the Steering and Advisory Committees of the Shaping the Future of Real Estate (2016). The Committees stated a numerical and time-bound threshold to identify the peak: it is the period preceding a deep value plunge of 20% over two years, identified by a 20% increase in the gap between a capitalisation rate spread and a 10-year government bond yield.

A ***capitalisation rate***, abbreviated as ***cap rate***, or ***yield*** is the annual return on a real estate in percentage term. It can be calculated by dividing the income per annum of a property by its capital (appraisal) value or price paid for the asset by a willing purchaser. Gross income is used to calculate ***gross yield***, whilst net operating income (i.e. gross income less operational costs) gives ***net yield***. ***Net initial yield*** is the numbers that most investors are interested in as it reflects the cap rate of the property based on the net income as at the purchase date. Differently from the above yield types, a ***prime yield*** of a sector is an assumed all-risk yield applicable for the best properties of that sector. Yields would fall, or "harden", in a buoyant market and go up, or "soften" during downturns.

Cap rate spread is a generic term describing the difference between a particular cap rate and a benchmark rate. For example, it is defined as the result of transactional cap rates subtracted by ten-year U.S. treasury yields according to Steering and Advisory Committees of the Shaping the Future of Real Estate (2016). In this paper, applying the same principle, this term refers to the difference between prime yields published by Cushman & Wakefield and ten-year Czech government bond yield. More details regarding calculation of cap rate spreads can be found in section 5.2.

3.1.2 Real estate market and Commercial real estate market

The real estate market in general is sizeable, heterogeneous and highly competitive, characterised by imperfect information and economic cycles. It is estimated that the

global stock of all developed real estate in 2015 stood at USD 217 trillion in value (see Figure 2), including all types of properties such as commercial, residential, forestry and land according to a research by Savills (Savills, 2016). The total value accounts for around "60% of mainstream global assets" based on the report. According to Barnes, Savills's director of world research, "real estate is the pre-eminent asset class which will be most impacted by global monetary conditions and investment activity and which, in turn, has the power to most impact national and international economies" (Savills, 2016).

Figure 2: Global real estate stock as opposed to other stores of value

Asset*	Investable (trillions)	Non-investable (trillions)	All (trillions)
ALL REAL ESTATE	**$81**	**$136**	**$217**
RESIDENTIAL	$54	$108	$162
HIGH QUALITY, GLOBAL, COMMERCIAL	$19	$10	$29
AGRICULTURAL LAND	$8	$18	$26
OTHER INVESTMENTS	-	-	**$155**
EQUITIES	$55	-	$55
OUTSTANDING SECURITISED DEBT	$94	-	$94
ALL GOLD EVER MINED	-	-	$6
GLOBAL MAINSTREAM ASSET UNIVERSE	-	-	**$372**

Source: Savills, 2016

Commercial real estate, in particular, has a long-term nature and requires substantial investments. Its performance trails closely to the broader macroeconomic situation, especially supply and demand factors (Brueggeman and Fisher, 2011). Investments in commercial real estates are all backed by an ample stock of physical assets, which is believed to be worth approximately USD 29 trillion, equating to around 13% of global RE stock or approximately 4.8 times total gold value ever mined (Savills, 2016). CRE investments can be done directly via an "asset deal", i.e. acquisition of an asset or a portfolio of assets. Indirect investments, on the other hand, are done either via a "share deal", i.e. purchasing shares of special purpose vehicles which own the properties, or by buying shares of a real estate investment trusts similar to investing in mutual funds.

Undoubtedly, commercial real estate has played an indispensable role in every economy. Compared to other financial instruments and economic indicators, movements in real estate market are considered to be more volatile and have smoother noise (Brooks and Tsolacos, 2010).

3.2 Determinants of CRE investments; relation between CRE investments and macroeconomic indicators

An intensive research by Lieser and Groh (2011) attempts to find main drivers of international CRE investments and further to rank each nation's attractiveness of institutional real estate transactions. Employing augmented panel regression analysis for a broad range of data series of 47 nations for 10 years from 2000, the paper examines 6 latent determinants, from both economic standpoint such as (1) the national economy, (2) investment opportunity and (3) capital market development to social characteristics such as (4) legal framework, (5) administrative system and (6) socio-cultural/political environment. On an aggregated level, only variables 2, 3 and 5 are statistically significant to the international investment volume according to the "within" estimates, whereas the "between" estimates detect also the significance of variable 4. Surprisingly, social-cultural/political situation and economic activity are found to be less important determinants.

Insignificant impact of the economic performance on the CRE investments would be attributed to the aggregation effect and linear model's assumptions in the paper according to the authors. To alleviate these drawbacks, the authors carried out a sub-level regression with 6 variables, recording significant effects of economic size, GDP per capita, unemployment rate, inflation, and innovation index for "within" estimations. Nonetheless, real GDP growth, which is the 3-year geometrical average, was found to be of less noticeable impact to the institutional investments.

In order to assess the remaining factors, more than 20 data series have been retrieved from various sources such as World Economic Forum, World Bank and IMF by the author of this thesis based on suggestion of Lieser and Groh in their research (2011). However, the data series for the Czech Republic have missing data points and persistent stickiness over the years. Moreover, monthly or quarterly frequency of these series are not available, making these series insufficient and unsuitable to use as variables for the model-based forecast in this thesis.

Due to the above reasons, only economic factors are examined together with indicators of the CRE development in this thesis. Overall status of the country in which a commercial building is located is unquestionably important to its returns and attractiveness as an investment product (Brueggeman, Fisher & Stone, 1989). As pointed out for the case study of major U.S. cities, extremes in CRE prices can be influenced by "developments in a few macroeconomic indicators – inflation rates, bond yields, consumer confidence, employment – and to growth in the sector's net operating

income" (Loungani, a member of Steering and Advisory Committees of the Shaping the Future of Real Estate, 2016).

For office properties, one would always need to evaluate the historical vacancy rates, rental levels, white-collar employment rate, changes in space required per employee, new supply and net absorption. "The Commercial Property Prices in the Central European Countries" (Hlavacek et al., 2013 and 2014) focuses specifically on this submarket. The authors assessed that CEE's commercial real estate market is relatively underdeveloped compared to that of other European member states, commenting that higher volatility is accompanied by higher investment risk, thus implying riskier loans. It is proved in the paper that main determinants of office property prices are both demand and supply factors, for instance GDP, consumer prices, total stock of office spaces, and share of loans to GDP, to name just a few.

For retail assets, essential indicators affecting this subsector include consumers' spending confidence, change in real wage and new projects delivered to the market. It may take years from the time when signals of consumers' demand change are noticed to the moment when new retail spaces are constructed and then open for trading.

On the other hand, industrial is a relatively special subsector in which supply and demand moves more conjointly since many industrial parks and retail warehouses were build-to-suit properties which are constructed according to tenants' specifications and requirements. Developers and owners of industrial assets are much less diverse and more specialised. There are also more owner-occupied properties in this segment compared to other subsectors due to the nature of involved business activities. As a matter of fact, activities in the Czech industrial market have been driven mainly by penetration and expansion of multinational retail chains in the country (such as food retailers, DIY shops and furniture stores), relation with the German automotive industry, the availability of low-cost but skilled blue-collar workforce, national industrial production, and the recent boom of demand for e-commerce warehouses.

3.3 Forecasting techniques in CRE research

Researches on various topics of the commercial real estate sector have used both qualitative and quantitative methods. The former type bases on informed judgements and intuitive opinions of specialised practitioners. With this method, market researches on movements of supply/demand are extremely useful; signals and trends are identified based on business cycle patterns; and historical analogy might be considered. Naïve approach is relatively common, assuming that the following period's values would be the most recent observed figures adjusted for any seasonal effects and average

periodical changes. The latter type, quantitative forecasting methods, focuses heavily on numerical data as inputs for analyses and econometric regression models.

3.3.1 Qualitative methods

Qualitative forecasts are done for various commercial real estate indicators. One of the simplest and straightforward techniques is to use Microsoft Excel's trendline function and moving average, which for instance can forecast rent growth based on movements of occupancy levels, assuming a strong relation between the two factors based on economic intuition (Brueggeman and Fisher, 2011). Another intuitive prediction of future rents could be done using the inflation-based adjustment, i.e. assuming a proportional increase in rents given a certain change in consumer price indices (Brueggeman and Fisher, 2011).

In the Central and Eastern Europe in particular, expert practitioners' forecasts have been carried out in a relatively simple manner without the use of statistical models and advanced techniques. Based on informal discussions of the author with several investment specialists active in the Czech Republic, most predictions are said to use one or some of the following measures: (1) chart analyses, (2) estimation of ongoing negotiations and subjective opinion on their success rate, (3) adjusting previous forecasts after observing trend in recent quarters, and (4) pure speculation. It is partially owing to a number of unavoidable disadvantages observed in a less mature environment, for example limited statistical databases, confidentiality issue, and the tendency to smooth fluctuations in property valuations from which many data are congregated. Consistency of the databases is also compromised because methodology of collecting and adjusting data have been revised from time to time.

In CZ, a number of periodical forecasts for both rental and capital markets have been published by some private firms and organisations. Common topics include total transaction volumes, share of transactions in each subsector, rental and yield outlook, and expected vacancy rates. Investment volumes of commercial real estate are forecasted in depth by the global real estate consultancy CBRE in its Real Estate Market Outlook and by the Association for Real Estate Market Development (ARTN) in its annual Trend Report, to name just a few. These reports are summarised later in this paper.

Expert predictions are often perceived as a good reference point by various market players. It is undeniable that behind these publications are prestigious professionals having access to real-time updates on ongoing negotiations and expectation of key financial providers. These market experts benefit from continuous communication with

prospective investors and vendors, the most up-to-date information regarding market newcomers and exclusive access to confidential databases.

Nonetheless, the above forecasts are for reference purposes only and no organisation would assure the accuracy of their published forecasts. One might doubt the reliability of such announcement given no thorough methodology being disclosed, together with an unavoidable bias, i.e. conflict of interest, in favour of positive news for the year ahead. Brooks and Tsolacos (2010) pointed out 7 highly possible issues with experts' judgemental forecasting, namely (1) exaggerating impacts of short-term market noise, (2) anchoring on the most recent events, (3) double-counting concurrent effects of similar economic indicators, (4) experts' overconfidence in the information they possess, (5) inconsistent opinions from different experts, (6) higher probability to provide bias forecasts compared to statistical models, and (7) "domineering and opinionated individuals" imposing stronger weight on their views against others' in periodic forecast review sessions.

3.3.2 Quantitative methods

The most relevant research to be reviewed is Zelenka's rigorous thesis, "Real Estate Cycle in the Czech Republic and Office Capitalization Rate Forecasts" (Zelenka, 2011). It forecasted successfully prime office yields in CZ. Firstly, previous yield trends in mature markets, namely the UK, Sweden and Ireland, are compared to yield trend of the Czech office market. The study then uses OLS to examine the relation between the variable in question and other macroeconomic-financial variables so as to find suitable variables for subsequent VAR models. The paper utilises both ARIMA model and a set of VAR models of up to 5 variables on comparable countries. R^2 is the criterion to select the best model variants, which are employed for finding medium-term forecasts for the Czech office yields. Forecast improvements then follow, in which published forecasts of macroeconomic variables are used as exogeneous variables in the revised model. The author expected a slight drop of office yields in 2011-2014, ranging between 5.75% and 6.25%. In reality, according to market report of Cushman and Wakefield and other leading real estate firms, prime office yields of 6.50% in Q1 2011 did decline to 6.25% in Q2 2011 and then remained unchanged until the end of 2014, which was within the range predicted previously by the author.

For the last 10 years, more modern models have been applied in forecasting research, yet they were found ineffective for Czech data. For instance, Borys and Horvarth (2009) concluded that the factor-augmented vector autoregressive model (or FAVAR) "does not appear to properly capture the developments in the Czech economy" and that

"the results based on FAVAR are very sensitive and the confidence intervals for the impulse responses are rather large". Bayesian VAR (BVAR) is another advanced technique proven to be superior to basic VAR models in terms of forecasting economic variables in CZ (Valeriu Nalban, 2015) by solving problems of over-parameterization. However, over-parameterisation is purposefully avoided in this thesis; therefore, this technique is not necessary.

3.3.3 Integrating qualitative forecasts and quantitative forecasts

It is imperative to produce final forecast result after examining outcomes from both branches of methods above. Even for studies targeting mature markets where data series are ample and relatively consistent, it is still necessary to apply expert judgements to solidify forecasting outcome, as evidenced for example in the case study for the United Kingdom by Gallimore et. al. in 2004 as reviewed by Brooks and Tsolacos (2010). The research further points out that (1) the more mature the market is, the less opinion-based adjustments are needed; (2) modification seems to be applied more in case a structural break or "turning point" is detected; (3) most forecasts usually provide similar results to each other (i.e. "herd behaviour") (Papastamos et al. 2015) and (4) there is a noticeable sign of forecasters' tendency to avoid extreme projections.

Brook and Tsolacos (2010) suggested 7 approaches to intervene quantitative forecasts using experts' judgements:

(i) choosing the most appropriate model(s) – at the input stage

(ii) choosing the most relevant variables – at the input stage

(iii) adjusting forecasted results from the chosen model(s) – at the output stage

(iv) altering observations, adding future expected values to amend outcomes – at the input and/or output stage

(v) altering coefficients calculated by the model(s), such as the constant term – at the output stage

(vi) integrating results from different forecasting methods, such as applying different weights on different model(s) and judgemental forecasts to reflect the expected importance and accuracy according to the expert's opinion

(vii) altering some first forecasting values in case they are considered as known facts, such as ongoing trend and soon completed plans.

Among the above, the first two ways of intervention are helpful in building the right model with the right set of variables. The remaining ones are done in the output stage where outcome from the models conflicts considerably to expectations of market experts, especially in terms of direction. The most common output intervention is via approaches (iii) and (vi), whilst approach (vii) is also commonplace when initial forecast values can be determined relatively well such as total completion of construction works in the short run (Brooks and Tsolacos, 2010).

The authors suggested 3 ways to incorporate qualitative forecasts and quantitative forecasts for approaches (iii) and (vi):

a) adjusting econometric forecasts mechanically

b) combining results from two branches of forecasts which are built separately

c) holding a forecast mediation forum

For the objective of this thesis, (b) is the best of three possible solutions suggested by Brooks and Tsolacos (2010) since the other two require direct and extensive involvement of market experts, which is conflicting with the nature of this paper as an independent master's thesis. Furthermore, given the fact that the author has collected final forecasting outcome from major consulting firms in CZ and ARTN, the result combination method is sufficient.

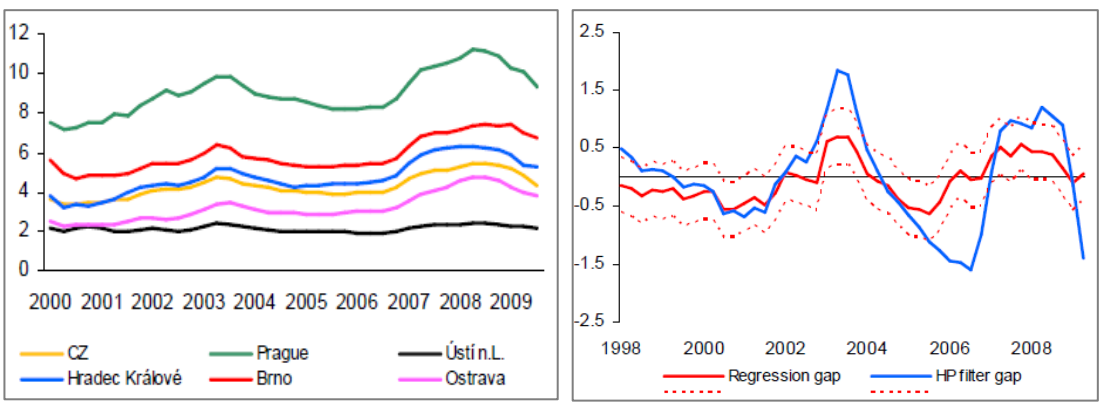
3.4 Researches on asset price bubbles in the Czech Republic

There are much more researches on Czech residential real estate price bubbles than the commercial counterparts. Given the lack for studies on CRE crises, it would be reasonable to derive implications from existing papers researching on housing bubbles. It might be reasonable to assume that both the sectors would undergo price bubbles during similar periods as commercial and residential property markets are proven to be closely related, both by supply/demand theory and from studies for the U.S. RE market. According to Gyourko (2009) for instance, the rate of price appreciation, the long-term horizon of real estate market cycle, and periods of booms and busts were recorded to be similar in the two sectors. It was also found by Lieser and Groh (2010) that commercial real estate market is considerably influenced by the housing counterpart.

A number of researches on the Czech housing market were carried out in the context of global crises in the last two decades. Although there were different opinions, it is concluded by the majority of studies that in the 2000s there exists signs of small residential real estate bubbles without catastrophic consequences.

Some of the most cited ones are working papers published by the Czech National Bank including "Housing price bubble analysis – Case of the Czech Republic" (Cadil, 2009) and "Housing Price Bubbles and their Determinants in the Czech Republic and its Regions" (Hlavacek et. al., 2009. In both studies, the residential sector in CZ was found to have closer relation to demand movements than that to the supply side, even though both researches warn against relying fully on their results by cause of low goodness-of-fit (R^2) and unavoidable disadvantages of short-term data, respectively. All authors defined the bubble as the period when prices deviate considerably from the intrinsic true value backed by fundamental factors (Cadil, 2009 and Hlavacek et. al., 2009), the same as the descriptions found in other sources as noted in section 3.1. The former paper, with the use of price to income ratio (P/I) as a detecting tool on a 32-observation dataset, provides an inconclusive answer to the question of bubble identification, pointing out only some alarming signals. On the contrary, the second paper, which was published 11 months later, found two periods of housing bubbles by employing both basic indicators (price to income and price to rent ratios) and a 46-observation time series regression model. In particular, the P/I chart were derived together with a regression price gap chart (Figure 3), indicating two price bubbles in 2002/2003 and in 2007/2008. They credited the first one to the speculation prior to CZ's official membership in the EU, and attributed a part of the second one to the contemporary downturn of socio-economic factors.

Figure 3: Charts of P/I (LHS) and Regression apartment price gap (RHS)



Source: Hlavacek and Komarek, 2009

Notes: P/I is the ratios of a representative 68 m^2 apartment's price on Czech average wage (prices for 2008 and 2009 are estimated); Regression price gap is the difference between actual prices and the author's estimated equilibrium prices (overvaluation = positive gap, undervaluation = negative gap)

A later study by Zemcik (2011) employs panel data unit root tests and a present-value models, detecting overpricing in relation to future cashflows. Even though some evidence of overvaluation was found, the author confirmed that the magnitude of the

bubble is relatively small and thus would not bust into large-scale crisis as in the case of the U.S.

As such, one would expect some overpricing or bubble periods in the Czech commercial real estate market during similar periods. This paper attempts to test this hypothesis in section 5.2.

3.5 A recent study of Early Warning System for CRE crash

The research of an early warning system was recently published by Steering and Advisory Committees of the Shaping the Future of Real Estate for a number of office properties in prime U.S. metropolitans (2016), predicting when an asset price bubble would burst of CRE market. One of the paper's goals is to detect signals of upcoming sudden downturns in each city. Three stages of the detection process are summarised as follow.

The first step is to find an appropriate series representing asset values for identifying CRE price peaks. Drawbacks of appraisal cap rates are eliminated by finding transaction cap rate. A regression model was built with appraisal yields on local level, appraisal yields on national level, the gaps between ten-year U.S. Treasury constant maturity yields and two-year U.S. Treasury constant maturity yields, and 2-year constant maturity yields, resulting in high quality estimates (Steering and Advisory Committees of the Shaping the Future of Real Estate, 2016).

Second, a "peak tagging" process starts with finding cap rate spreads, which are calculated by subtracting 10-year treasury yields from the above transaction cap rates. The data is adjusted for (high) inflation in case it causes negative cap rate spreads. It is then necessary to tag the so-called "damage periods", which is defined as "a point where commercial cap rate spreads increase more than 20% from minimum values over two years" (Steering and Advisory Committees of the Shaping the Future of Real Estate, 2016). The 20% threshold for the original series equates to 6% for the adjusted series. Among periods which have zero drawdown values (i.e. the zero values among the data points calculated for the damage periods), the last period is tagged as a peak.

The last step is to build a risk model which can identify risks of downturn. A special model created only for prediction of regional CRE crash was established in the paper, combining Logit/Probit model and Hazard model into a Hybrid model having all desired characteristics of the original two. The following variables are used in the research (in the significance order): change in national CPI, change in 10-year treasury rates, change in 2-year treasury yield, consumer confidence, growth rates of implied

net operating income (NOI), and change in local white-collar employment rate. Output of the model provides probability of CRE downturn for a specific time. The model successfully detected 5 major downturns between 1978 and 2014 for 10 sample markets; for instant, it forecasted the 2007 bubble burst “with substantial accuracy” (Steering and Advisory Committees of the Shaping the Future of Real Estate, 2016).

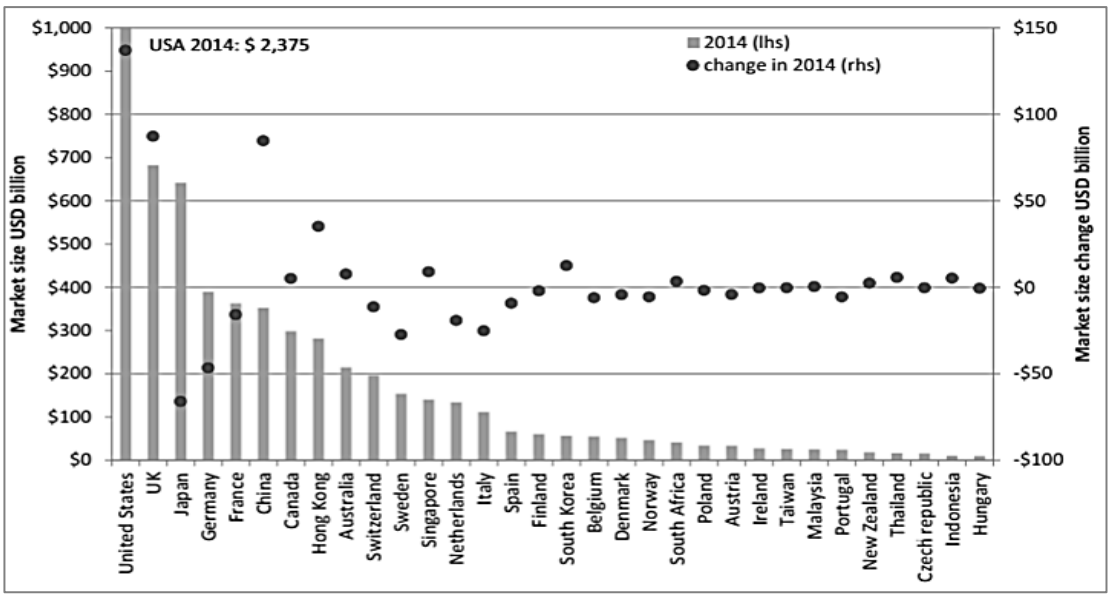
4 The Czech CRE market

4.1 Brief history, market size, capital market

The modern CRE market of the country dated back to the first half of the 1990s and mainly in the capital Prague. Office and retail commenced their modern era with the first new administrative buildings opened in mid-1990s (Drtina et. al., 2014), Vinohradsky Pavilon shopping mall in 1994 and Myslbek shopping mall in 1996. The industrial market commenced its strong presence around 2005 when many industrial parks and warehouses were newly built. Thanks to the fast-growing economy and the freedom of trade and ownership after the fall of communism, coupled with participation in the EU in early 2000s, the country soon established a strong foothold in the European real estate market.

Regarding market size, according to the Real Estate Transparency Index 2016 report (JLL, 2016), the Czech CRE market is relatively small, standing at the 53rd position in 2016 among 109 nations in question. The total Czech CRE stock for investment in 2014 was estimated to amount to approximately US$ 15.7 billion (Teuben and Clacy-Jones, 2015, illustrated in Figure 4), or roughly 8.8% of national GDP.

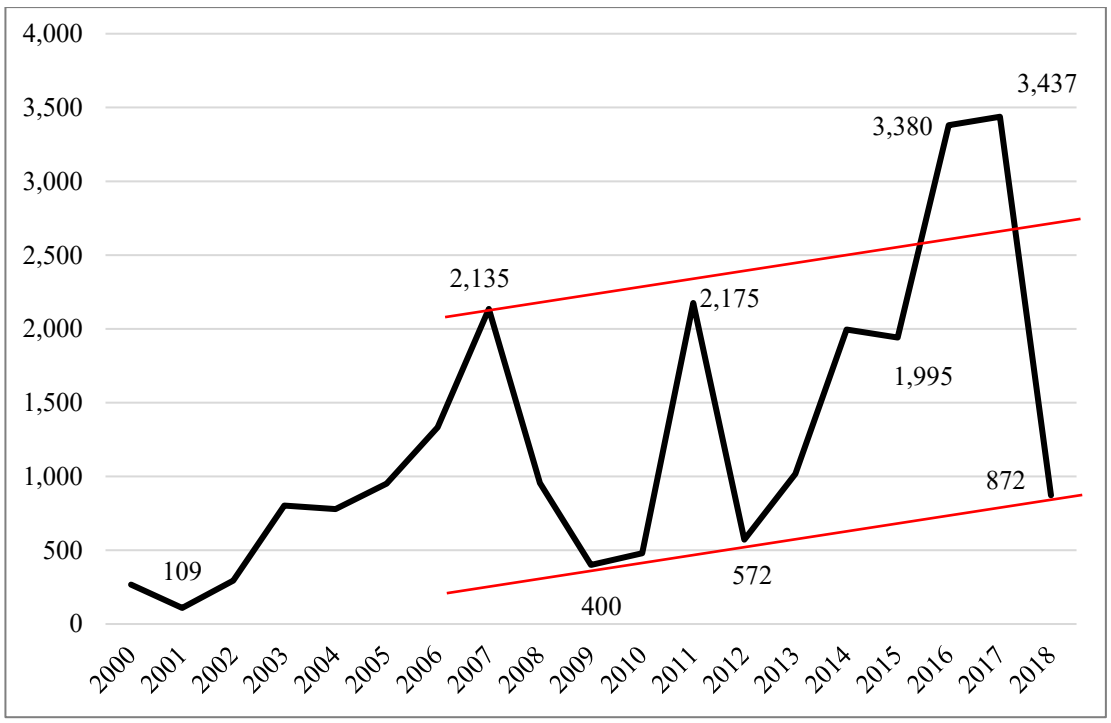
Figure 4: Absolute market size, 2014



Source: original graph of Teuben and Clacy-Jones, 2015 (MSCI Inc.).

Figure 5 demonstrates the evolution of institutional transaction volumes in CZ since 2000. During the first few years, the annual volumes were very low perhaps due to the low stock of institutional-grade products, the less advanced method of data collection by agencies, and the less advantageous investing environment in the country. In 2007 the total volume crossed the EUR 2 billion level for the first time. In 2011 the record was surpassed again albeit by a minimal margin. Main reasons for this surge include the wait-and-see strategy of investors in the previous years (Lonie, 2017), investment backlogs and positive impact of the ECB's intensive monetary policies in 2010-2011.

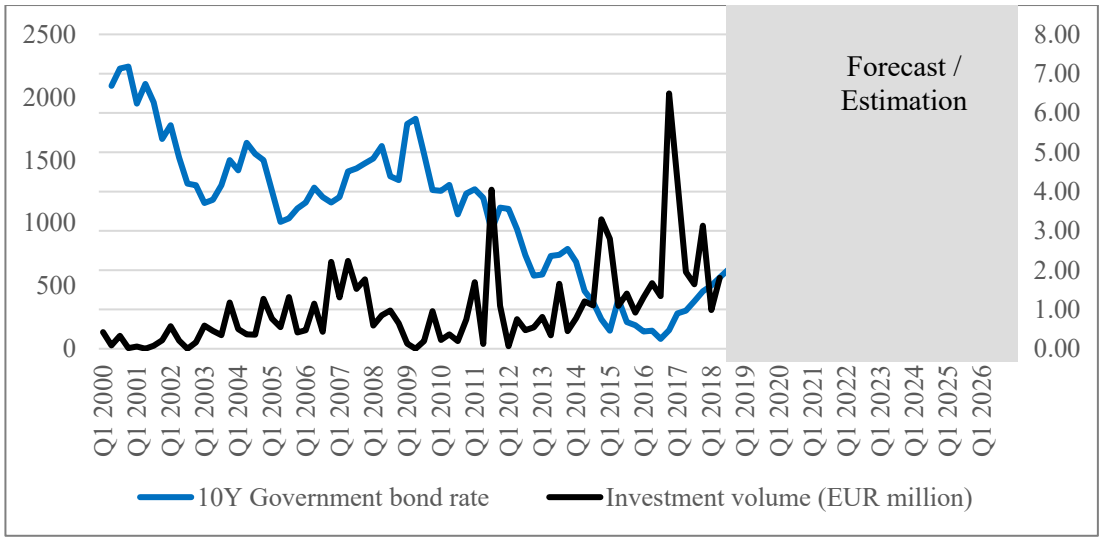
Figure 5: Investment volumes in CZ (€ million), annual, 2000-2017



Source: Cushman & Wakefield.

The record of 2011 was then crossed in 2016, when for the first time the total transaction volume surpassed the EUR 3 billion milestone. The soar was attributed to the ECB's massive quantitative easing since early 2015 and several interest rate cuts since 2012, which have driven all types of loan rates down and encouraged banks to lend money. Record-low interest rates, including ECB's negative deposit rate, have maintained a frenzy across the EU for the past few years. In CZ, directly effects of ECB's policy is reflected clearly in the 10-year government bond yields, as depicted in Figure 6. The growing momentum of the Czech CRE investment continued throughout 2017, making 2017 become the most active year in history. As the ECB announced in June 2018 that it will terminate the quantitative easing measures by the end of the year, impact of this act on the capital market for upcoming years is assessed in section 6.3.

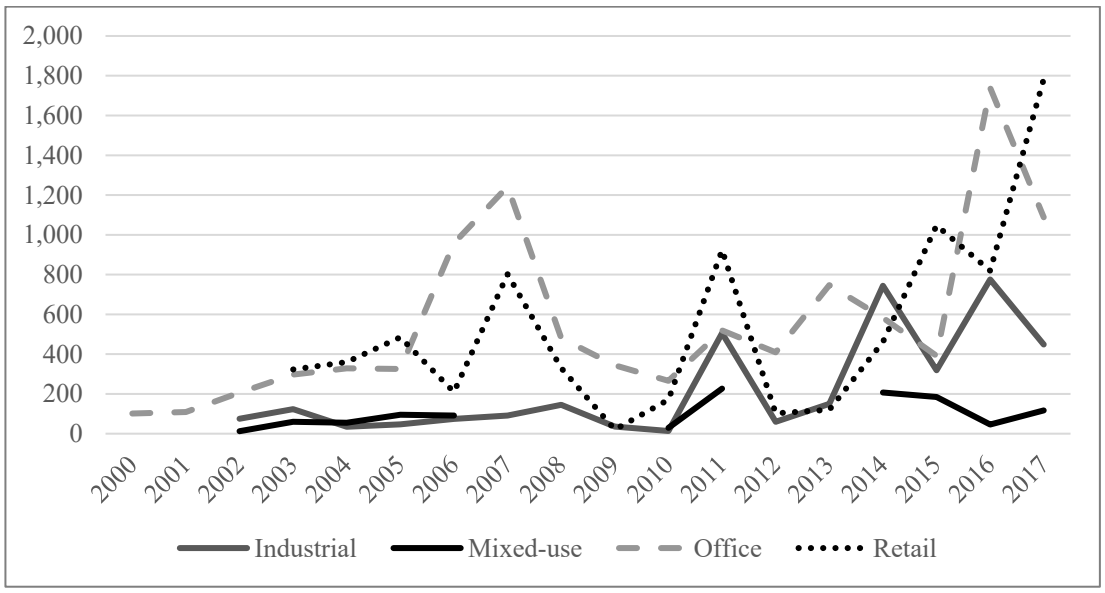
Figure 6: Total investment volume and 10-year government bond yield



Source: Cushman & Wakefield, forecast by Oxford Economics.

Breaking down by property types, it is clear that office and retail have been the most traded subsectors (Figure 7), being the main contributors behind well-performing years. Hikes in investment volume are seen in all subsectors, the most prominent ones being seen in retail.

Figure 7: Transaction volume by sector



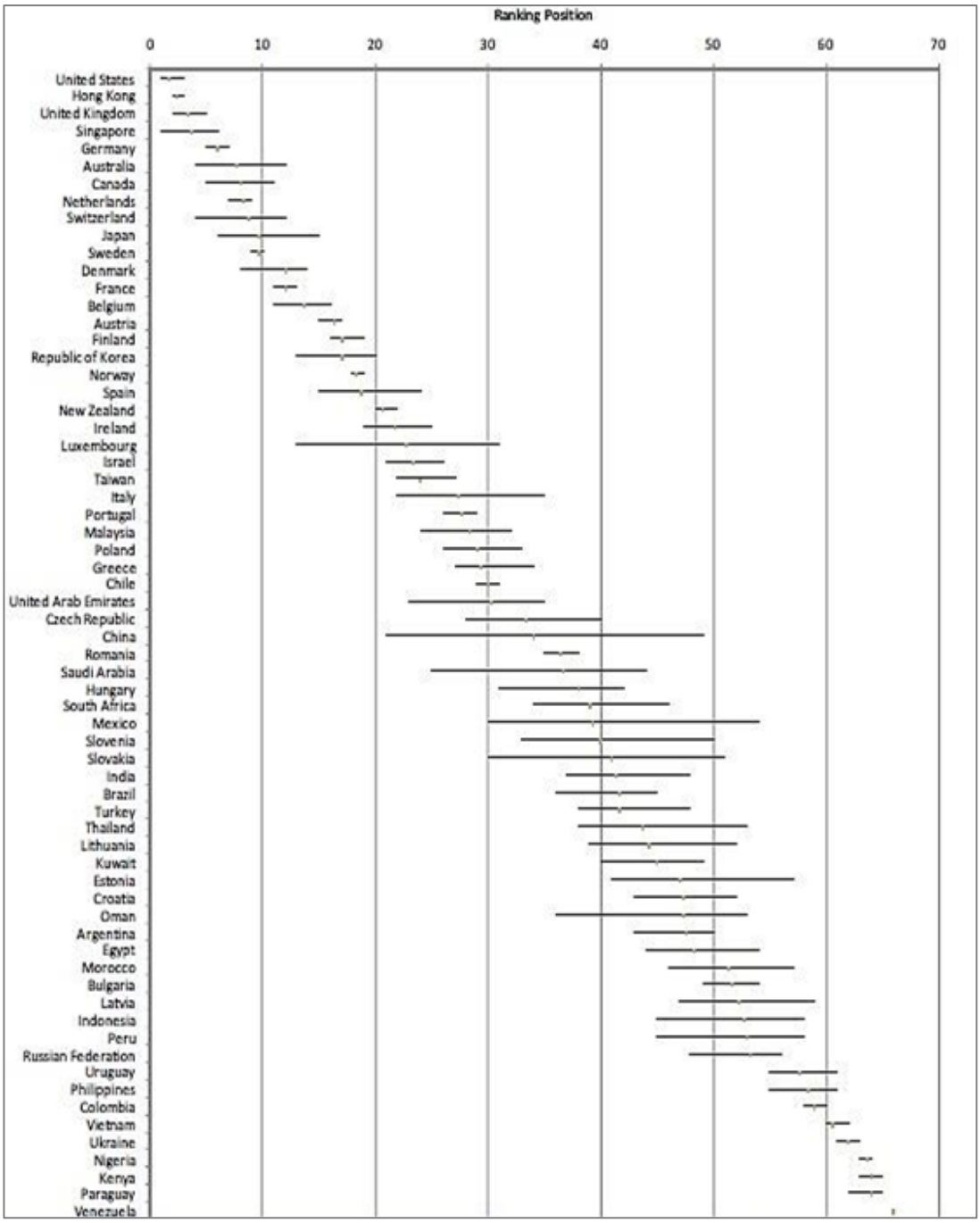
Source: Cushman & Wakefield.

4.2 Attractiveness for institutional investments

Within the investment sphere, CZ ranked around the 33rd position according to a composite index of international investment attractiveness among 66 countries

worldwide, identified by Lieser and Groh (2010). Sensitivity analysis was carried out, affirming its mid-range position between the 28th and 40th place, as can be seen in the following Figure 8 (Lieser and Groh, 2010).

Figure 8: Ranking of institutional RE markets' attractiveness, 2009-2010

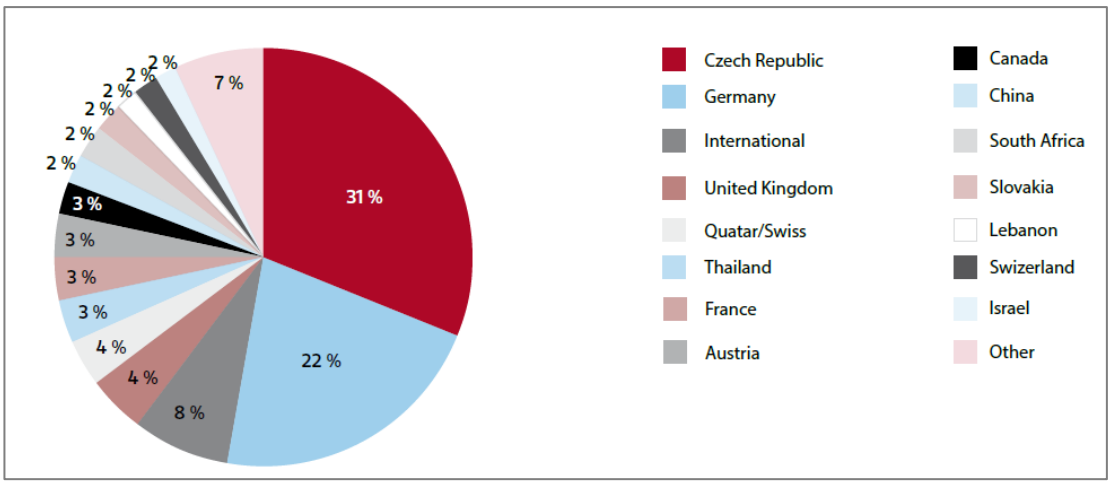


Source: original graph of Lieser and Groh (2010).

Another characteristic of the Czech market is that the vast proportion of acquisitions in the country is attributed to overseas investors, ranging from around 75% to more than 90% between 2006 and 2017 (Cushman & Wakefield, quarterly data from 2000).

This would imply that investors in the Czech CRE market are slightly less prone to domestic shocks. In 2015, the largest investors by nationality are entities from the U.S. and Germany, together accounted for more than 50% of total traded volume (Cushman & Wakefield, quarterly data from 2000). Similar to other CEE nations, the dominance of overseas investors is a persistent fact, whilst for a broader understanding it is important to note that a RE global leader such as the UK has roughly a 50-50 ratio, for instance only 43% of transaction amount were purchased by foreign buyers in 2016 (Colliers International, 2017). In 2017, domestic investors' share reached 31% as shown in Figure 9 (ARTN, Trend Report 2018).

Figure 9: Investment transactions by source of capital, 2017

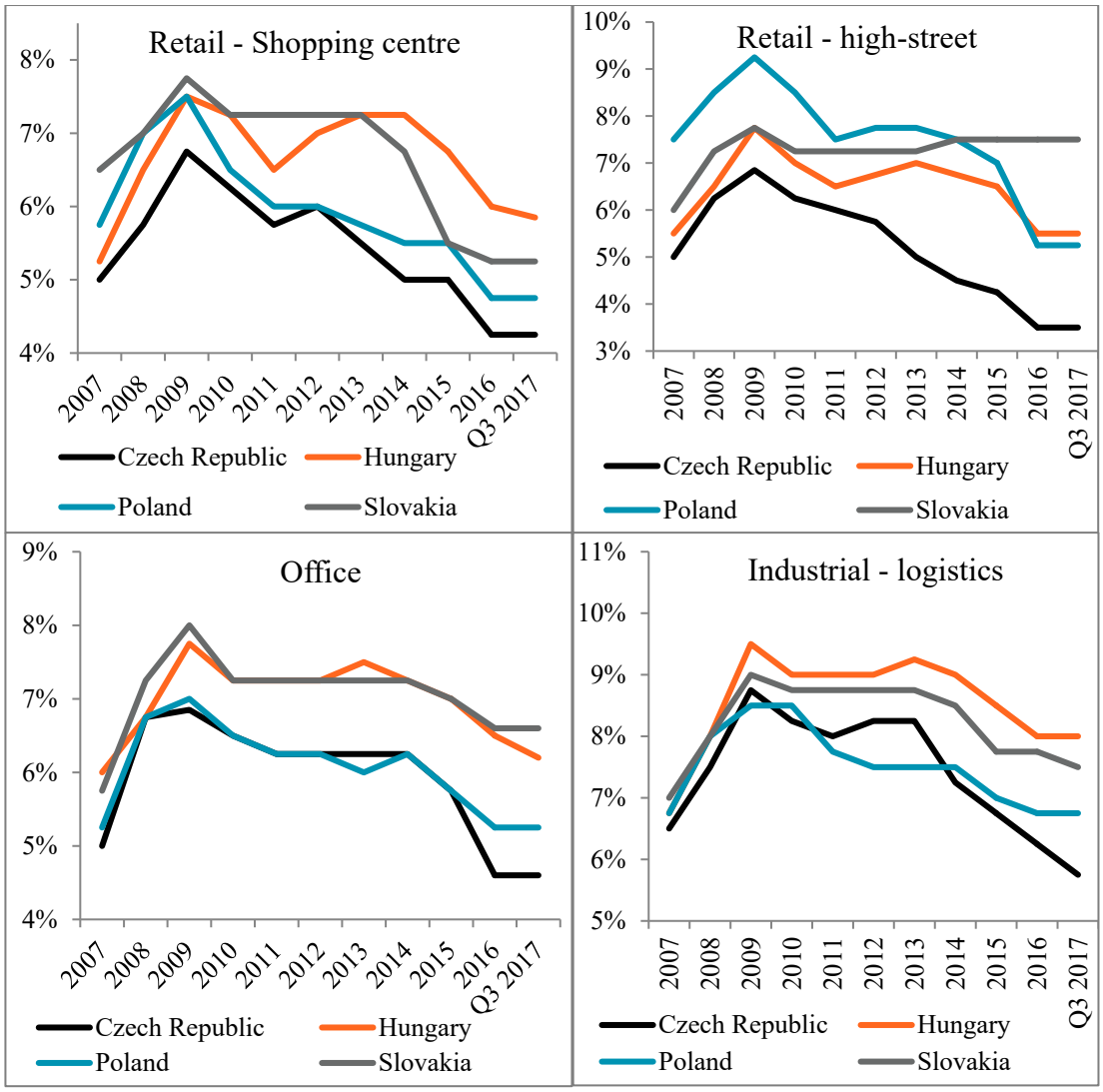


Source: ARTN, Trend Report 2018 (primary source: BNP Paribas Real Estate).

4.3 Prime rents and prime yields

Prime yields of all subsectors in CZ have strengthened throughout the years, surpassing the levels recorded before the outbreak of the global crisis. Compared to other CEE nations (Figure 10), prime yields in the Czech Republic have maintained a higher position than those in Poland, Slovakia and Hungary for the majority of periods. High-street retail, the strongest subsector of CZ, have noticeably outperformed other CEE countries in terms of prime yields. The convergence of Czech yields towards levels in more mature markets is visible across all subsectors.

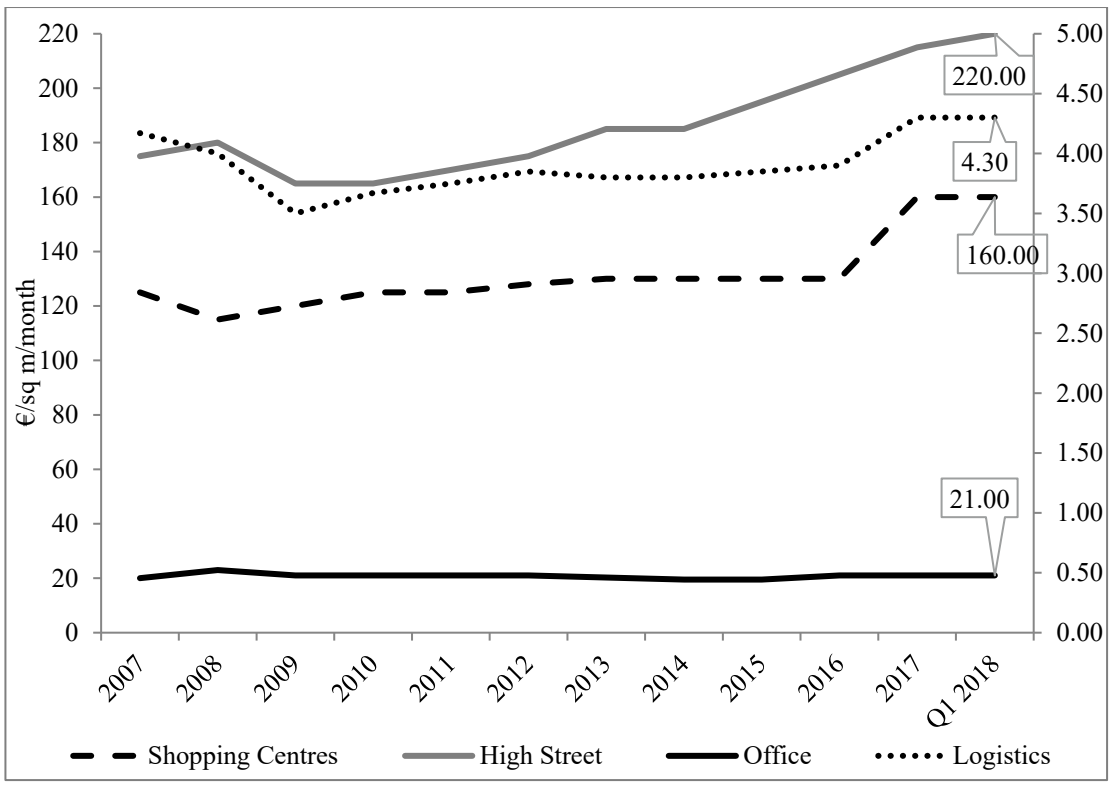
Figure 10: Prime yields of CZ and other CEE countries



Source: Cushman & Wakefield.

Regarding rental levels, increase in prime rents occurred for all subsectors in the last 10 years (Figure 11). The most significant improvements were seen for shopping centre and high street retail, the numbers in Q1 2018 is 28% and 26% higher than those in 2007, respectively. Industrial (logistics) rents are the most stable, having changed very slightly over the last decade.

Figure 11: Movements of prime rents in CZ

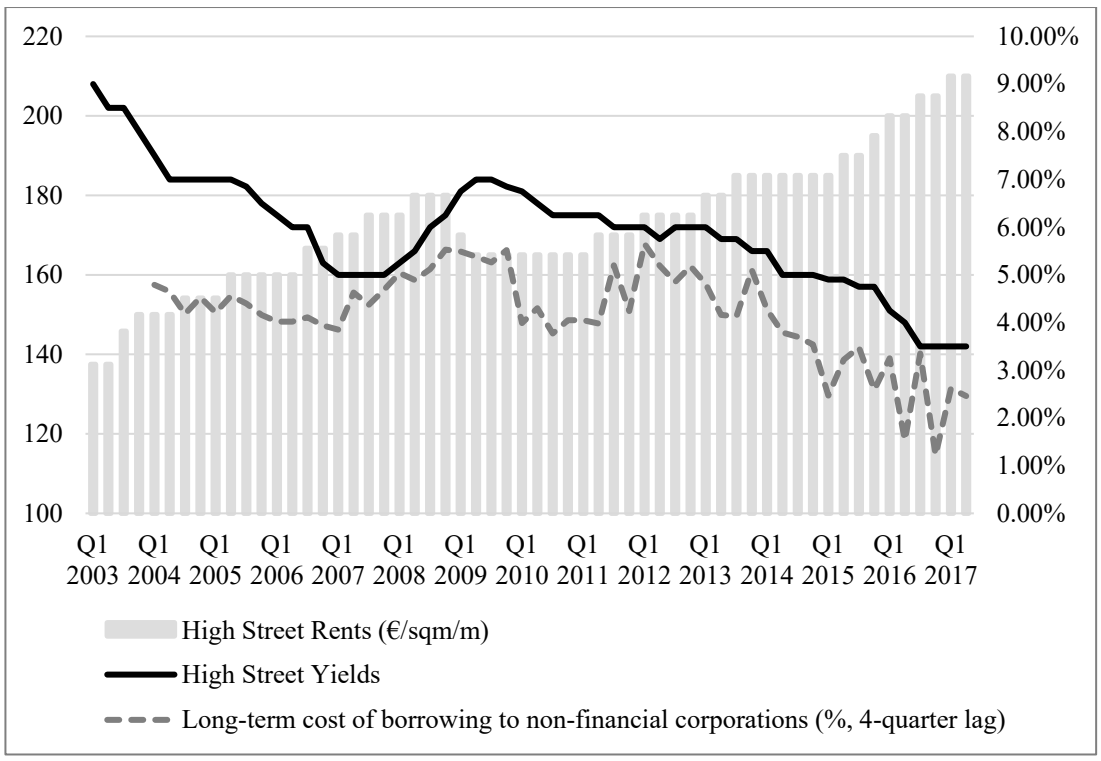


Source: Cushman & Wakefield.

Note: Shopping centre, High Street and Office on LHS; Logistics on RHS.

As one of the best performing subsector in the Czech RE market, high street retail subsector would be a good representation of the enormous potential that the emerging country is having. The graph below (Figure 12) demonstrates historical development of prime high-street yields and rents and long-term interest rates. It is noticeable that high street yields have been contracting over time, from 9% in 2013 and crossing the 5% threshold in 2007 to 3.50% in 2016-2017. Prime yields generally move in conjunction with the long-term lending rate with a 4-quarter lag. Yields were always higher than the costs of borrowing throughout the entire period. Gaps between the two rates were wider during economic expansion, while being the closest around the peak of the 2007 crisis and at the height of European sovereign crisis (2012/2013) when the ECB's extensive support measures started. For the most recent 6 years, high-street prime yields have followed more closely to the fluctuation of interest rates.

Figure 12: Rents, Yields and Interest Rates – high-street retail



Source: Cushman & Wakefield, Czech National Bank.

4.4 Proxies for CRE market performance and pricing in CZ

4.4.1 Investment volume as proxy for CRE market performance

Owing to a relatively young free-floating property market, a lack of long-run historical and comprehensive data for CZ is unavoidable. Together with macroeconomic indicators published by the Czech National Bank, a number of datasets created and/or gathered by a unified consistent methodology dated back to around 2003-2004 by multinational agencies. Finding reliable proxies for the Czech CRE market performance and property pricing for a sufficiently long period is one of the challenges of this research.

In a mature market such as the U.S., a handful of options are present. Some of the common candidates for long-term proxies are indices of real estate investment trusts (FTSE Nareit U.S. Real Estate Index, FTSE Nareit PureProperty Index, FTSE EPRA/NAREIT Global Real Estate Index) since REITs usually have a relatively high proportion of commercial asset class within their portfolios, while the data are real-time, accurate and sufficiently available for a relatively long period. NCREIF Property Index (NPI, or National Council of Real Estate Investment Fiduciaries Property Index) is also famous for its power in representing the movement of the U.S. commercial

property market, since it is a "quarterly, unleveraged composite total return for private commercial real estate properties", comprising of retail, office, industrial, apartment, and hotel assets, dated since 1977. While NPI is based on appraisal values, NTBI (NCREIF Transaction Based Index) includes transacted prices of non-hotel NCREIF properties sold in given periods, which is more accurate thanks to real market evidence, yet compared to NPI it is anecdotal and does not cover the entire market. The Czech Republic has neither a system nor an organisation centralising such extensive database.

Another source to look at is MSCI, which is an independent research provider, having been generating a number of indices to integrate global-scale CRE datasets of both public and private segments. It further attempts to create a benchmark for market players and meanwhile to increase the transparency of the worldwide CRE market as a whole. One series worth mentioning is IPD Property Fund index, which contains annual data on asset value and return in Europe, the UK, the U.S. and Australia on national, regional and global levels. The company has gathered data of total return, income return, capital growth, rental growth and yields of the Czech Republic since 2004 for all three main subsectors. Nevertheless, data sources are from less than 20 funds owning some hundreds of properties in the country, a negligible proportion to qualify as a good representative for the entire nation's CRE market.

With the lack of generalised indices and a central data gatherer, CRE investment volume time series of a private global agency would be the best replacement. Its best advantages in comparison with IPD index is its length and scale of coverage: a time series from 2000 to 2016 gives 68 quarterly observations, whilst the database only records all deals transacted for at least EUR 5 million nationwide.

One may doubt the accuracy of the aforementioned transaction database knowing the fact that non-disclosure agreements have always been prevalent in almost all transactions in CZ in order to prevent agencies sharing details of the deals they get involved. It is true that the dataset available for this research is collected solely by Cushman & Wakefield and it may in no way confirm 100% correctness. Nonetheless, there are several convincing reasons that this source is acceptable for the purpose of this study. Firstly, this company has got an extensive exposure to the market to produce relatively close estimates regarding transaction prices years before the starting period studied in this research. Secondly, thanks to its provision of full-fledged services to the majority of prominent clients, even when the company did not involve directly in a property sale, it would have been familiar with the property via previous property management services or a valuation services, for instance. Thirdly, Cushman & Wakefield as of today benefits from combined data sources from its merged entity,

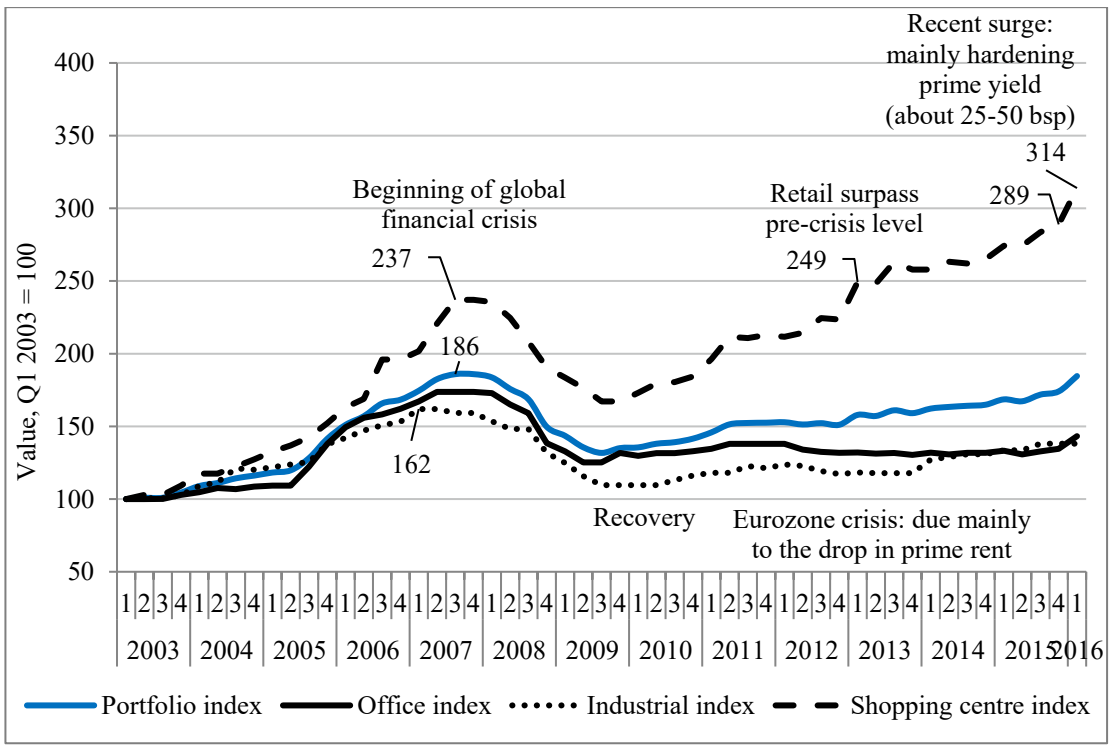
DTZ in 2015. Finally, the database of C&W was recently refreshed thanks to a new research forum opened recently by major real estate brokerage firms in the Czech Republic. The forum encourages information sharing; and gradually it aims at creating a common higher quality database for research purposes similar to that of mature markets, which will lead to a more transparent market.

All things considered, for the time being, this dataset is the best proxy available for CRE market performance in CZ.

4.4.2 CRECVI as commercial real estate price index

Czech Commercial Real Estate Capital Value Index (hereinafter "Czech CRECVI" or "Czech CRECVI index") is a new tool to understand CRE investments, illustrated in Figure 13. It was developed by Sotak (2015) for a 13-year period from 2003 to mid-2015, with the first quarter of 2003 being the base period. Different from NCREIF Property Index of the U.S. and IPD Property Fund index of the UK, this is an index of capital value instead of an index of property return.

Figure 13: Czech CRECVI index (Q1 2003 = 100)

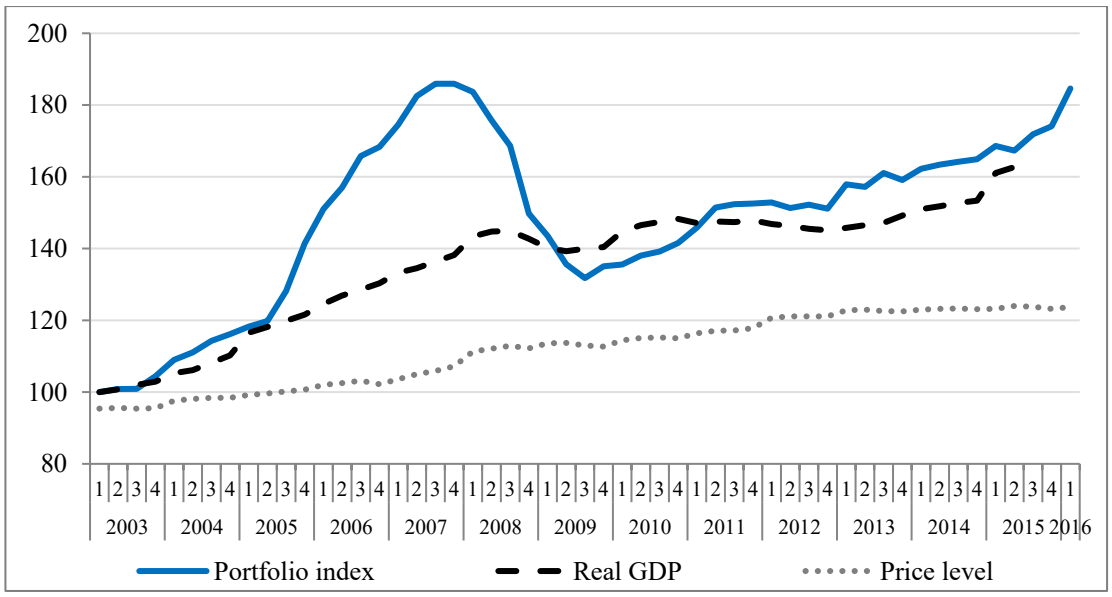


Source: Sotak (2015); author's series extension and commentary.

It is demonstrated in Figure 14 and Figure 15 that portfolio CRECVI has higher volatility than both real GDP index and price levels, while it trailed very closely to the movement of the UK's IPD property fund index. CRECVI significantly surpassed GDP

around the global financial crisis period, but followed GDP closely during other time. It outperformed the price levels throughout the years, most dramatically before the crisis, and since mid-2009 it still outperformed the changes in inflation. Additionally, the CRECVI index only surpassed the UK's IPD during the global crisis 2007-2009, perhaps due to the fact that the UK's economy suffered more severely from the crisis than the Czech one did.

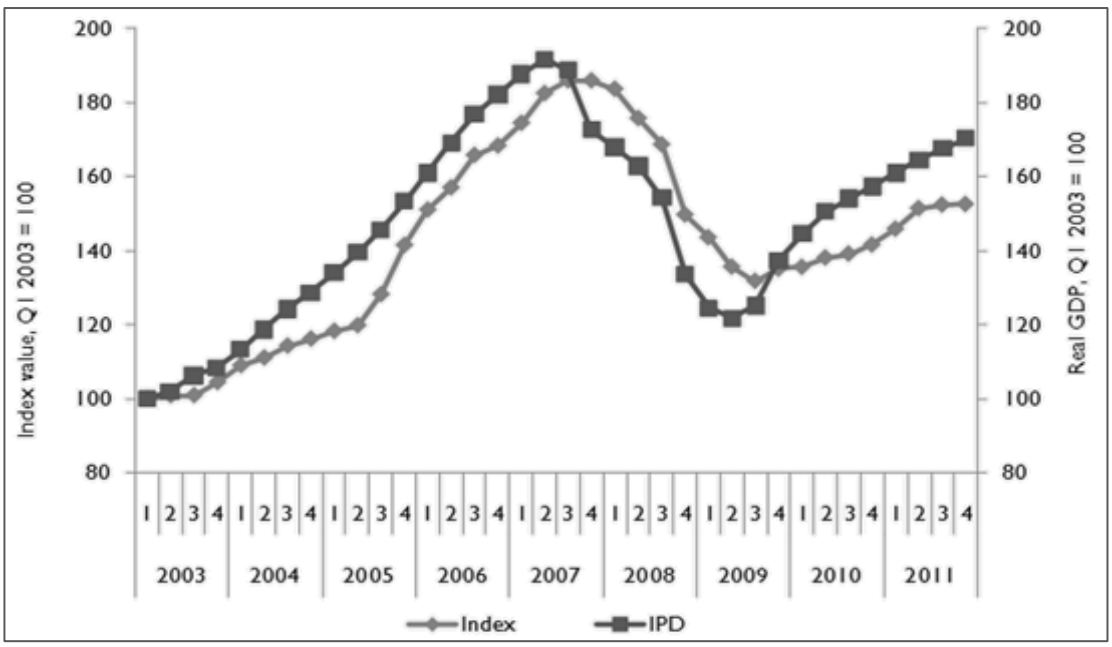
Figure 14: Portfolio CRECVI, real GDP index and price level



Source: Sotak (2015); author's series extension.

Notes: Portfolio CRECVI index and real GDP index has a base quarter, Q1 2003 = 100. Price level (inflation) has a base year, 2005 = 100.

Figure 15: Portfolio CRECVI (LHS) and the UK's IPD (RHS) (Q1 2003 = 100)



Source: original graph of Sotak (2015), MSCI Inc.

The index is a "theoretical" composite capital value per square metre of a representative portfolio, which is explained in detailed as follows. For the purpose of this study, CRECVI is rebuilt completely to have data from 2000 to 2016. First, from the market database of Cushman & Wakefield, quarterly data of prime yields and prime rents per square metre are used to calculate a prime value per square metre for each chosen prime asset (or group of assets) in each subsector (retail, office and industrial). Then an asset's index is found before calculating the sectoral index. Formulas are as below:

$$\text{Prime value per sq m of a prime asset} = \frac{\text{(Prime) Rent per sq m of the asset}}{\text{(Prime) Yield of the asset}}$$

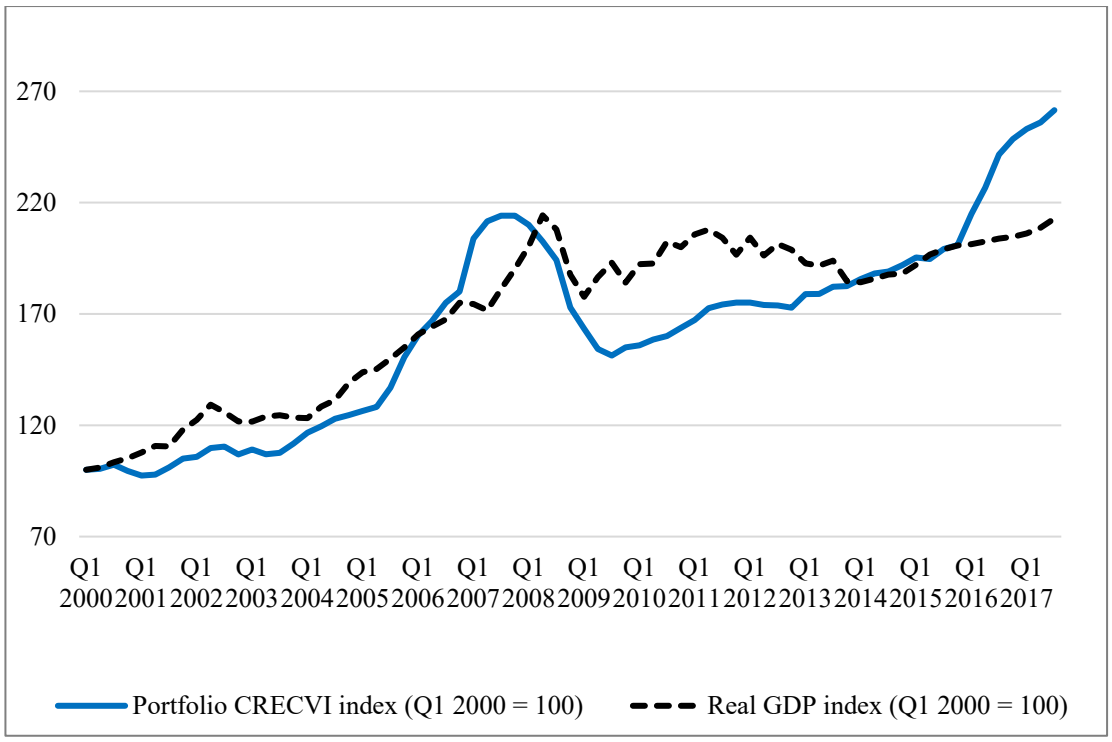
$$\text{(Prime) Asset index} = \frac{\text{(Prime) Value per sq m of an asset in a Respective quarter}}{\text{(Prime) Value per sq m of an asset in the Base Quarter}}$$

"Sectoral index" = Arithmetic average of asset indices in that sector.

From Q1 2000 to Q3 2002, a "representative/weighted portfolio" is assumed to comprise of 50% office, 40% industrial and 10% retail in terms of value. The retail weight during this period contains high-street indices only to the lack of shopping centre yield data. From Q4 2002 to Q4 2016, with the availability of shopping centre yields, the portfolio index has 50% weight of office, 25% industrial, and 25% retail (with 20% shopping centre and 5% highstreets) based on assumptions of Sotak (2015). CRECVI portfolio index (hereinafter also "portfolio index") for the Czech Republic is

established, representing a proxy of the movement of CRE prices over time. Figure 16 illustrates the CRECVI development compared to real GDP index.

Figure 16: Portfolio CRECVI index (LHS) and real GDP (RHS)



Source: Oxford Economics, Sotak (2015), author's time series reconstruction.

Note: Base period of portfolio CRECVI index is Q1 2000. Real GDP index is calculated based on absolute amount of Real GDP in € billion after converting real GDP in CZK (using end-of-period exchange rate).

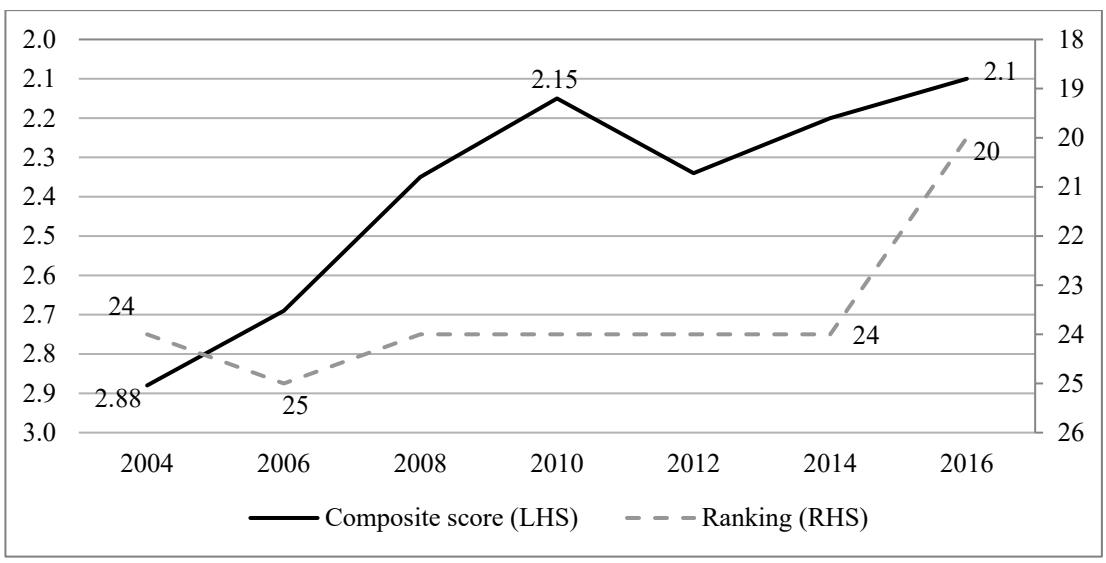
The portfolio index has no adjustment to a varying risk-free rate, which is suitable for this study since risk-free rate is added to regression models separately (in this thesis it is the time series of 10-year government bond yields). The index is also ungeared, meaning no lending option or interest rate is taken into account. Due to the fact that prime yields and prime rents used for this index's generation process are subjective opinion of Cushman & Wakefield in each period, this index is classified as a theoretical index. Notwithstanding, Figure 19 in section 5.2.1 in this paper shows that prime yields reported by international agencies trail very closely to the transacted yields, proving that the prime yields used for calculating this index are sufficient estimate of prime market cap rates.

4.5 Transparency of the Czech CRE market

Being an emerging market with enormous potential, the Czech property market has shown a significant improvement in its transparency level in terms of both world

ranking and its composite score since 2004 according to Jones Lang LaSalle's Global Real Estate Transparency Index biennially reports (JLL, Real Estate Transparency Index, 2004-2016). According to the Figure 17, it is undoubted that the nation's transparency scores have shortened the distance towards the top tiers over the years, in line with the upward movement in position from the 24th place in 2004 to the 20th in 2016. Whilst Slovakia and Romania just reached the "transparent" tier in 2016, CZ has stayed in this group 8 years in advance, alongside Poland. Standing at the mid-point of the transparent tier and outperforming even Norway and Luxembourg, CZ has maintained its second-best stance among CEE nations. It is important to note that this index is considering not only traditional commercial real estate but also other subsectors such as residential and hotel products.

Figure 17: Real estate transparency index, Czech Republic, 2004-2016



Source: Jones Lang LaSalle, 2004-2016.

5 Qualitative-based forecasts

5.1 Global and regional CRE market outlook

It is predicted by PwC (2016) that an enormous growth of institutional-grade real estate stock will be witness worldwide, with an increase of more than 50% from 2012 to 2020 and from 2020 to 2030. Emerging markets would see the largest stock expansion together with more opportunities in terms of risks, returns and a soar of construction projects (PwC, 2016). Strengthening competition for prime products are expected due to new creation of wealth in emerging nations, resulting in more investments and constructions of high-risk types of assets, whilst potential from ever-evolving technology and sustainability requirements (PwC, 2016). Government's role in RE markets would become more crucial with regards to, for instant, urban planning and infrastructure in fast-growing economies according to PwC (2016). The international consulting firm also warned against new threats such as climate change and political risks (PwC, 2016). As an emerging nation, CZ would embrace these medium and long-term trends to narrow the gap with established RE markets. It is thus expected that investment volumes in the Czech CRE would follow a long-term upward movement.

On a regional scale, most European economies are predicted to intensify their positive economic growth in both 2018 and 2019, according to CBRE's 2018 Europe Real Estate Market Outlook 2018 (CBRE, 2018 Europe Outlook, 2017). Property prices might be influenced by an increase in long-term lending rates expected to be announced by a number of governments (CBRE, 2018 Europe outlook, 2017). In office market, white-collar employment would remain stable or improve further in 2018, while flexible spaces will be on higher demand (CBRE, 2018 Europe outlook, 2017). European logistic available stock which has been swiftly taken up thanks to soaring demand will become scarcer because of even stronger rise in e-commerce related demand, leading to potential rent uplifts (CBRE, 2018 Europe outlook, 2017). For retail, prime rents are also predicted to climb as retailers are aiming at setting the right concept for their properties (CBRE, 2018 Europe outlook, 2017). The report further states that the vast majority of main European RE markets are coming closer to the full investment capacity, excluding France and UK's stable growth potential (CBRE, 2018 Europe outlook, 2017). Higher amount of global capital will be invested in the European RE markets (CBRE, 2018 Europe outlook, 2017). Secondary yields are predicted to compress whereas prime yields will be likely to reach a plateau in 2018;

and at the same time lending rates are forecasted to remain at the current low levels (CBRE, 2018 Europe outlook, 2017).

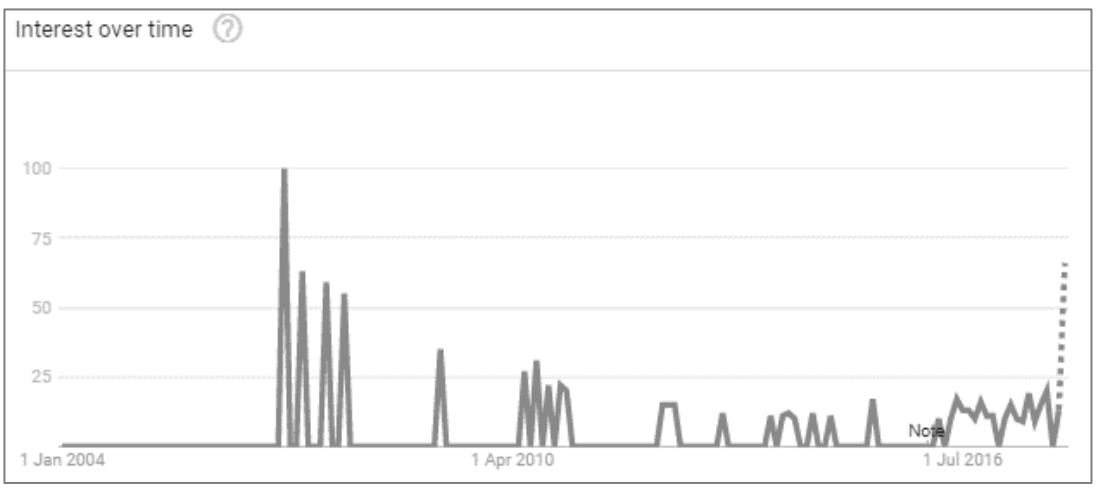
CEE region seems to have the most positive outlook by CBRE. The highest growth potential of GDP over a 5-year span is expected in this region (CBRE, 2018 Europe Outlook, 2017). CEE countries have seen record high investment activities in both 2016 and 2017.

The above papers suggest that investment in the Czech Republic would generally increase over time, yet in the medium term some decreases are expected.

5.2 Detection of historical and upcoming CRE downturns and price bubbles in the Czech Republic

It is now crucial to detect signals of potential downturn in the next few years. As can be seen in the graph of monthly search interest (Figure 18), the term "realitní bublina" in Czech (in English: "real estate bubble", or "asset bubble") has witnessed an exponential increase in users' interest in 2016-2017, approaching the highest popularity in 2006/2008. The peak of the global crisis was already 10 years ago, which has made the question of this cycle's ending time resurface as a controversial topic nationwide in the Czech Republic.

Figure 18: Search trend index for "realitní bublina"



Notes: According to the note on Google Trends' official website, an interest over time index should be interpreted as a point of "search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. Likewise, a score of 0 means the term was less than 1% as popular as the peak." The last value is for December 2017 with incomplete data point. From 1st January 2016, Google's data collection system was improved.

Source: original graph on Google Trends, retrieved 31st December 2017.

This section will detect downturns and price bubbles in the Czech commercial real estate sector in three methods. Firstly, market peaks will be identified by calibrating the detection mechanism of the Early Warning System research reviewed above. Secondly, a chart analysis of Commercial Real Estate Capital Value Index development over time will be implemented in conjunction with comparing its movements with those of key macroeconomic variables. Thirdly, interviews with real estate specialists are carried out so as to collect market insiders' actual opinion regarding the existence of CRE bubbles in the Czech Republic as well as comparing their reasoning with results found by the other methods. After that, detection results can be concluded.

5.2.1 Detection using peak-tagging technique and a numerical threshold

This paper aims at calibrating only the first two stages of the Early Warning System for the Czech Republic. For the time being, the author of this thesis has found neither Net Operating Income (NOI) dataset nor any suitable proxy as an appropriate input for the third stage's model. In fact, even in the original EWS study, the authors had to develop the NOI variable themselves, relying on a well-established dataset of the U.S. REIT return, of which Czech counterpart does not exist. In lieu of the third stage's econometric model, patterns observed from the results of the previous two steps will be analysed together with intuitive implications.

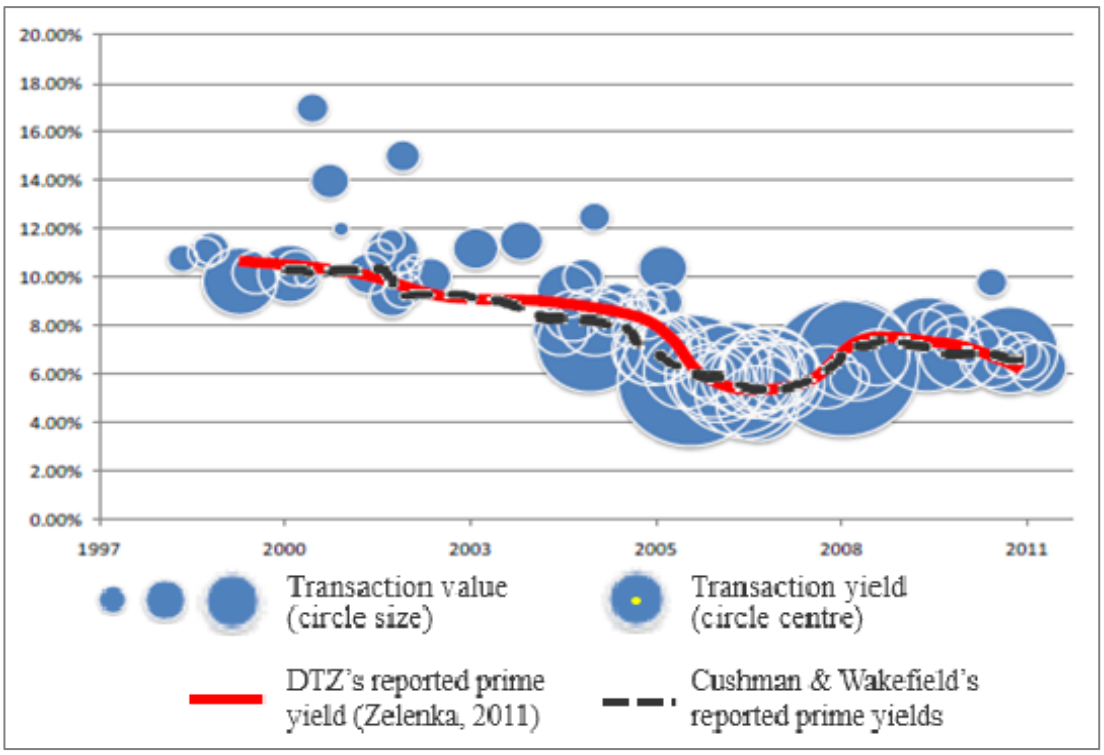
Stage 1 aims at finding a representative of CRE price values suitable for detection.

It is required to derive transaction cap rates to avoid smoothing effect, backward-looking biasness and other limitations of appraisal-based yields before calculating regional cap rate spread in the U.S. Since database for CRE in CZ differs greatly in comparison with that in the United States, there exist no equivalent series for appraisal-based cap rates, neither on the national level nor on the regional level.

Despite these disadvantages, a series of quarterly prime yields recorded by Cushman & Wakefield is found to be suitable representatives for the transaction cap rates. Firstly, prime yields are chosen for detecting CRE downturns and bubbles since worsened yields in secondary or lower asset classes usually follow or coincide with a softening prime yield. By definition, prime assets are the most commonly traded ones thanks to their promising performance and excellent risk profile. When prime properties undergo a plunge in value after a period being overvalued, investors' interest towards secondary assets drops even more deeply. Secondly, as illustrated in Figure 19, DTZ's office prime yields (solid line) trail closely to the actual transactional cap

rates. Cushman and Wakefield's prime office yields (dash line) which is integrated into this graph for comparison are almost identical to the data from DTZ. The similarity between the two series is not surprising, because most leading agencies have access to relatively quality data which enable them implying relatively precise prime yields. Furthermore, after the merger of these two firms in 2015, combined transaction database of DTZ and Cushman & Wakefield has led to a more accurate prime yield series as can be seen in Figure 19, especially during 2000-2002 and 2004-2005. Based on the fact that each agency evaluates prime yields of all subsectors using a unified method, it is reasonable to assume that prime yields of industrial and retail sectors are qualified to represent transaction cap rates of those subsectors as well.

Figure 19: Office transacted yields versus agencies' prime yield series



Source: Zelenka, 2011 (primary sources: DTZ before merger with Cushman & Wakefield, Discovery Group Fund, Zelenka's calculations); Cushman & Wakefield (after merger with DTZ).

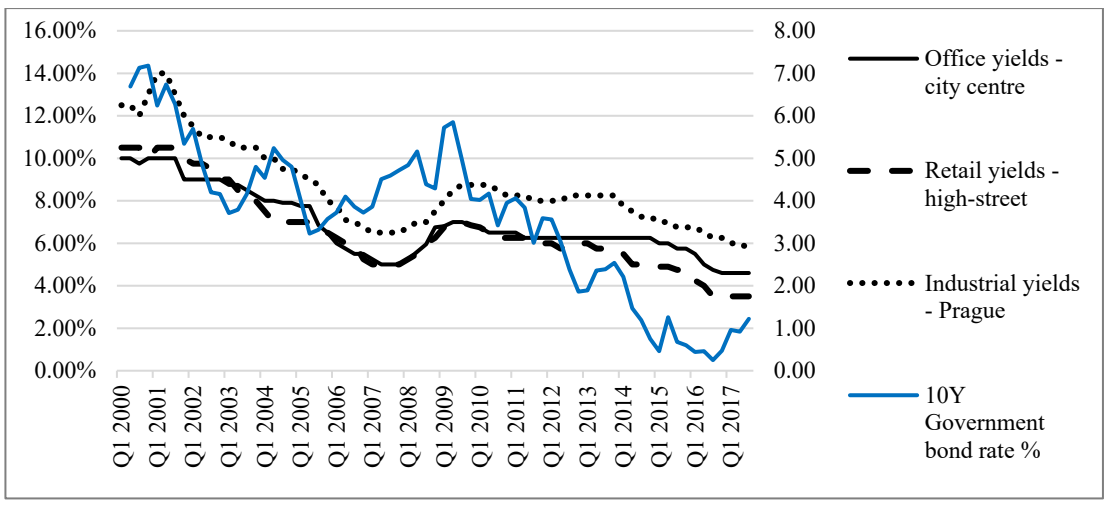
The above reasonings demonstrates that the prime yield series published by Cushman & Wakefield are perfect tools for detecting CRE downturns and price bubbles.

Stage 2 is to recognise damage periods and to determine market cycle peaks.

The EWS's methodology (summarised in section 3.5) is implemented on a dataset of prime yields and 10-year government bond rates from Q1 2000 to Q3 2017, illustrated in Figure 20. For the case of the U.S., transaction cap rates are adjusted for

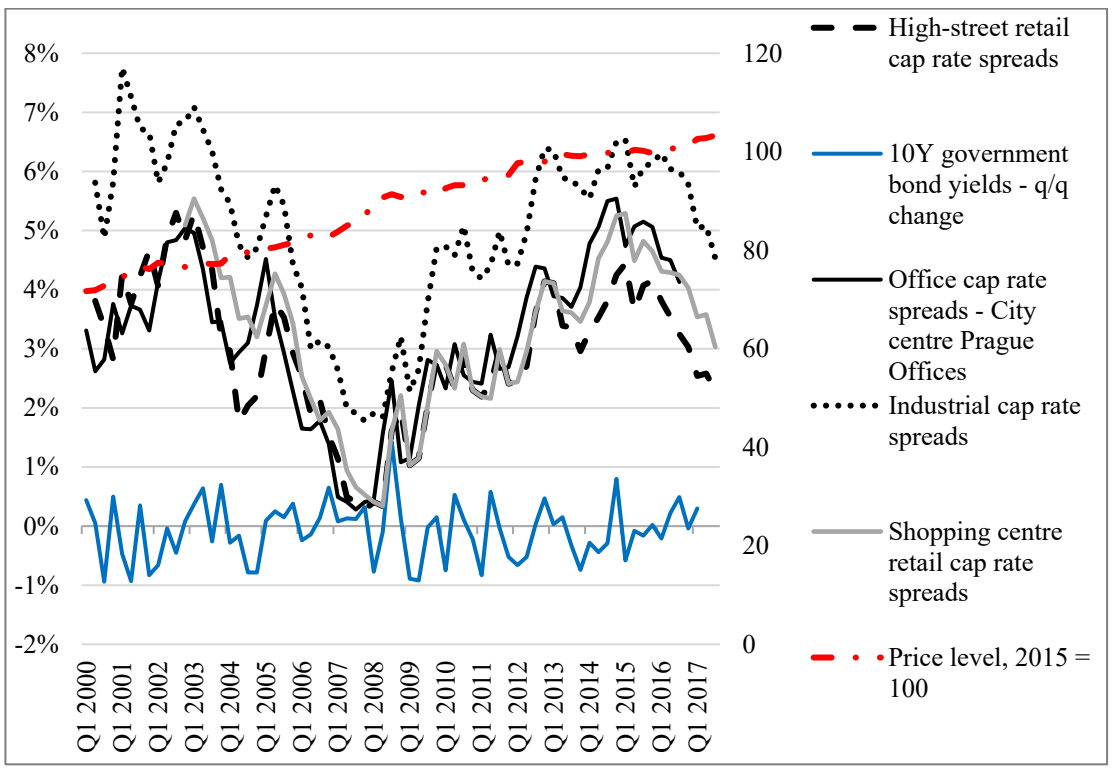
long-term inflation to avoid negative cap rate spread due to high inflation; however, this is not necessary for the case of CZ since Czech price levels have always been stable during the period studied in this paper (Figure 21). Low cap rate spread in CZ, which occurred between 2006 and 2009, were in fact a result of high bond yields as opposed to prime real estate yields. It is noticeable in Figure 21 that movements of all cap rate spreads follow direction of movements in 10-year government bond yields as expected in the EWS research, albeit with significantly larger volatility.

Figure 20: Prime yields (LHS) and 10-year government bond yields (RHS)



Source: Cushman & Wakefield, Czech National Bank

Figure 21: Cap rate spreads vs change in 10Y government bond rates

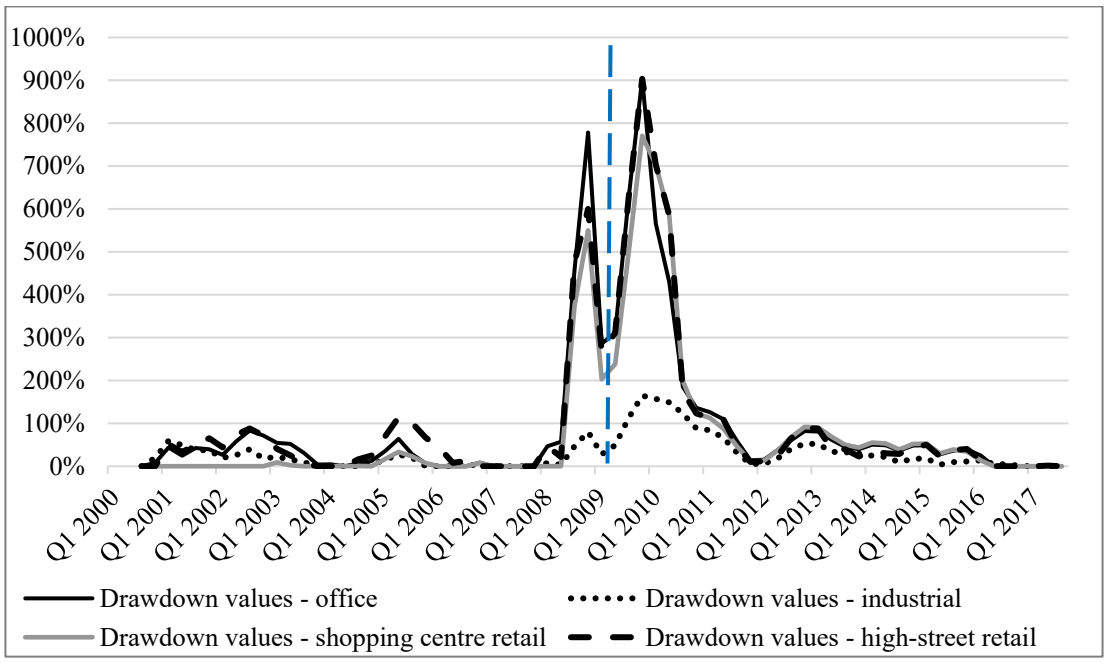


Source: Cushman & Wakefield, Czech National Bank, author's calculations.

Note: price level's axis on RHS, others' on LHS.

Drawdown values are calculated to identify damage periods. Figure 22 illustrates all drawdown values calculated to detect damage periods.

Figure 22: Drawdown values for detecting damage periods



Source: author's calculations

Note: lines for office and high-street retail are on LHS; lines for industrial and shopping centre retail are on RHS. The dot line is the horizontal middle line separating two relatively symmetrical patterns. Each drawdown values of zero indicates that the cap rate spread in that specific quarter reaches a two-year low. In case a few zeros occur continuously in consecutive periods, around 2006/2007 for instance, it is understood that the cap rate spread keeps decreasing further, the later quarter hits the new record low position. Hence, the latest period of the zero series is tagged as a local peak.

When applying EWS's suggested threshold (i.e. 20% drop in values), too many signals for damage periods are detected as the vast majority of drawdown values are higher than 20%. This indicates that the 20% threshold is not applicable for the Czech market, since it is not as mature as the main metro markets examined in the EWS study.

By visual checking Figure 22, three scenarios can be analysed in order to determine an appropriate tagging threshold: a 100%, a 200% and a 400% drop in value. Based on summary of the scenarios' results (Appendix A), the most reasonable way is to use the 100% threshold as a signal to tag damage periods. In that case, damage periods were recorded in retail and office subsectors between Q3 2008 and Q2 2011, a total of 12 quarters. Those for industrial would be 5 quarters from Q3 2009 to Q3 2010. In 2005, the 100% threshold was crossed for high-street retail, however, these damage

periods do not flag up any cycle peak as they lasted only for a short amount of time (2 quarters).

After damage periods are found, a peak can be identified by choosing "the last period with a drawdown value of zero" before each damage period (Steering and Advisory Committees of the Shaping the Future of Real Estate, 2016). Table 1 below lists all potential peaks detected by this definition. As a result, from Q1 2000 to Q3 2017 there is only one cycle peak in Q4 2007. This finding coincides with one of the two housing bubble periods concluded by Hlavacek and Komarek (2009).

Table 1: Peak tagging based on zero drawdown values

Subsector	Potential peaks
Office – Prague	Q4 2007
Industrial – logistics, Prague and Brno	Q4 2007
Retail – high-street, Prague and Brno	Q4 2007 (Prague) or Q2 2008 (Brno)
Retail – shopping centre, Prague and Brno	Q4 2007 or Q2 2008 depending on sample properties

Source: author's calculations and findings

Stage 3 is to draw implications and conclusions from the above findings.

When analysing the chart pattern in Figure 22, the line graphs of drawdown values looks relatively symmetrical comparing pre-Q2 2009 and post-Q2 2009. A common rule of thumb is that history repeats in any market. Until the peak period of Q4 2007, zero drawdown values were seen across subsectors, from 5 to 10 periods each, while there were already about 5 similar periods recorded between Q2 2016 and Q3 2017. Additionally, from 2016, government bond yields have increased sharply while all types of yields decrease slightly (Figure 20), which resulted in a declining trend of all cap rate spreads (Figure 21). From a chartist's point of view, there is a high probability that a relatively steep drop in a cap rate spread is expected to continue to approach zero values, hinting that a new cycle peak is likely to be reached by 2019.

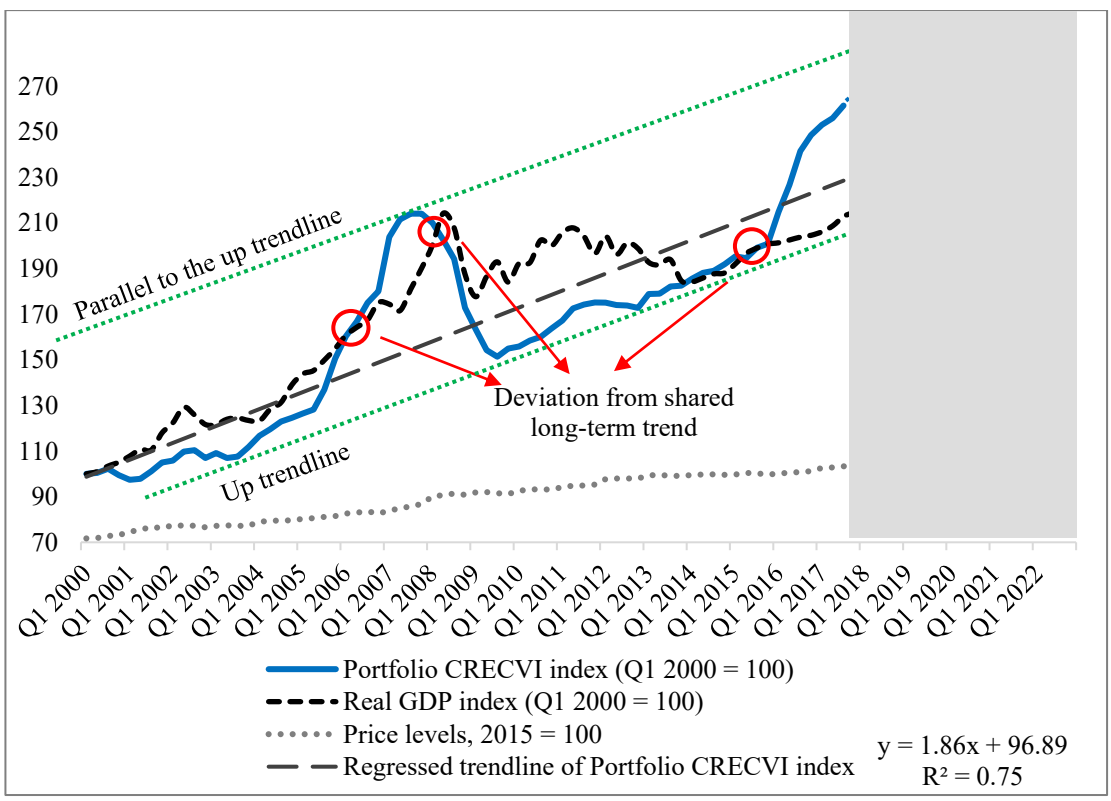
Based on the definitions in section 3.1.1, the result of stage 1 and stage 2 above is a peak period signaling only a market downturn; it cannot confirm the existence of a CRE bubble. As a conclusion of detection using peak-tagging technique suggested by the EWS research, prior to the downturn across CRE subsectors in 2008/2009, Q4

2007 is the only market peak period for the Czech commercial real estate market since 2000, while a new cycle peak might be seen by 2019.

5.2.2 Detection using chart analysis for CRECVI index

Based on the relation between CRECVI index and real GDP illustrated in section 4.4.2 of this paper, the CRE cycles could be predicted by comparing the movement of CRECVI index versus that of real GDP index and price levels using chart analysis techniques. Both real GDP and inflation of CZ are forecasted to maintain their gradual uplift for the next few years (Figure 23). On the contrary, since Q1 2016, the portfolio CRECVI index has deviated largely from both the macroeconomic indicators.

Figure 23: Bubble detection using CRECVI index



Source: CRECVI by Cushman & Wakefield, price levels and real GDP index by Czech Statistical Office with forecasts by Oxford Economics, author's calculations & commentary.

Note: Real GDP index has base period of Q1 2000. It is derived from real GDP in EUR, which is calculated from real GDP in CZK and end-of-period exchange rate. For avoidance of doubt, Figure 23 should not be compared with Figure 16 due to the difference in base period.

Major deviation points since 2000 are circled in Figure 23. The first one marks continuous value acceleration from around Q2 2006 to Q4 2007 whilst the second one marks a period of value correction from Q2 2008 to Q3 2009. The most recent period that CRECVI index outgrew macroeconomic indicators was recorded in Q2 2015 and

is still ongoing. It also raises concerns that for the last 3 years the CRECVI has repeated the surge between 2006 and 2008, during which a market cycle peak is present. This suspects the beginning of another critical time.

The regressed trendline is then added to the graph to identify long-term mid-point trend of the capital value index, suggesting a general upward movement. The up trendline is identified by connecting 3 low points; in this case it is nearly parallel to the regressed trendline. With a positive slope, the up trendline acts as a support which CRECVI is not expected to cross. There are not enough peaks to draw a valid down trendline; however, a line parallel to the up trendline can be a good substitute, representing a resistance. As shown on the graph, even though the asset value index is approaching the resistance level gradually, its increase in 2017 is less steep than that in 2007/2008. If CRECVI continue the same growth rate in 2017 as illustrated as blue dot line in Figure 23, its line graph will hit the resistance line at the end of 2019, similar to the conclusion in section 5.2.1. Otherwise, if CRECVI growth decreases in the upcoming years, the risk of major downturn is unlikely.

5.2.3 Opinions of market experts

This part presents two branches of information gathered from market specialists: the existence of CRE bubble and the upcoming CRE investment trend.

With regards to the topic of CRE bubble, by definition, a bubble cannot be detected only by price surges (Case and Shiller, 2004). In order to identify a bubble, actual prices must also be proved to be significantly different from values backed by market fundamentals. Gathering opinions of market experts would be one of the ways to answer this question.

An article published in February 2007 on the daily Economic Newspaper (in Czech "Hospodářské noviny") claims that "the commercial real estate bubble had not burst" (Economic Newspaper, 2007), indirectly acknowledging the existence of a CRE bubble in 2007/2008. The article quotes comments from Brend (B & Law, a London's law firm), Chapman (Cushman & Wakefield) and ARTN's Trend Report 2007 to prove that interest from investors towards Czech properties were high and steadily rising (Economic Newspaper, 2007), especially administrative buildings. In August 2008, an article on euro.cz reaffirmed the above claim, commenting that even though the bubble would not burst into a catastrophe, price corrections would come indeed, stated Vyroubal from Atlantik FT (Martinovičová, 2008). Sadil from Hypotecni banka (Mortgage bank) emphasized that the continuation of good performance was thanks to contemporary positive factors occurred within the Czech state, namely interest rate

hike and tax reform, implying that consequences of the financial crisis were in fact compensated for (Martinovičová, 2008). Hradecky from Czech Chamber of Realtors agreed with this, adding that demand was still outgrowing supply particularly in office and industrial subsectors (Martinovičová, 2008). Real Spektrum's Fajkus, on the contrary, warned against some overheated sub market, perhaps also including industrial sector (Martinovičová, 2008).

On the other hand, according to Michl from Raiffeisenbank, the rise in real estate price was typical for such an improvement in the contemporary economy; and that the bubble, if any, was caused by some poor policies speculated or enacted around the time (Martinovičová, 2008). It can be noticed in his sentence that Michl did not totally agree with the use of the term CRE bubble during that period. He further commented on the enormous potential for future project development, enhancement of infrastructure and innovation in the construction market, which would affirm promising income growth in the Czech real estate market as a whole (Martinovičová, 2008).

In the summary of Trend Report 2008 and Trend Report 2010 by ARTN which are available for the public, the term "bubble" was not mentioned. In 2008 report, despite some increases in yields the Czech CRE market was still stable at the time, stated Klapalova (Trend Report 2008, 2008). The strongest impact of the U.S. crisis was seen mainly in segments of real estate financing and investment (Trend Report 2008, 2008). Two years later, Klapalova confirmed that "no massive sale of distressed assets" were recorded (Trend Report 2010, 2010). Professor Jan Frait from Czech National Bank commented on the stable and well-managed Czech economy which supported a relatively good operation of commercial banks in the country, which in turn prevented the CRE market from collapsing.

Furthermore, informal individual interviews were carried out to obtain different views from market specialists. According to Naskos and Lonie, who have been active in the commercial real estate sector in the Czech Republic for nearly 20 years, since the year 2000 to date the Czech CRE market has not undergone any real estate bubble (Naskos, 2017 and Lonie, 2017). During the 2003/2004 period when a price bubble was detected for the housing market, it is clear from the annual investment graph (Figure 5) that there was no negative change in the CRE transaction volume, whilst the fluctuation of yields during this period was not alarming. Prior to the global crisis in 2007/2008, record high levels of commercial property prices, being contributed by both high rents and strong yields, were believed to be backed firmly by fundamental factors such as continuously strong economic growth of the local market (Naskos, 2017). This was opposite to the speculative investing behaviour of residential investors and home

buyers during the time. The steep drop in investment volumes between 2008 and 2010 were the result of nearly frozen investment activities; as the non-zero volumes in most quarters were attributed to some investment backlogs and very few voluntary sales (Naskos, 2017). This situation is led by many banks' strategy to provide their borrowers with covenant waivers for their default loans, using the so-called "extend and pretend" or "delay and pray" strategies (Lonie, 2017). Given the limited transactional evidence and some gap of expectation between vendors and investors, prime yields recorded by Cushman and Wakefield in some quarters were in fact based on subjective opinions of the firm's investment experts. It was further explained that the largest changes in CRE yields at the time was mainly the scissor effect between prime yields and secondary yields, which became widened after years of parallel movements (Naskos, 2017). In terms of rent, landlords' rental income decreased noticeably due to a considerable climb in tenant incentives as affected by the global crisis, making the occupier market become in favour of tenants.

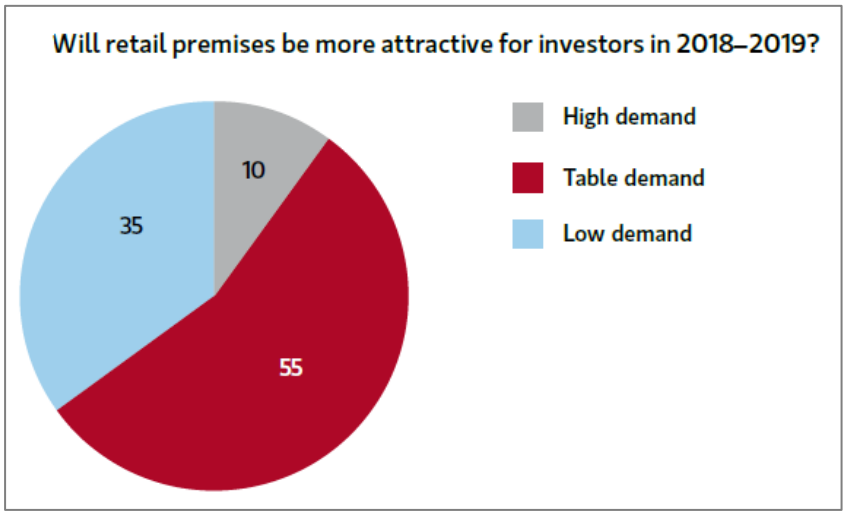
In terms of future trend forecasts, at the current time there are two sources: the world's largest real estate consulting firm CBRE and ARTN, which is a prestige non-profit association for real estate market development in the Czech Republic joined by leading professionals in various fields of the property market.

The first source is CBRE's periodical outlook reports which mention market insights on a regional and national level. At the current time, "the market is in a prolonged stage of the cycle", while investments in RE sector is "at elevated levels" (CBRE, 2018 Europe outlook, 2017). Despite the stretch of continuous investment growth, Europe is believed to continue its "robust investment activity in 2018, supported by positive occupier and investment market fundamentals" (CBRE, 2018 Europe outlook, 2017).

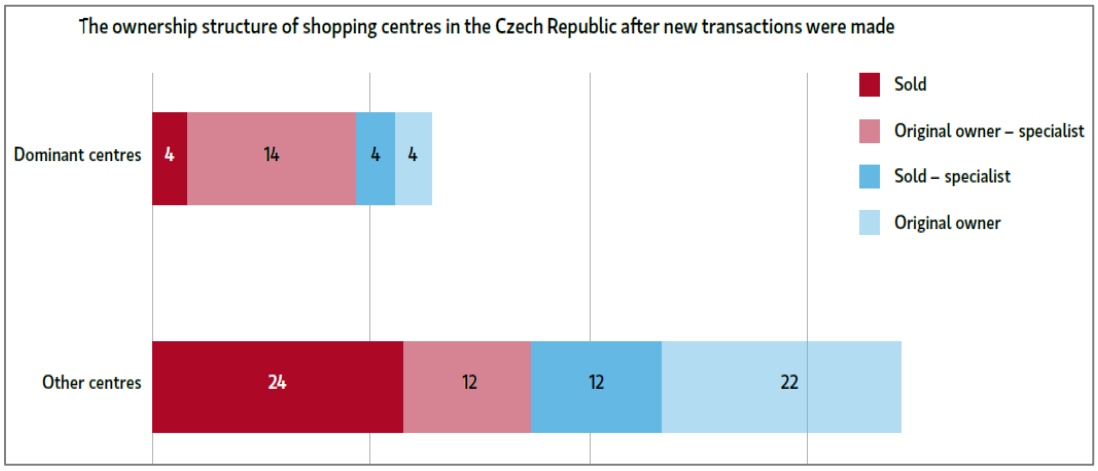
According to ARTN (Trend Report 2018, 2018), there have been noticeable signs of market slowdown since late 2017, especially in terms of number of available properties on sale, the limited supply of top-rated assets, and the slowdown of value appreciation. More than half of investment volume in 2016 was contributed by sale in office sector; meanwhile retail sector accounted for more than half of the investment volume traded in 2017. With a stable demand, there will be much fewer retail assets for sale in 2018-2019 as demonstrated by survey results in Figure 23. While prime rents in all sectors continue to grow, prime yields in industrial and retail sector in Q2 2018 stopped compressing (Cushman & Wakefield, 2018), resulting in slower growth of CRECVI index.

Figure 24: Survey - retail properties' attractiveness & ownership structure

(a)



(b)



Source: ARTN survey, Trend Report 2018 (primary source of graph b: Cushman & Wakefield).

5.2.4 Remarks on detection results

Cycle peaks in the Czech CRE market can be detected thanks to both the methodology of EWS research and the chart analysis of CRECVI index. There were 12 quarters of continuous market downturn from Q3 2008 with the only historical peak period being Q4 2007.

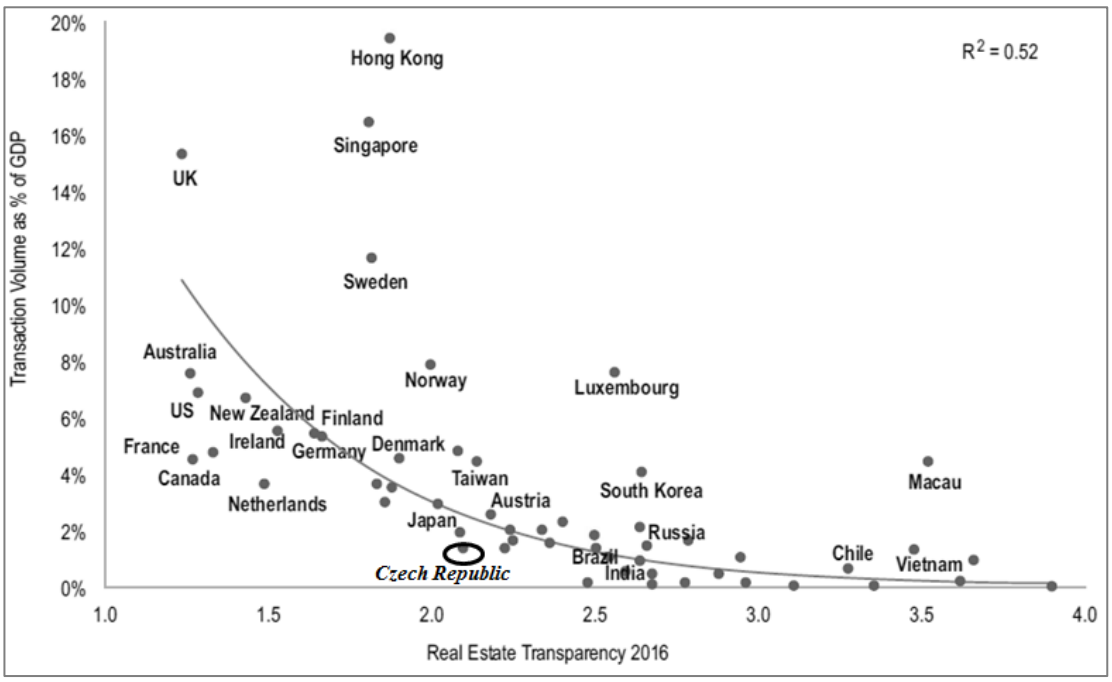
Meanwhile, most market experts disproved the existence of CRE bubbles based on the fact that market fundamentals have always been the supporting factors of the rises and falls in asset values. While it is true that there were some periods during which asset values (represented by prime yields recorded by multinational agencies) surge

continuously for at least 2 years, the economic performance and outlook were proved to justify the climb. Comparing this finding to the definition of asset price bubble (section 3.1), it is concluded that there has been no asset price bubble in the Czech commercial real estate market since 2000 to date, even though minor overpricing might have occurred sparingly.

In the near future, although chart analyses suggest a potential downturn in 2019, there are some signs of slowdown in investment volume from 2017 to date. By implementing tightened lending environment and increasing interest rates as scheduled in 2019, the Czech National Bank intends to minimize all hint of crisis, reducing both risk and magnitude of the CRE market. Investors are seen with cautious behaviour in H1 2018 so as to minimize potential speculative investing. ECB will also halt its 3-year quantitative easing. Therefore, from the year 2019, some value corrections might be seen during a calmer market, as evidence is found to disqualify all signals of major downturn.

5.3 Non-economic and other factors

Figure 25: Real estate transparency and Investment volumes



Source: Jones Lang LaSalle, 2016.

It is found out that there are strong relations between the transparency of a market and (1) investment volumes, (2) corruption level, (3) favourable business environment, (4)

share of institutional real estate (JLL, Real Estate Transparency Index, 2016). Figure 25 confirms the positive correlation with regards to transaction volumes.

Factors affecting the global RE market size comprise of current properties' value appreciation, new supply, and sale-and-leaseback activity (Hobbs and Chin, 2007). Trading volume of existing properties far outweigh that of newly built stock, therefore new supply would not be considered as an essential factor influencing investment volume. On the other hand, the demand for rental space is a direct factor influencing investors' appetite towards commercial property acquisition. The demand for retail and warehouse spaces is led by the overall consumer demand for goods and services; whilst the demand for offices comes from demand in white-collar employment market.

It is commented that the more mature the market, the lower the share of owner-occupied properties in that market. Some emergent economies such as CZ and Poland are believed to have over 70% of owner-occupied real assets, in comparison with below 40% in the UK and the U.S., or up to 90% in Russia and China (Hobbs et al., 2007).

The emerging markets will also see many positive changes in its tax system, monetary regime and exchange rate intervention. Based on personal observation of the thesis author, the end of the foreign exchange intervention in April 2017 was not regarded as an important event influencing the investment outlook in the country.

Prime properties in Prague attract a wider pool of investors, and with an improvement in market transparency, continuously strong economic development and increasingly favourable investment environment, the Czech CRE market is approaching the level of other mature markets step by step. Investor mix would see more domestic investors even though the share of foreign ones will still be high. Newcomers of investors recently include Australia (Macquarie bank), South African (NEPI, Rockcastle), Middle East, Lebanon (CFH Group), Ukraine (Focus Fund) and Asia (investors from Singapore and China). More new investors are expected to enter. Therefore, in the long-run, the Czech Republic is generally expected to have more active investment market than the current time based on these fundamental improvements.

In terms of new constructions, there are numerous development plans in the country across sectors, which will provide new investment products to the market in a few years. Nonetheless, recently new developments have been restrained by the authorities' slow response in approving projects and issuing permits, which is an unwanted situation affecting CRE development in the short-run.

5.4 Judgemental forecasts and their accuracy

This section reviews several CRE investment forecasts for CZ available for the public. Forecasts for investment volume in 2017 and the upcoming years are the focus.

A periodical research "Real Estate Market Outlook Report – Czech Republic" by CBRE is the only official forecasts released in advance, i.e. outlook reports for a certain year was released around the end of the previous year. In December 2016, the company predicted that in 2017 total investments of main subsectors (i.e. industrial, mixed-use, office and retail) would be higher than EUR 3.3 billion, dominated by sales of retail assets with 47% of volume, mostly based on proprietary information of ongoing negotiations monitored by its in-house team (CBRE, Czech Republic Outlook, 2016). The above expected volume was stated to be supported by economy growth, strengthening prime yields, and rental rate improvement across sectors amidst increasing demand and stagnating supply (CBRE, Czech Republic Outlook, 2016). The actual transaction volume in 2017 is EUR 3.44 billion according to Cushman and Wakefield's database. This indicates that CBRE's 2016 forecast is relatively accurate with 4.2% lower than the reality.

CBRE's forecasts for 2018 investment activity stated a total expected volume to be of at least EUR 2.4 billion. 2018 would see office and retail deals most likely being be the main driver, accounting for 88% of total volume or approximately EUR 2.1 billion (CBRE, 2018 Czech Republic Outlook, 2017). This forecast is close to prediction of Sotak from Cushman & Wakefield, that minimum transaction volume of office and retail subsectors would be EUR 2.2 billion, out of which EUR 1.7 billion is expected to be contributed by office deals (Sotak, 2017). Since retail investments have been very strong in the last two years, most core and prime retail assets have been already transacted, remaining a very low supply of retail properties on sale (Sotak, 2017). This comment is agreed by CBRE's 2018 Europe outlook, which points out the low supply across sectors in most European markets. Industrial sector is predicted to witness a stable investment activity compared to the previous two years (CBRE, 2018 Czech Republic Outlook, 2017).

Another periodical publication to consider is the Trend Reports, produced by ARTN since 2002. Until 2014, the report was first published biennially, then from 2015 onwards it is issued annually. Each report consists of extensive reviews of all market information collected from various specialists from different fields such as Czech National Bank, CSOB bank, Cushman & Wakefield, CBRE, Colliers, KPMG, Havel-Holasek and Partners, to name just a few. Furthermore, each year ARTN report is published in Q2 of the respective year, meaning that forecast errors would come mainly

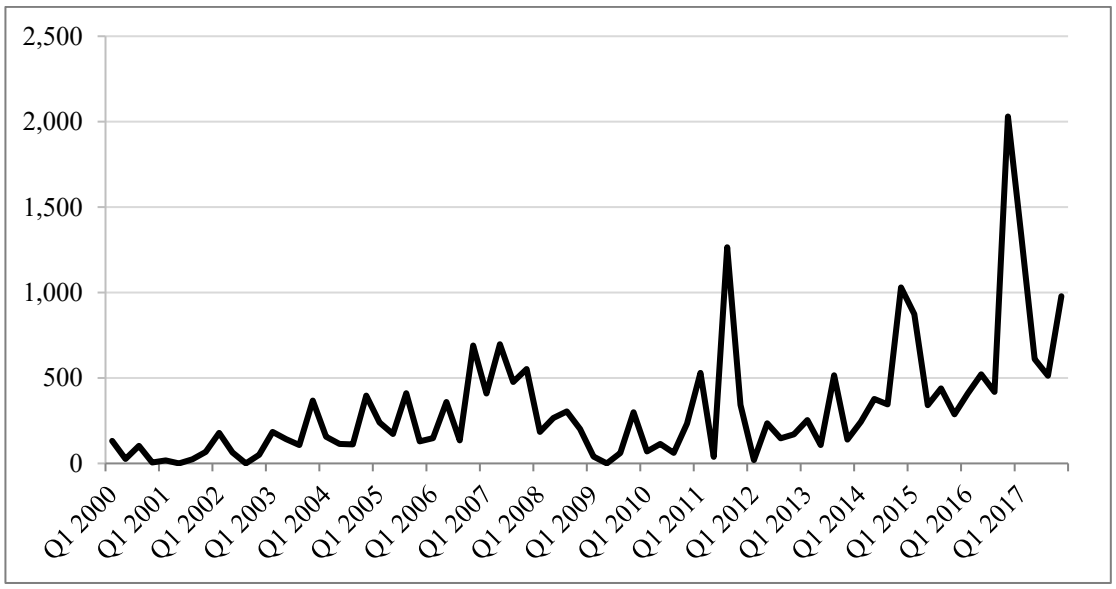
from the second half's estimation. In its Trend Report 2017, the association forecasted EUR 3.0 – 3.5 billion as the total investment volume in CZ including hotel and residential transactions. If excluding hotel and residential sectors, both of which are estimated to account for a total of 5% in 2014, 31% in 2015, 8% in 2016. It can be implied that ARTN expected around EUR 2.07 – 3.32 billion being the total volume traded in 2017 considering only mixed-used and the three main CRE subsectors. Even though the range is broad, the actual investment volume in 2017 is 3.6% higher than the upper end of this range. For the year 2018, EUR 2.5 – 3.0 billion in total volume is predicted by ARTN.

At the current time, no concrete forecasts are found for the years after 2018.

6 Model-based forecasts

Figure 26 below illustrates the quarterly movement of the investment volume since 2000. There are 3 periods with zero value as there were no transactions being recorded during these periods. The data is collected continuously since 2000 by Cushman & Wakefield.

Figure 26: Investment volume, Q1 2000 – Q4 2017, Czech Republic (€ million)



Source: Cushman & Wakefield.

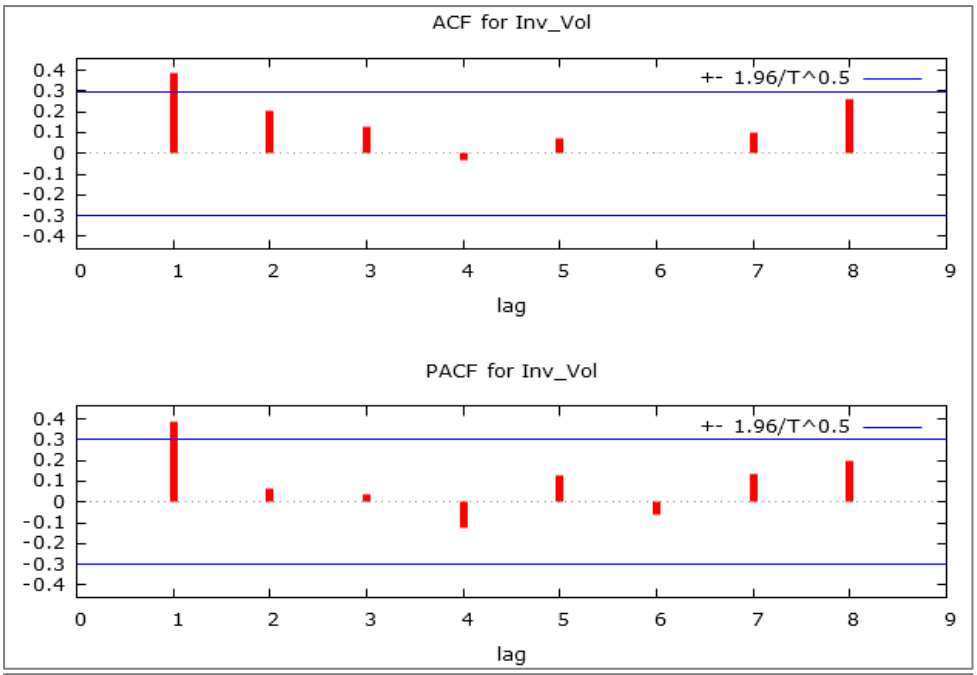
6.1 ARIMA model

An autoregression model is built as the first model-based forecast. The quarterly investment volume series in its nominal form is confirmed to be stationary by augmented Dickey-Fuller unit-root test (Appendix C). It is also proved to be non-seasonal (details in section 6.2.5 and Appendix D).

For ARIMA model, the period of investment volume data series is chosen to be Q1 2007 – Q3 2017. 43 observations would be sufficient as ARIMA model does not require long-term data. Furthermore, the upcoming years' performance would be influenced more by recent situation than dated periods. The following is the correlogram with 8 lags (Figure 27) of the reduced series, based on which a non-seasonal ARIMA (1,0,0) model is selected. Two models are regressed, one without

time variant and the other with time as an exogeneous variable. Regression results of these models are present in Appendix B.

Figure 27: Correlogram and autocorrelation functions for investment volumes



Autocorrelation function for Inv_Vol
***, **, * indicate significance at the 1%, 5%, 10% levels
using standard error 1/T^0.5

LAG	ACF		PACF		Q-stat.	[p-value]
1	0.4301	***	0.4301	***	12.9559	[0.000]
2	0.2901	**	0.1289		18.9400	[0.000]
3	0.1976		0.0418		21.7618	[0.000]
4	0.0355		-0.1104		21.8541	[0.000]
5	0.1053		0.1148		22.6815	[0.000]
6	0.0466		-0.0214		22.8458	[0.001]
7	0.1320		0.1319		24.1887	[0.001]
8	0.2483	**	0.1714		29.0191	[0.000]

Source: author's calculation, Gretl software.

Test statistics shows that the distribution of the without-time-variable model's error term is non-normal and ARCH effect of order 4 is also present (Appendix B). These problems might be the result of the recent step rises and falls in quarterly investment volume.

The model with time variable has slightly lower Akaike information criterion (AIC) compared to that of the other. Lower AIC indicates a better fitted model. However, it still has non-normally distributed error term and ARCH effect.

Table 2 summarises the two ARIMA models.

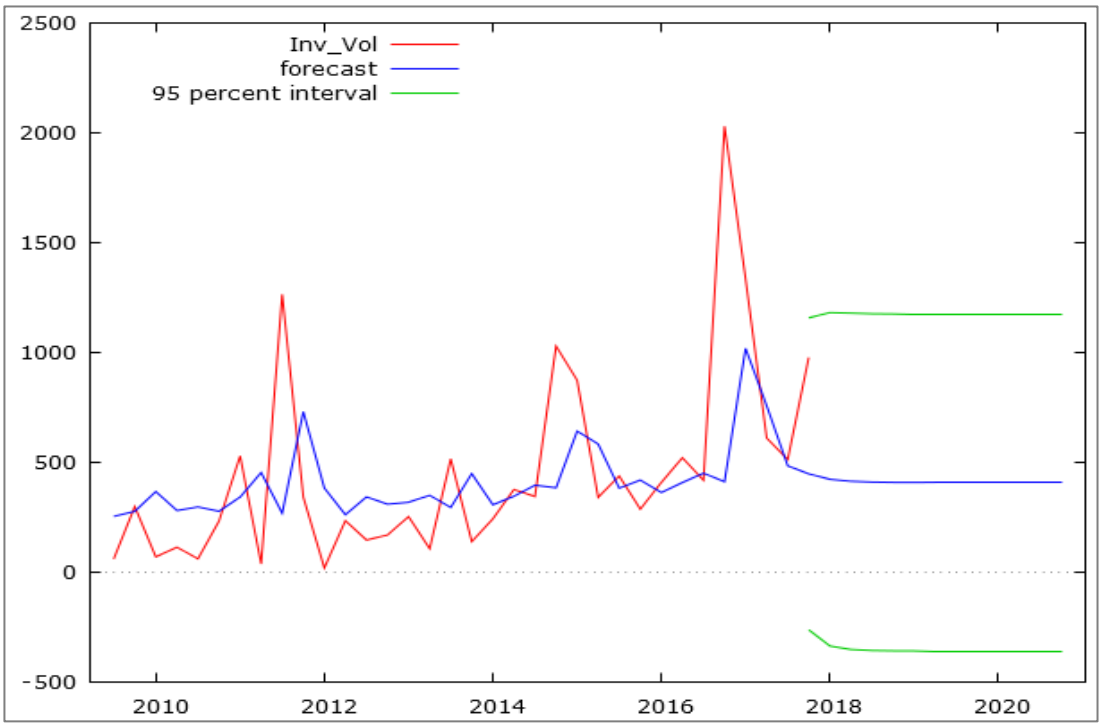
Table 2: Summary – ARIMA models

Model	**ARIMA (1,0,0) without time variable**		**ARIMA (1,0,0) with time variable**	
Period	2007:1 - 2017:3		2007:1 - 2017:3	
Number of RHS variables	1		2	
Number of observations	43		43	
Normality of residual	$p < 0.05$	rejected (unwanted result)	$p < 0.05$	rejected (unwanted result)
ARCH effect of order up to 4	$p > 0.05$	accepted (unwanted result)	$p > 0.05$	accepted (unwanted result)
AIC	634.9	higher = worse	633.4	lower = better

Source: author's calculation, Gretl software

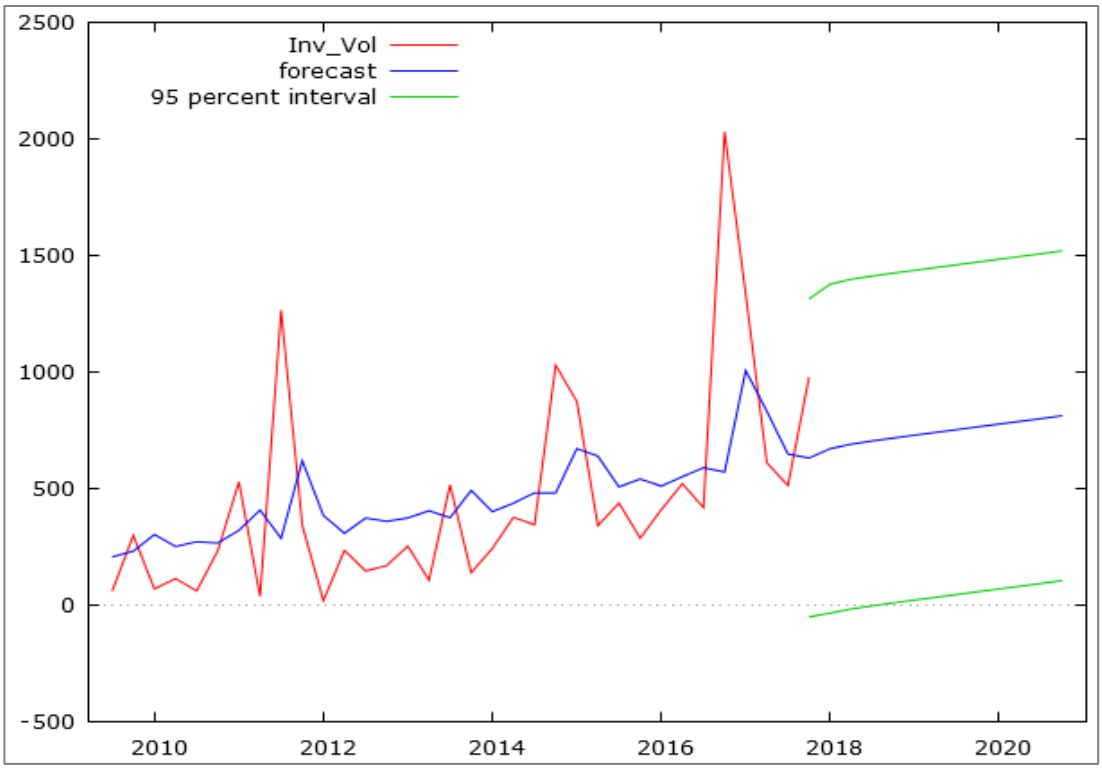
Forecast values of two models are illustrated in the following graphs (Figure 28 and Figure 29).

Figure 28: ARIMA (1,0,0) without time variable



Source: author's calculation, Gretl software

Figure 29: ARIMA (1,0,0) with time variable



Source: author's calculation, Gretl software

Error terms of both models are not normally distributed, and ARCH effect of order up to 4 is present in both cases. Besides, given the large span of the 95% confidence interval, forecasting power of the above models are rather weak. It is predicted by the former model that investment volumes will remain at an estimated long-term mean of around EUR 410 million per quarter without much fluctuations over time. ARIMA (1,0,0) with time variable, on the contrary, shows a constant growth rate in the long-run. The latter is slightly better than the former based on Akaike criterion.

ARIMA models, even with non-normally distributed disturbance, can be used for forecasting. Based on AIC, ARIMA (1,0,0) with time variable is chosen for final forecasting steps in section 7.

6.2 OLS and VAR models

6.2.1 Formation

Based on Pfaff (2008), a typical VAR(p) process for multivariate time series with K variables has the below reduced form:

$$y_t = C_0 D_t + C_1 y_{t-1} + \ldots + C_p y_{t-p} + \varepsilon_t \qquad \text{(Equation 1)}$$

where:

- $\boldsymbol{y_t}$ is the set of variables at time **t**, t = (1, …, T);
- $\mathbf{C_0}$ is the coefficient matrix of the deterministic term $\mathbf{D_t}$. Dimension of C_0 is (K x M) and that of D_t is (M x 1);
- **p** is the VAR order, i.e. number of lag period;
- $\mathbf{A_i}$ are coefficients matrices with dimension (K x K) for $\mathbf{i} = (1, \ldots, p)$;
- $\boldsymbol{\varepsilon_t}$ is a disturbance term at time t with (K x 1) dimension. The error terms must satisfy a number of condition: (1) having zero mean, (2) their contemporaneous covariance matrix must be time-invariant and positive definite, i.e. $E(\varepsilon_t \, \varepsilon'_t) = \Sigma\varepsilon$

6.2.2 Lag length selection

According to Brooks and Tsolacos (2010), lagged values of variables are indispensable when considering the dynamics of the capital market performance. Researchers in CRE often compare the current performance and the situation in the last 12 months. Hence, based on a rule of thumb, a lag length of 4 periods is selected, in line with the fact that this paper uses quarterly data for the multivariate VAR model.

6.2.3 Data selection and hypotheses

As suggested by various researches and the charting analyses mentioned above, there would be countless factors which would influence the CRE investment volume, some are numerically unmeasurable. Nonetheless, the limited set of data restrains the dimension of multivariate VAR model, which imposes a bias-variance trade-off. The more variables, the lower the degrees of freedom; leading to less precise out-of-sample forecasts as a result of overfitting problem. On the other hand, excluding any data from the model might cause the regression to omit certain features carried by the omitted factors.

A generally recommendation in econometric studies is to maintain at least 30 degrees of freedom so that the t-distribution is similar to normal distribution. This condition is indispensable in case statistical tests are needed to be done and relied on. Using 67 quarterly observations, then applying 4 lags and add a deterministic term, the model should have no more than 7 variables.

Description on datasets for the multivariate VAR model is summarised in Table 3, including intuitive arguments for each variable in the rightest column. 7 variables which are underlined in Table 3 are selected based on their data availability, their quality and how relevant they are to the aim of this thesis. This table also includes arguments which are in line with Hypothesis #2 of this paper.

Table 3: Potential variables

Data name, *expected correlation with investment volume*	**Comments, notes**	**Source of data**	**Reasoning for the expected sign of relation with investment volumes**
Investment volume *Positive*	Quarterly series Relatively good quality	Cushman & Wakefield	In general, if the previous periods witness positive growths in investments, the following quarter will be expected to have increased transaction volume as stronger competition is expected*.
10-year government bond yields *Positive*	Good quality	Oxford economics	This is considered as the risk-free rate, based on which yields of properties are assessed. Also, it is the benchmark that commercial banks use to set interest rate for the purchasers' loan. If bond yield increases, investors expect a future increase of cost of borrowing and property yields will catch up in the near future, encouraging investors to buy CRE now. The acquisition process would take some time, therefore an increase in 10Y bond rate would translate to an increase in investment volume after some quarters*.

Inflation rate, base = 2015 *Negative*	Yes, good quality, seasonally adjusted	Oxford economics	The inflation rates reflect a fundamental risk that an investor makes when deciding whether to purchase a property. When inflation rate increase, yields of properties will increase to adapt to the increased risk of value depreciation, properties' attractiveness as an investment will go down therefore investment volume will go down*.
Proxy of property price (Portfolio CRECVI index) *Positive*	Yes, relatively good quality	Cushman & Wakefield	This variable represents the capital value of the best asset in the country. It is found to capture real GDP of CR. For prime asset, whenever prime value is high, the market would be considered as improved with lower risks and thus would be more attract to investors, most probably resulting in more transaction occurring when this variable increase*.
Interest rate spread (Long-term cost of borrowing to non-financial corporations less 3M PRIBOR) *Negative*	Yes, relatively good quality; there is a change in data methodology in 2004	Oxford economics	When the interest rate spread increases, long-term investments will be more expensive than short-term ones, not favourable for real estate investors. Hence investors are less willing to purchase properties*.
Private consumption (proxy for consumer confidence) *Positive*	Yes, good quality, seasonally adjusted	Oxford economics	When consumer's confidence is high, sales of retailers increase and more demand for retail and warehouse spaces increases; firms also need to hire more people. Higher demand with slower response on the supply side would increase rent, making investment worthier for investors, thus investment volume would increase*.

<u>Unemployment rate</u> *Negative*	Yes, good quality, seasonally adjusted	Oxford economics	Unemployment rate's increase will translate to lower purchasing power and less demand for all types of spaces, lowering the attractiveness of properties, thus investment volume will go down*. This reasoning is similar to results of a research by Cardew et. al. (2004).
Real GDP growth in EUR, base = 2001 Q1 *Positive*	Yes, good quality, seasonally adjusted	Oxford economics	The real GDP movement is captured in the CRECVI index, proven in section 5.2.2, therefore this variable is not necessary for the model.
Industrial production, base = 2010 *Positive*	Yes, good quality, seasonally and calendar adjusted	Czech Statistical Office	Given the importance of industrial sector in the Czech Republic, it might be convincing that an increase in Czech industrial production can boost demand for industrial spaces, improving the attractiveness of this type of properties, thus investment volume for industrial assets would go up*. However, this data would only influence the industrial property submarket in which the proportion of transactions over the years is relatively small compared to the remaining subsectors. Moreover, most real estate transactions are related to warehouses (which are partially linked to retail sector) instead of factories, making the industrial production data being irrelevant to the property market performance.
Net operating income of properties	Not available	-	There is no aggregated data on operating income of properties in the Czech Republic suitable for this study.
New stock (each subsectors)	Insufficient	-	There are more data on new supply of each sector for the last 10 years, nonetheless, historical data for new supply of industrial and retail is lacking, making data on new stock insufficient for this research.

Vacancy rate (each subsectors)	Not available for retail sector	-	Vacancy rates of office and industrial are available; however not for retail due to high volatile activities of each retail properties along with a lack of proper data collection process.
Changes in space required per employee	Insufficient in terms of time	-	This is a factor related only to office subsector, and would change minimally over the years, thus it is not suitable for this study.

Source: as stated in the table. For the data retrieved from Oxford Economics, their primary sources are Czech Statistical Office, Haver Analytics, Czech National Bank, Statistical Office of the European Communities, Reuters.

Note: * ceteris paribus.

The relation between investment volumes and each of the remaining variables can also be two-way. The interrelation among the variables are also present, for instance the interest rate is affected by movement of the consumer spending, unemployment rate and bond yield. A VAR model consisting of the aforementioned 7 variables would be considered as valid, since the only requirement for a VAR model is the intertemporal impact of the variables among each other.

A few inconsistencies are present in two of the series. There is a small change in the portfolio composition from Q4 2002 onwards (as mentioned in section 4.4.2), when shopping centre index was first introduced. Moreover, the new method for reporting the lending interest rate was first applied in 2004 as announced by the Czech Statistical Office.

6.2.4 Order of variables in VAR models

It is important in VAR modelling to place all variables by level of relative exogenity, i.e. the exogenity of one variable relative to the each of the others. The most exogeneous one is placed first, followed by less exogeneous one and the last variable is the most endogenous.

The above order is chosen based on Goodhart and Hofmann (2008) and some subjective assessments. In the working paper “House prices, money, credit and the macroeconomy”, Goodhart and Hofmann set the ordering with the price level as the first variable, followed by the interest rate and the house prices, then the monetary/financial instruments such as broad money and bank credit. The order of the remaining factors, namely unemployment rate, consumer spending and investment

volume are found by applying a mathematical assumption that shock to one variable affects the variable following it at the same time whilst being influential to the variable before it only by its lag value. Firstly, it is common to see that private consumption is generally considered to be stickier than inflation rate. Unemployment rate varies more than inflation based on historical movements, yet compared to interest rate spread which is subject to continuous adjustment it is more exogeneous. Meanwhile, investor's sentiment toward real estate investment, i.e. the investment volume, would immediately reflected in the view of real estate brokers' opinion on capital value index. Lastly, "the property cycle lags behind movements of macroeconomic variables" (Cardew et. al., 2004).

To sum up, the transformed series of chosen variables would be applied in VAR models in this order:

(i) Private consumption

(ii) Inflation rate

(iii) Unemployment rate

(iv) Interest rate spread

(v) 10-year government bond yield

(vi) Investment volume

(vii) Portfolio CRECVI index

6.2.5 Data adjustment process

Stationarity

According to Luetkepohl (2011), impulse response analysis is valid if only the vector autoregression process is stable, i.e. all variables in a VAR model must be stationary. Macroeconomic time series are prone to non-stationary issue, and most datasets listed in Table 3 are no exception after using unit root tests. This problem can be removed by transforming original data set to percentage change quarter on quarter and first difference. It is suitable to the dataset as several of the variables are already in percent form.

Stationarity of all transformed variables are tested by Augmented Dickey-Fuller unit root test, using 4 maximum lag orders and Bayesian information criterion (BIC). The

test examines a null hypothesis of H_0: unit-root is present. Appendix C shows all p-values, which are all below 0.05. Null hypothesis is hence rejected for all variables, confirming that all variables entering the VAR process are stationary.

Seasonality

Seasonally adjusted data are available for 3 out of 7 chosen series: inflation rate, private consumption and unemployment rate. It is therefore imperative to perform seasonality test for the other 4 series.

Periodogram is mostly helpful for visual check, while F-tests for seasonality are able to formally detect the issue. The U.S. Census Bureau's X-12-ARIMA software is an effective tool for detecting and handling seasonal series, especially when it needs to be adjusted for seasonal effect. Using the X-12-ARIMA package built for gretl, the F-tests for seasonality performed on the stationary series of each variable in question verify that no seasonality is detected at any of the 0.1%, 1% and 5% levels. Results of the tests are in Appendix D.

Table 9 in Appendix E summarizes descriptive statistics for all selected variables.

6.2.6 OLS model

OLS model is run to test the direction of correlation between investment volumes and the remaining variables. A lag period of 4 is applied on independent variables. Output of the OLS model is as follows (Figure 30):

Figure 30: OLS model, using observations Q1 2002 - Q4 2017 (T = 64)

```
Model 51: OLS, using observations 2002:1-2017:4 (T = 64)
Dependent variable: Inv_Vol
HAC standard errors, bandwidth 2 (Bartlett kernel)

                      coefficient  std. error  t-ratio  p-value
  ------------------------------------------------------------------
  const                 433.428     72.5541     5.974   1.59e-07 ***
  PrivConsu_chg_4       -42.0466    50.4060    -0.8342  0.4077
  Infl_pc_chg_4        -202.307     80.0335    -2.528   0.0143   **
  Unemp_chg_4           -247.915    119.533     -2.074   0.0426   **
  i_Spread_chg_4         -94.4209    87.0147    -1.085   0.2824
  GovtBond10Y_chg_4       36.4489    65.3589     0.5577  0.5793
  PortfoIndex_1d~_4       16.3852     5.95696    2.751   0.0080   ***

Mean dependent var   353.8842   S.D. dependent var   357.7378
Sum squared resid    6145879    S.E. of regression   328.3633
R-squared            0.237721   Adjusted R-squared   0.157482
F(6, 57)             2.346760   P-value(F)           0.042848
Log-likelihood      -457.9292   Akaike criterion     929.8583
Schwarz criterion    944.9705   Hannan-Quinn         935.8118
rho                  0.133591   Durbin-Watson        1.705368

Excluding the constant, p-value was highest for variable 13 (GovtBond10Y_chg_4)
```

Source: author's calculation, Gretl software

Durbin-Watson statistics is close to the value of 2, confirming that this regression is not spurious. This is sufficient to rely on the result of OLS regarding direction of correlations between variables in the model. On this basis, Figure 30 points out that 5 out of 6 variables follow the aforementioned expectation regarding direction of correlation. The only one having opposite sign is private consumption. It might be due to the lag applied to this variable. Private consumption is the stickiest variable among the dataset; meanwhile it is an important factor influencing investors' investing decision. While a change in the inflation rate today will affect the investment volume in 4 periods, for example, a change in private consumption trend can affect investment activities within a few months. Retail sector is perhaps the first sector to be affected; its yields and rents are vulnerable to fundamental changes while prices per square metre of retail assets are the highest among all sectors. Therefore, it is more reasonable to assume shorter lag for this variable, for instance 2 lags. The above OLS model is revised with 2 periods being the lag length of private consumption variable, and as can be seen in Figure 31, the revised model has all expected signs.

Figure 31: Revised OLS model, using observations 2002:1-2017:4 (T = 64)

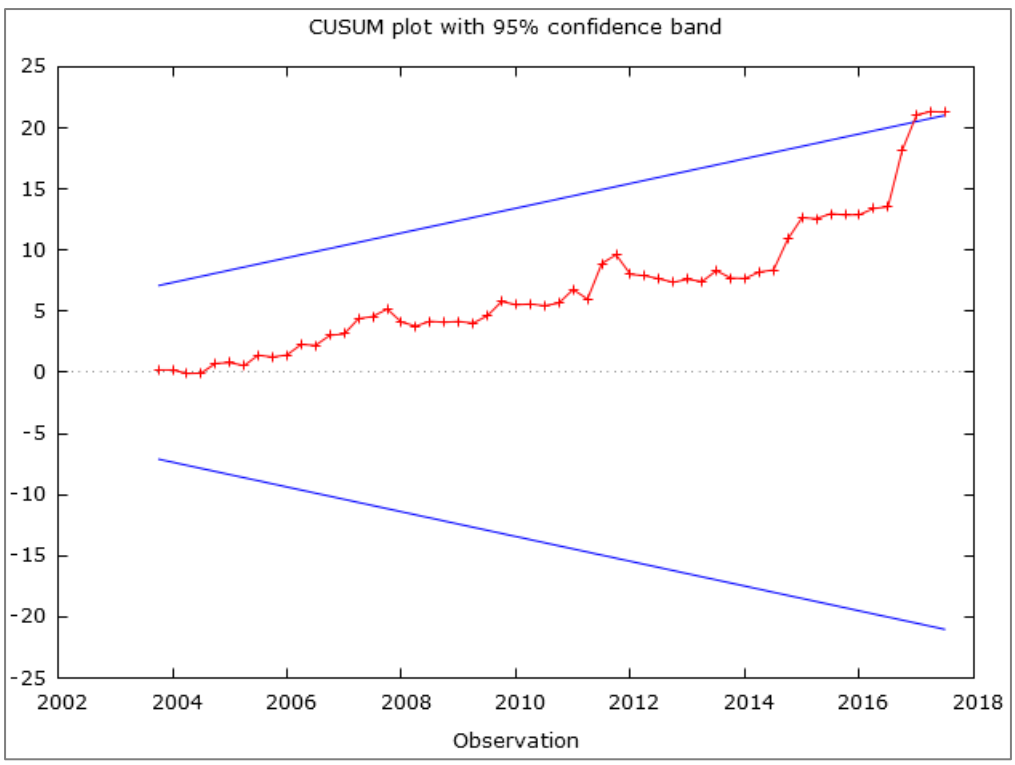
```
Model 54: OLS, using observations 2002:1-2017:3 (T = 63)
Dependent variable: Inv_Vol

                     coefficient  std. error  t-ratio   p-value
  ---------------------------------------------------------------
  const                401.479      66.9252     5.999    1.53e-07 ***
  PrivConsu_chg_2        3.70249    62.4792     0.05926  0.9530
  Infl_pc_chg_4       -196.861      75.2860    -2.615    0.0114   **
  Unemp_chg_4         -200.004     143.970     -1.389    0.1703
  i_Spread_chg_4       -90.3599     63.0206    -1.434    0.1572
  GovtBond10Y_chg_4     20.3671     88.1441     0.2311   0.8181
  PortfoIndex_1d~_4     14.5876      8.66013    1.684    0.0977   *

Mean dependent var   343.9746   S.D. dependent var   351.6452
Sum squared resid     5941543   S.E. of regression   325.7284
R-squared            0.225006   Adjusted R-squared   0.141971
F(6, 56)             2.709776   P-value(F)           0.022144
Log-likelihood      -450.2050   Akaike criterion     914.4100
Schwarz criterion    929.4119   Hannan-Quinn         920.3103
rho                  0.163668   Durbin-Watson        1.672612

Excluding the constant, p-value was highest for variable 15 (PrivConsu_chg_2)
```

Source: author's calculation, Gretl software

To find out whether the revised OLS model can provide more implications, a few tests are done. The residual normality test shows that the error term does not have normal distribution, hence significant correlations between variables cannot be implied. The values of estimated coefficients are also not reliable because adjusted R^2 (goodness of fit) is very low. CUSUM test for stability of parameters of this model shows that there exist some values outside of 95% confidence band in the model, occurring from Q1

2017 until the end of the testing period. This detects a structural break, a similar signal mentioned in section 5.2.1 and 5.2.2. The CUSUM plot is illustrated in Figure 32.

Figure 32: CUSUM – test for stability of parameters



Source: author's calculation, Gretl software

6.2.7 VAR models

A number of VAR models are run with a deterministic term (constant) and heteroskedasticity and autocorrelation consistent (HAC) standard errors.

In this stage, models with data up to Q4 2016 are built, assuming the data for 2017 being unknown. The 2017 actual data points are "hold-out sample" in this case. Version A considers all 7 variables as endogenous, while version B takes macroeconomic and financial variables as exogenous to take advantage of 10-year forecasts done by Oxford Economics. Results of two VAR models are summarised in Table 4, together with results from tests for model adequacy as suggested by Luetkepohl (2011) and Pfaff (2008).

Table 4: Summary – VAR models Detailed results can be found in Appendix F.

Table 4: Summary – VAR models

Variables	VAR model version A – 2016		VAR model version B – 2016	
	Type of variable	**Observations, test conclusion**	**Type of variable**	**Observations, test conclusion**
Private consumptions	Endogenous	2002:1-2016:4	Exogenous	2002:1-2026:4
Inflation rates	Endogenous	2002:1-2016:4	Exogenous	2002:1-2026:4
Unemployment rates	Endogenous	2002:1-2016:4	Exogenous	2002:1-2026:4
Interest rate spread (10Y govt less 3M PRIBOR)	Endogenous	2002:1-2016:4	Endogenous	2002:1-2016:4
10Y government bond yields	Endogenous	2002:1-2016:4	Exogenous	2002:1-2026:4
Investment volumes	Endogenous	2002:1-2016:4	Endogenous	2002:1-2016:4
Portfolio CRECVI	Endogenous	2002:1-2016:4	Endogenous	2002:1-2016:4
Lag order	4		4	
Number of variables	7		7	
Number of observations	60		60 (up to 96 for exogeneous variables with available forecast values)	
Adjusted R^2 of Investment volume equation	0.287038		0.307269	
Durbin-Watson statistics of Investment volume equation	1.932623		1.760749	
p-value of Doornik-Hansen test / Normality of residual	0.4506	accepted (desirable result)	0.0072	rejected (unwanted result)
Test for ARCH of order up to 2 p-value for lag 1	0.2579	accepted (desirable result)	0.9968	accepted (desirable result)
Test for ARCH of order up to 2 p-value for lag 2	0.3428	accepted (desirable result)	0.9942	accepted (desirable result)
Lag order 4 - AIC	27.3805	-	22.0626	better AIC
Lag order 3 - AIC	27.5291	-	22.0334	better AIC
Portmanteau test: p-value for residual autocovariance	0.0000	rejected (desirable result)	0.0168	rejected (desirable result)

Source: author's calculation, Gretl software

Given Durbin-Watson statistics of all equations are close to 2, both VAR models are not spurious. The goodness of fit R^2 of 28%-30% are low; which are perhaps caused by numerous outliers in the dataset, especially the recent hikes in investment during 2016. Based on AIC, it is expected that version B is better than version A. However, even with higher R^2, only version A's residual is normally distributed. As a result, only version A is adequate for further analysis and forecasting.

It can be seen in Figure 33, forecast by the chosen VAR, i.e. version A, have very large range of 95% confidence interval. Nonetheless, the interval band can be considered mainly as an upper limit, as in reality investment volume cannot be lower than 0. This means the confidence interval is relatively reasonable. A wide fluctuation aiming downwards is predicted in the first few years. The fluctuation is expected to become narrower over time and eventually hover around a stable level of approximately EUR 370 million per quarter.

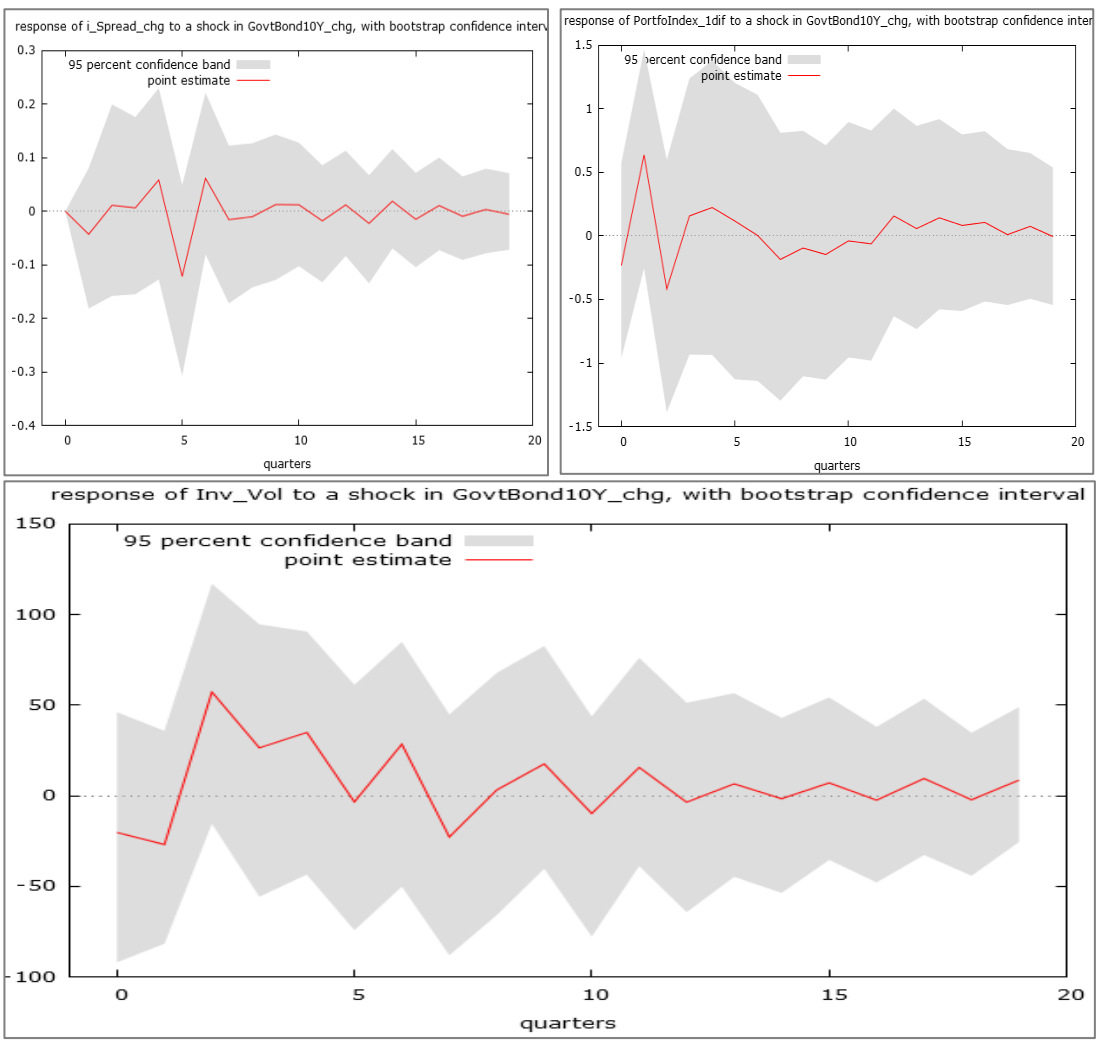
Figure 33: Forecasting by VAR model - short-term (upper) & long-term (lower)

Source: author's calculation, Gretl software

6.3 Impulse response analysis

The purpose of impulse response analysis is to determined potential impact of a change in ECB's monetary policy, in particular the quantitative easing. As mentioned in section 4.1, the ECB's intensive stimulant is planned to end by the end of 2018, which will directly affect the Czech 10-year government bond yield. Oxford Economics forecasted an increase in the 10-year rate as well based on Figure 6. Three graphs in Figure 34 depict impulse response functions created based on the VAR model chosen above, i.e. version A. An increase in the 10-year rate would lead to a rapid temporary fluctuation in CRECVI portfolio index, lasting around 3 quarters. Fluctuation would be an immediate reaction of investment volume also; it however lasts longer (about 5 quarters) with a slightly positive effect, in line with the findings in section 6.2.6. The stickiest among the three variables is interest rate spread, which reacts strongly to the shock after a 5-quarter lag.

Figure 34: Impulse response – VAR model



Source: author's calculation, Gretl software

7 Integration of forecast approaches

Forecasting both direction and magnitude of the Czech CRE capital market is one of this thesis' aim. The downward trend is relatively certain thanks to evidence mentioned in section 5.2.4 and section 5.4. In contrast, predicted amount of total transaction volume should be regarded with caution.

From section 6.1 and 6.2, the ARIMA (1,0,0) with time variable and VAR model version A can be relied on for forecasting purposes. Forecast points of the two models are collected. In order to test the models' accuracy, both models are replicated two times: one using dataset with actual investment volume in 2016 and 2017 removed, and one using the dataset with all actual data until Q3 or Q4 2017 based on availability. Due to the degree-of-freedom requirement, i.e. the limited number of observations, the VAR model is not applicable for any dataset which lacks actual series from 2015 and earlier. Forecast values of the chosen models are listed in Table 5, together with actual values and two sources of judgemental forecasts for comparison.

Table 5: Integration of forecast approaches

Period	Actual volumes	Forecast of CBRE	Forecast of ARTN	Forecasted investment volume (€ million)		Time range of dataset	Final forecast values - after integration
				ARIMA (1,0,0) with time variable	VAR version A		
2015	1,941.47	n/a	1,540 – 1,680	1,702.11	1,798.18	n/a	1,645.04
2016	3,379.88	≥ 2,000	> 2,100	1,550.73	2,332.06	2001 - 2015	2,154.10*
2017	3,437.33	≥ 3,300	2,070 – 3,325	3,118.46	1,764.81	2001 - 2016	2,859.47*
2018	n/a	≥ 2,400	2,500 – 3,000	2,796.91	3,825.08	2001 - 2017	2,759.00*
2019	n/a	n/a	n/a	2,833.19	4,353.53	2001 - 2017	2,833.19**
2020	n/a	n/a	n/a	2,981.46	4,227.31	2001 - 2017	2,981.46**

Source: CBRE (2015, 2016, 2017), ARTN (Trend Report published in 2015, 2016, 2017, 2018), author's calculations.

Note: * As transaction lead times are usually from 6 to 12 months, a weight of 75% can be reasonably assumed for forecast values suggested by market experts; the remaining 25% is the weight assumed for model-based forecasts. Two model-based forecasts are assumed to have the same weight. Whenever a forecast by experts is a range, the middle point of the range is used for calculating combined integrated values. When a forecast by experts is a minimum level, the minimum level is used for calculating integrated forecast values. ** As pointed out by fundamental analysis and experts' opinion, commercial real estate investment will unlikely to cross the € 3 billion mark in the upcoming years. During the integration process, this opinion is taken into account. For 2019 and 2020, forecast results of VAR model seems unrealistic based on market experts' opinion and the trend of CRE investment in the Czech Republic, therefore they are disregarded. ARIMA model's forecast is used as an alternative.

With too few forecast points, statistical or econometric forecast tests are not necessary. It is more reasonable to comment on the forecasts based on direct comparison of actual values and forecast values, as well as looking at the errors in percentage. It can be seen in Table 5 that the sudden increase in CRE transaction volume in 2016 was not detected by both the experts and the two models. In 2017, the prediction by CBRE is the closest to actual volume, whilst forecasts by ARTN and ARIMA model are not far from actual figure. In 2019 and 2020, as there are no experts' forecast, results of the two models are compared, pointing out that ARIMA's forecast values are more realistic.

Table 6 compares errors of different forecasts. The errors are large with probably no consistency in each forecast's accuracy. The sudden increase in transaction volume in 2016 was not detectable by any parties, given the known cause of ECB's quantitative easing. A positive point is that errors of all 2017 forecasts are smaller than those of 2016 forecasts. Author's forecast errors fall between the errors of CBRE and ARTN thanks to the weighting technique; however, post-integration forecast values do not reflect the sudden increase in the Czech capital market in 2016, neither the excellent performance of the market in 2017. There is no clear difference in the three forecasts to point out the best one, or to determine which is better than which.

Table 6: Evaluation and comparison of forecast values

Period	CBRE's forecast error	ARTN's forecast error	Author's post-integration forecast error
2015	n/a	-17%	-15%
2016	-41%	-28%	-36%
2017	-4%	-22%	-17%

Source: author's calculations.

8 Conclusion

In this section, all main findings and discoveries of this thesis about the commercial property market in the Czech Republic are summarised.

To begin with, the Czech CRE market has been developing rapidly for the last two decades in both large metropolitans and regional cities despite of its small size and relatively young age. Noticeable improvements can be seen across subsectors, in terms of continuous growth in rents and yields, market stability, attractiveness for institutional investors and transparency, and its leading position compared to other CEE countries. This trend of development is ongoing and will continue both in the long term and in the short term.

The first hypothesis is disproved. While the Czech residential market underwent two housing bubbles in the last 2 decades, it is confirmed that no bubble has occurred in the CRE sector. Increases in CRE prices were proved to be supported firmly by market fundamentals instead of being the result of investors' speculation. A downturn was recorded between Q2 2008 and Q2 2011, followed by a period of value appreciation which is partially thanks to several ECB's monetary policies implemented at the time. Since 2000, only Q4 2007 is identified as a market cycle peak so far. On one hand, it is true that a few signals flag up 2019 as the year witnessing a new downturn of property prices in the market. On the other hand, Czech National Bank has been actively intervening to put a break on the market growth by increasing key interest rates and future stricter lending policies. Furthermore, thanks to ECB's plan to end quantitative easing, along with cautious behaviour of investors and the ongoing labour shortage, the slowdown in price acceleration was recorded. As a result, the upcoming years should be described as a cooling period with value corrections rather than a major downturn.

On the contrary, the second hypothesis is fully proven. Expected directions of correlation between the investment volume and macroeconomic indicators are verified by OLS regressions. Changes in price levels and in unemployment rates have negative correlation with CRE investment. Positive correlation is found with regards to the change in ten-year government bond yields, changes in portfolio capital value index, changes in interest rate spread and changes in private consumption.

The third hypothesis, which assumes positive growth in investment volume of the Czech CRE market from now until 2020, is disproved by both qualitative and model-based analyses in this paper. Market specialists supported a future slowdown period of the Czech capital market, implying that the record-high trading volume in 2017 is expected not to be surpassed any time soon. Judgemental forecasts on a regional level provide similar messages; although at the same time predict that in the long run the country's capital market could be more attractive with higher trading potential. Despite the confidence interval band is large, final forecast values for 2018, 2019 and 2020 are estimated to be € 2.76 billion, € 2.83 billion and € 2.98 billion, respectively.

There are many possibilities of future research in this field. Firstly, even though this paper does not seek ways to deploy entirely the Early Warning System Prototype, according to the authors of the EWS study, it is possible to develop their model for any market, provided that proxy variable for value is available and peak periods can be found. Secondly, more precise forecasts could be done when gaps among databases of different real estate firms are eliminated. In order to reach a higher transparent tier, it is essential for all market players to consider the use of centralised open public database such as Real Capital Analytics, which has been widely used in mature markets such as the UK.

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Data sources

ARTN

CBRE

Cushman and Wakefield

Czech Statistical Office

Oxford Economics (its primary sources are Czech Statistical Office, Haver Analytics, Czech National Bank, Statistical Office of the European Communities, Reuters.)

Appendix A: Drawdown values

Table 7: Drawdown values of cap rate spreads using 11 sample prime properties

	Drawdown values (unit: %)										
Prime property	**Office**			**Industrial (logistics)**		**Retail - high-street**	**Retail - shopping centres**				
	#1	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**	**#10**	**#11**
Q2 2005	64	56	56	27	18	114	33	33	38	35	29
Q3 2005	28	31	22	20	9	101	23	23	21	25	20
Q3 2008*	**457**	*232*	197	47	36	**475**	-638	*374*	*374*	*374*	71
Q4 2008*	**779**	**411**	*386*	80	85	**600**	-1,013	**550**	**550**	**550**	142
Q1 2009*	*286*	189	170	28	33	*268*	-431	*203*	*203*	*203*	65
Q2 2009*	*311*	*211*	188	49	49	*311*	-506	*238*	*238*	*238*	90
Q3 2009*	**629**	*379*	*323*	113	99	**629**	-1,219	**500**	**500**	**500**	148
Q4 2009*	**904**	**458**	*386*	165	139	**904**	-1,794	**771**	**771**	**771**	208
Q1 2010*	**566**	**405**	*389*	157	134	**703**	-1,650	**703**	**703**	**703**	170
Q2 2010*	**430**	*380*	*267*	149	128	**585**	-1,556	**585**	**585**	**585**	141
Q3 2010*	185	134	115	123	101	175	**481**	199	199	199	81
Q4 2010*	136	99	71	89	75	123	*334*	123	148	148	50
Q1 2011*	126	76	65	84	63	113	*294*	113	137	137	36
Q2 2011*	110	76	53	66	52	110	*232*	88	110	110	26
Q3 2011	59	47	34	32	26	47	53	47	59	59	23
Q4 2011	14	17	9	5	4	10	3	12	14	14	6

Source: Cushman & Wakefield, author's calculations

Notes: **Bold (red)**: > 400% only;

Italic (yellow): 200% - 400%;

Underline (green): 100% - 200%;

* major damage periods of most sample properties in all sectors tagged by 100% threshold.

Appendix B: ARIMA models

Model 1: ARIMA (1,0,0) & test results (without time variant)

```
Model 47: ARMA, using observations 2007:1-2017:3 (T = 43)
Estimated using Kalman filter (exact ML)
Dependent variable: Inv_Vol
Standard errors based on Hessian

            coefficient   std. error     z     p-value
  ---------------------------------------------------------
  const      408.709       87.3946      4.677   2.92e-06 ***
  phi_1        0.376590     0.138768    2.714   0.0067   ***

Mean dependent var   407.2404   S.D. dependent var   397.1093
Mean of innovations -0.000298   S.D. of innovations  362.2339
Log-likelihood      -314.4593   Akaike criterion     634.9186
Schwarz criterion    640.2022   Hannan-Quinn         636.8670

                      Real  Imaginary    Modulus  Frequency
  ------------------------------------------------------------
  AR
    Root  1           2.6554     0.0000     2.6554     0.0000
  ------------------------------------------------------------

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 50.0275
  with p-value = 1.36984e-011

Test for ARCH of order 4 -
  Null hypothesis: no ARCH effect is present
  Test statistic: LM = 0.730492
  with p-value = P(Chi-square(4) > 0.730492) = 0.947516
```

Source: author's calculation, Gretl software

Model 2: ARIMA (1,0,0) & test results (with time as an exogeneous variable)

```
Model 45: ARMAX, using observations 2007:1-2017:3 (T = 43)
Estimated using Kalman filter (exact ML)
Dependent variable: Inv_Vol
Standard errors based on Hessian

            coefficient   std. error      z      p-value
  ---------------------------------------------------------
  const      -139.338      270.969      -0.5142   0.6071
  phi_1         0.264482     0.146326    1.807    0.0707  *
  Time         11.9014       5.68073     2.095    0.0362  **

Mean dependent var   407.2404   S.D. dependent var   397.1093
Mean of innovations -1.541145   S.D. of innovations  347.9135
Log-likelihood      -312.6846   Akaike criterion     633.3693
Schwarz criterion    640.4141   Hannan-Quinn         635.9672

                      Real  Imaginary    Modulus  Frequency
  ---------------------------------------------------------
  AR
    Root  1          3.7810     0.0000     3.7810     0.0000
  ---------------------------------------------------------

Test for normality of residual -
  Null hypothesis: error is normally distributed
  Test statistic: Chi-square(2) = 42.0185
  with p-value = 7.51281e-010

Test for ARCH of order 4 -
  Null hypothesis: no ARCH effect is present
  Test statistic: LM = 0.471817
  with p-value = P(Chi-square(4) > 0.471817) = 0.976186
```

Source: author's calculation, Gretl software

Appendix C: Unit-root tests

Table 8: Results of Augmented Dickey-Fuller test on variables

Data name (unit)	asymptotic p-value of test with constant	**Data name**	asymptotic p-value of test with constant
Investment volume, nominal values (€ million)	$7.437e^{-005}$	**Private consumption, % change qoq (%)**	$3.419e^{-006}$
10-year government bond yield, change qoq (%)	$2.584e^{-009}$	**Unemploy-ment rate, first difference, change qoq (%)**	0.005468
Inflation rate, first difference, change qoq (%)	0.00019	**Portfolio CRECVI index, first difference (index)**	0.04834
Interest rate spread, first difference, change qoq (%)	$5.846e^{-013}$		

Source: author's calculations using Gretl software

Note: maximum 4 lags, criterion BIC, data from Q1 2001 to Q3 2017.

In Augmented Dickey-Fuller tests, the null hypothesis is that there is a unit root in the sample time series. When p-value < 0.05, null hypothesis can be rejected, proving that no unit root is present. According to the above p-values, all data series are without unit root, i.e. they are stationary.

Appendix D: F-test for seasonality

Test 1: F-tests - investment volume (nominal form)

(a) Q1 2001 - Q3 2017

```
D 8.A  F-tests for seasonality
   Test for the presence of seasonality assuming stability.

                    Sum of squares  Dgrs.freedom  Mean square      F-value
 Between quarters       49508.5221         3      16502.84070       1.441
         Residual      721250.1102        63      11448.41445
            Total      770758.6323        66

             No evidence of stable seasonality at the 0.1 per cent level.

 Nonparametric Test for the Presence of Seasonality Assuming Stability

          Kruskal-Wallis statistic  Dgrs.freedom  Probability level
                            5.6953         3          12.741%

           No evidence of seasonality at the one percent level.

 Moving Seasonality Test

                    Sum of squares  Dgrs.freedom  Mean square      F-value
    Between Years       105698.5783        15      7046.571889       1.475
            Error       214965.2256        45      4777.005013

           No evidence of moving seasonality at the five percent level.

 COMBINED TEST FOR THE PRESENCE OF IDENTIFIABLE SEASONALITY

           IDENTIFIABLE SEASONALITY NOT PRESENT
```

(b) Q1 2001 - Q4 2017

```
D 8.A  F-tests for seasonality
   Test for the presence of seasonality assuming stability.

                    Sum of squares  Dgrs.freedom  Mean square      F-value
 Between quarters      175036.5954         3      58345.53180       4.199*
         Residual      889227.6804        64      13894.18251
            Total     1064264.2758        67

           * No evidence of stable seasonality at the 0.1 per cent level.

 Nonparametric Test for the Presence of Seasonality Assuming Stability

          Kruskal-Wallis statistic  Dgrs.freedom  Probability level
                           11.9674         3           0.750%

           Seasonality present at the one percent level.

 Moving Seasonality Test

                    Sum of squares  Dgrs.freedom  Mean square      F-value
    Between Years        97707.1889        16      6106.699309       0.903
            Error       324496.4722        48      6760.343171

           No evidence of moving seasonality at the five percent level.

 COMBINED TEST FOR THE PRESENCE OF IDENTIFIABLE SEASONALITY

           IDENTIFIABLE SEASONALITY NOT PRESENT
```

Source: author's calculation, Gretl software

Test 2: F-tests for seasonality - portfolio CRECVI index (first difference, q-o-q)

```
D 8.A  F-tests for seasonality
   Test for the presence of seasonality assuming stability.

                    Sum of squares  Dgrs.freedom  Mean square      F-value
 Between quarters          26.2796         3          8.75986       3.744
         Residual         147.4178        63          2.33996
            Total         173.6974        66

             No evidence of stable seasonality at the 0.1 per cent level.

 Nonparametric Test for the Presence of Seasonality Assuming Stability

          Kruskal-Wallis statistic  Dgrs.freedom  Probability level
                           11.0711         3           1.135%

           No evidence of seasonality at the one percent level.

 Moving Seasonality Test

                    Sum of squares  Dgrs.freedom  Mean square      F-value
    Between Years          27.3394        15         1.822627       2.396
            Error          34.2326        45         0.760724

           Moving seasonality present at the five percent level.

 COMBINED TEST FOR THE PRESENCE OF IDENTIFIABLE SEASONALITY

           IDENTIFIABLE SEASONALITY NOT PRESENT
```

Source: author's calculation, Gretl software

Test 3: F-tests for seasonality - 10-year government bond yield (first difference, quarter on quarter)

```
D 8.A  F-tests for seasonality
   Test for the presence of seasonality assuming stability.

                    Sum of squares  Dgrs.freedom  Mean square      F-value
 Between quarters          1.7060         3          0.56866       4.770*
         Residual          7.5106        63          0.11922
            Total          9.2165        66

           * No evidence of stable seasonality at the 0.1 per cent level.

 Nonparametric Test for the Presence of Seasonality Assuming Stability

          Kruskal-Wallis statistic  Dgrs.freedom  Probability level
                           13.3948         3           0.386%

           Seasonality present at the one percent level.

 Moving Seasonality Test

                    Sum of squares  Dgrs.freedom  Mean square      F-value
    Between Years          1.2292        15         0.081948       1.442
            Error          2.5571        45         0.056824

           No evidence of moving seasonality at the five percent level.

 COMBINED TEST FOR THE PRESENCE OF IDENTIFIABLE SEASONALITY

           IDENTIFIABLE SEASONALITY NOT PRESENT
```

Source: author's calculation, Gretl software

Test 4: F-tests for seasonality – interest rate spread

```
D 8.A  F-tests for seasonality
   Test for the presence of seasonality assuming stability.

                    Sum of squares  Dgrs.freedom  Mean square      F-value
 Between quarters          0.7793         3          0.25977        0.593
         Residual         27.5812        63          0.43780
            Total         28.3605        66

             No evidence of stable seasonality at the 0.1 per cent level.

 Nonparametric Test for the Presence of Seasonality Assuming Stability

          Kruskal-Wallis statistic  Dgrs.freedom  Probability level
                            1.2942         3          73.052%

           No evidence of seasonality at the one percent level.

 Moving Seasonality Test

                    Sum of squares  Dgrs.freedom  Mean square      F-value
    Between Years          8.4820        15          0.565465       4.684**
            Error          5.4323        45          0.120718

         **Moving seasonality present at the one percent level.

 COMBINED TEST FOR THE PRESENCE OF IDENTIFIABLE SEASONALITY

           IDENTIFIABLE SEASONALITY NOT PRESENT
```

Source: author's calculation, Gretl software

Appendix E: Summary statistics

Table 9: Summary statistics, Q1 2001 – Q4 2026

Variable	Mean	Median	Minimum	Maximum
PrivConsu_chg	0.58619	0.51120	-1.4513	2.5350
Infl_pc_chg	0.51113	0.44614	-0.40026	2.7470
Unemp_chg	-0.054474	-0.012260	-0.73334	1.1333
i_Spread_chg	0.0092188	-0.0050000	-2.1300	1.8400
GovtBond10Y_chg	-0.037788	0.014060	-0.94000	1.4300
Inv_Vol	334.67	237.16	0.0000	2030.1
PortfoIndex_1dif	2.1927	2.2429	-19.149	13.689
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
PrivConsu_chg	0.57711	0.98452	-0.10586	2.4959
Infl_pc_chg	0.45963	0.89926	1.4212	4.9180
Unemp_chg	0.25813	4.7385	1.2964	5.5655
i_Spread_chg	0.68252	74.036	-0.071242	1.4437
GovtBond10Y_chg	0.40619	10.749	-0.11886	1.2115
Inv_Vol	355.48	1.0622	2.3716	7.1426
PortfoIndex_1dif	5.3618	2.4453	-0.80029	3.0264
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
PrivConsu_chg	-0.41466	1.5482	0.45849	0
Infl_pc_chg	-0.18602	1.3660	0.45938	0
Unemp_chg	-0.42500	0.33333	0.17860	0
i_Spread_chg	-1.0375	1.3725	0.67000	37***
GovtBond10Y_chg	-0.83000	0.62500	0.36750	0
Inv_Vol	8.0550	1159.1	304.79	36**
PortfoIndex_1dif	-7.9930	12.369	4.8721	37***

Source: author's calculation, Gretl software

Note: * Actual data Q1 2001 – Q3 2017, forecast data from Q4 2017 – Q4 2026;

** Actual data Q1 2001 – Q4 2017, no forecast available;

*** Data series from Q1 2001 to Q3 2017, no forecast available.

Appendix F: Outputs of VAR models

Model 3: VAR equation for investment volumes – Version A, 2002:1-2016:4

HAC standard errors, bandwidth 2 (Bartlett kernel), 60 observations

	coefficient	std. error	t-ratio	p-value	
const	267.957	123.766	2.165	0.0382	**
PrivConsu_chg_1	89.6669	50.8916	1.762	0.0879	*
PrivConsu_chg_2	-64.7568	45.5667	-1.421	0.1653	
PrivConsu_chg_3	29.3367	36.5937	0.8017	0.4288	
PrivConsu_chg_4	-85.4843	48.2351	-1.772	0.0862	*
Infl_pc_chg_1	-41.6202	71.0920	-0.5854	0.5625	
Infl_pc_chg_2	-142.091	78.8334	-1.802	0.0812	*
Infl_pc_chg_3	48.2198	59.2965	0.8132	0.4223	
Infl_pc_chg_4	-38.3422	62.0560	-0.6179	0.5412	
Unemp_chg_1	173.305	163.975	1.057	0.2987	
Unemp_chg_2	-290.459	124.064	-2.341	0.0258	**
Unemp_chg_3	-65.8870	112.257	-0.5869	0.5615	
Unemp_chg_4	-130.784	112.341	-1.164	0.2532	
i_Spread_chg_1	31.2059	52.3635	0.5959	0.5555	
i_Spread_chg_2	256.515	76.2421	3.364	0.0021	***
i_Spread_chg_3	97.8144	96.2052	1.017	0.3172	
i_Spread_chg_4	-214.583	92.6378	-2.316	0.0273	**
GovtBond10Y_chg_1	-78.3145	57.9805	-1.351	0.1866	
GovtBond10Y_chg_2	228.668	57.4505	3.980	0.0004	***
GovtBond10Y_chg_3	119.195	78.1455	1.525	0.1373	
GovtBond10Y_chg_4	1.04338	53.8259	0.01938	0.9847	
Inv_Vol_1	0.0463825	0.153608	0.3020	0.7647	
Inv_Vol_2	0.501285	0.159653	3.140	0.0037	***
Inv_Vol_3	0.00365227	0.151058	0.02418	0.9809	
Inv_Vol_4	-0.0933173	0.135592	-0.6882	0.4964	
PortfoIndex_1d~_1	-4.66019	10.2262	-0.4557	0.6518	
PortfoIndex_1d~_2	18.9237	13.0503	1.450	0.1571	
PortfoIndex_1d~_3	24.7106	11.4074	2.166	0.0381	**
PortfoIndex_1d~_4	-30.2192	10.7915	-2.800	0.0087	***

Mean dependent var	320.1877	S.D. dependent var	333.1997
Sum squared resid	2453790	S.E. of regression	281.3441
R-squared	0.625393	Adjusted R-squared	0.287038
F(28, 31)	6.636287	P-value(F)	6.30e-07
rho	-0.033187	Durbin-Watson	1.932623

F-tests of zero restrictions:

All lags of PrivConsu_chg	F(4, 31) =	1.0973	[0.3753]
All lags of Infl_pc_chg	F(4, 31) =	1.3449	[0.2756]
All lags of Unemp_chg	F(4, 31) =	1.7669	[0.1607]
All lags of i_Spread_chg	F(4, 31) =	5.9392	[0.0011]
All lags of GovtBond10Y_chg	F(4, 31) =	4.5616	[0.0052]
All lags of Inv_Vol	F(4, 31) =	2.8480	[0.0404]
All lags of PortfoIndex_1dif	F(4, 31) =	2.3417	[0.0768]
All vars, lag 4	F(7, 31) =	2.3938	[0.0443]

For the system as a whole:

Null hypothesis: the longest lag is 3
Alternative hypothesis: the longest lag is 4
Likelihood ratio test: Chi-square(49) = 106.917 [0.0000]

Comparison of information criteria:
Lag order 4: AIC = 27.3805, BIC = 34.4664, HQC = 30.1522
Lag order 3: AIC = 27.5291, BIC = 32.9046, HQC = 29.6318

Source: author's calculation, Gretl software

Model 4: VAR equation for investment volumes – Version B, 2002:1-2016:4

Equation 2: Inv_Vol
HAC standard errors, bandwidth 2 (Bartlett kernel)

	coefficient	std. error	t-ratio	p-value	
const	156.633	63.6135	2.462	0.0179	**
i_Spread_chg_1	52.9351	51.2757	1.032	0.3077	
i_Spread_chg_2	200.808	89.2731	2.249	0.0297	**
i_Spread_chg_3	22.3175	68.0981	0.3277	0.7447	
i_Spread_chg_4	-212.651	100.133	-2.124	0.0395	**
Inv_Vol_1	0.171713	0.130631	1.314	0.1956	
Inv_Vol_2	0.449693	0.179285	2.508	0.0160	**
Inv_Vol_3	-0.0189477	0.115841	-0.1636	0.8708	
Inv_Vol_4	0.0510030	0.0938018	0.5437	0.5894	
PortfoIndex_1d~_1	3.56711	8.15924	0.4372	0.6642	
PortfoIndex_1d~_2	15.6980	10.8805	1.443	0.1563	
PortfoIndex_1d~_3	23.2756	11.4171	2.039	0.0477	**
PortfoIndex_1d~_4	-18.9141	10.7113	-1.766	0.0845	*
PrivConsu_chg	-73.3494	49.3488	-1.486	0.1445	
Infl_pc_chg	-82.4076	33.7217	-2.444	0.0187	**
Unemp_chg	-15.4125	168.325	-0.09156	0.9275	
GovtBond10Y_chg	-73.6102	71.6269	-1.028	0.3098	

Mean dependent var	320.1877	S.D. dependent var	333.1994
Sum squared resid	3307056	S.E. of regression	277.3234
R-squared	0.495128	Adjusted R-squared	0.307269
F(16, 43)	5.122942	P-value(F)	9.23e-06
rho	0.043827	Durbin-Watson	1.760750

F-tests of zero restrictions:

All lags of i_Spread_chg	F(4, 43) =	2.6177 [0.0481]
All lags of Inv_Vol	F(4, 43) =	2.6401 [0.0466]
All lags of PortfoIndex_1dif	F(4, 43) =	1.6183 [0.1870]
All vars, lag 4	F(3, 43) =	1.6404 [0.1941]

For the system as a whole:

Null hypothesis: the longest lag is 3
Alternative hypothesis: the longest lag is 4
Likelihood ratio test: Chi-square(9) = 16.2468 [0.0619]

Comparison of information criteria:
Lag order 4: AIC = 22.0626, BIC = 23.8428, HQC = 22.7589
Lag order 3: AIC = 22.0334, BIC = 23.4994, HQC = 22.6068

Source: author's calculation, Gretl software