

Krzysztof Adam Nowak

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Krzysztof Adam Nowak 

University of Rzeszów, Department of Financial Markets and Consumer Finance, ul. Ćwiklińskiej 2,
35-601 Rzeszów, Poland
corresponding author: krnowak@ur.edu.pl

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Impact of Different Economic Areas on Yield Rates in the V4's Capitals' Office Markets

Abstract

The aim of the article is twofold. Its first goal is to identify the primary economic areas generating determinants that cause fluctuations of yield rates in the office markets in Bratislava, Budapest, Prague and Warsaw. To achieve this, four sets of potential determinants were predefined: the National, the Visegrád Group, the European Monetary Union, and the USA. The second goal of the study is to verify potential asymmetric dependencies that impact the yield rates. The study was conducted with a use of the autoregressive distributed lag model (ARDL) and its nonlinear equivalent (NARDL). The main conclusion of the study is that the four office markets do not follow a homogenous pattern when it comes to determinants of the yield rates. In accordance with this, variables of different economic areas best fit the ARDL model in each city — particularly inflation rates and interest rates on government bonds, which impacted the yield rates with the largest magnitude. Asymmetric relationships were also found between the yield rate and independent variables, especially the inflation rate, S&P stock index, and rent growth rate in Bratislava.

Keywords

yield rate | capitalization rate | office market | the Autoregressive Distributed Lag model (ARDL) | the Nonlinear Autoregressive Distributed Lag model (NARDL)

JEL Codes

R33, G15

1. Introduction

The evaluation of real estate cap/yield rate determinants has been of interest for a long time (see, e.g., Sirmans & Webb, 1978). Since the 1990s, there have also been a great deal of publications on the time series specifically affecting the office cap/yield rates. According to the oft-recalled approach proposed by Sivitanidou and Sivitanides (1999), local market factors, together with the capital market, wield the most influence over the office cap/yield rate. The importance of the capital market was particularly strongly indicated by Jud and Winkler (1995), as well as McGough and Tsolacos (2001). Many studies apply macro variables with a focus on the impact of monetary liquidity (Chervachidze et al., 2009). The emphasis is often put on the fact that the office market, to a great extent, has become a global market. This, in turn, indicates the growing influence of international capital flows on the current state of the market in a particular city (McAllister &

Nanda, 2016). In that case, the spillover effect should be visible, especially in the relatively small office markets that function within small open economies. However, most articles covering office cap/yield rates focus on the office markets in Western Europe, the USA, Australia, and Asia. There is a lack of such studies on Central and Eastern Europe (CEE) cities that fit into the aforementioned mould.

The contribution of this article lies its efforts to fill the research gap on the CEE office markets. To the best of our knowledge, it is the first paper that identifies the determinants of yield rates in the capitals of Slovakia, Hungary, Czech Republic, and Poland. A specific trait of the office markets in the capital cities of the Visegrád Group countries is that cross-border capital flows play a substantial role. Moreover, when it comes to modern office space (the subject of this study), buy/sell transactions, as well as leasing contracts, are typically concluded in euros, not in local currencies.

Thus, in this study, four sets of explanatory variables were deployed for each of the four office markets. One represented the national dataset; one depicted the interrelations of the Visegrád Group; and two additional ones expressed factors related to the European Monetary Union (the EMU) and the USA. Our findings indicate that, in each city, different ensembles of variables dominate. This proves that particular variables representing each of the groups of factors — the monetary and the capital market impacts, the local market situation, and the state of the economy — explain the volatility of yield rates within the Gordon growth approach. Asymmetric relationships were confirmed only for the office market in Bratislava. The models were built using an autoregressive distributed lag (ARDL) framework, together with the nonlinear autoregressive distributed lag (NARDL) approach.

The paper is organised as follows. The next section details the literature background and research approach; this is followed by presentations of the data and methodology. In the fifth section, the results are reported, and this is followed by a discussion section. The conclusions contain the main findings and references to the research questions.

2. Literature background and concept of the study

The models on the profitability of investing in commercial real estate can generally be divided into two groups. In the first case, the dependent variable is the cap/yield rate or the risk premium. In the second group, the explained variables are the NOI (net operating income), rent growth, and returns (e.g. Plazzi et al., 2008). There are some differences between cap/yield rates and total returns — high total returns are good for an investor, while high/rising yields may indicate falling capital values and thus decreasing total returns. Literature on both is recalled below, since in both approaches, similar independent variables are usually used. The disparities fade away, however, when the initial yield is under consideration, as in this study.

Sivitanidou and Sivitanides (1999) calculated the impact of the local market characteristics and the influence of the capital market on office cap rates. Initially, the local factors in the literature were most often reflected in the market vacancy rate, rent, net

absorption, and the state of the economy at the local level (e.g., employment levels). The second group contained yields of government bonds, yield spread between government and corporate bonds, term spread, default risk, and the like.

In the 21st century, this basic division has solidified but also transformed. The impact of local circumstances is often investigated using spatial analysis, digging deeper into transaction data and local conditions. Studies based on transaction data mainly point out the influence of a building's features — such as location, building space stock, its vacancy rate, and the quality of the building (e.g., its age or degree of wear) — on its cap/yield rate (McDonald & Dermisi, 2008, 2009; McDonald, 2015). In that context, inter-market location is also often of interest (Netzell, 2009; Unbehaun & Fuerst, 2018). As far as the effects of the local factors are concerned, the variables express development factors, such as unemployment (De Wit & Van Dijk, 2003) or population growth (Chuangdumrongsomsuk & Fuerst, 2017), but also more advanced data. Bialkowski et al. (2023) included variables derived from urban models that indicate the importance of an urban agglomeration's externalities, such as its public transportation, commute times, job density, its proximity to IT universities and technology centres, and its GDP per capita. In their in-depth spatial study, Sirmans et al. (2023) examined the impact of the characteristics of US Metropolitan Statistical Areas, such as size, wealth, poverty, crime etc., on retail cap rates.

The second group of variables (reflecting the capital market influence) can be nowadays referred to as “macro,” or, to some extent, even global factors. In this context, links between the stock market and commercial real estate are quite widely described in the literature (e.g. Quan & Titman, 1997; Hendershott & MacGregor, 2005). GDP at the national level is also applied (Wang & Hartzell, 2021), and measurements of market sentiment and risk are also referenced (McGough & Berry, 2020).

However, there are two main topics that prevail in the literature when it comes to modelling cap/yield rates or returns in the office market with the use of macro data: liquidity and globalisation. Ametefe et al. (2016) argued that it is liquidity that plays the most critical role for both public and private real estate. Monetary liquidity is expected to negatively impact yield rates, and this has borne out in numerous studies (e.g. Devaney et al., 2019; Kim et al., 2019). Monetary variables usually express the impact of

money aggregates and debt, which are often applied in proportion with the GDP (e.g. Chervachidze et al., 2009; Chervachidze & Wheaton, 2013). Inflation rates are also used in this manner (De Wit & Van Dijk, 2003; Bialkowski et al., 2023) as they are linked to monetary policy and liquidity.

Liquidity — defined as the amount of capital on the market — can stem from macroeconomic factors, but it can also be an outcome of international financial flows, including globalisation. The commercial real estate market is an increasingly globalised market with international capital flows. Foreign money entering the market results in real estate price increases, which, in turn, bring the cap/yield rates down. Such an impact of foreign investment was proven by Oikarinen and Falkenbach (2017) and by McAllister and Nanda (2015, 2016). The number and size of transactions made by foreign investors can reflect the impact of globalisation.

Variables representing the foreign financial, economic, or monetary situation can also be of use. For instance, Coën et al. (2018) exercised monetary index consisting of M2 aggregates of countries from which investment capital came to the Central London office market, weighted by its share of the total capital inflow. Exchange rates could also work as monetary determinants of cap/yield rates if they are seen as implicative of office building prices in foreign currency. In that way they stimulate foreign capital inflows, as the prices serve as the denominator of office cap/yield rates.

The globalisation of the office market also creates an impetus for studies simultaneously exploring several different office markets, often from multiple countries. It can then be verified whether the cap/yield rates follow the same path, whether the same factors affect them in each market, and if they do so in the same fashion. Interestingly, this is frequently found not to be the case. Chuangdumrongsomsuk and Fuerst (2017) found that the drivers of capitalisation rates varied considerably across New York City, Chicago, and Los Angeles. Sivitanides et al. (2001) attributed the differences in cap/yield rates across markets to fixed market characteristics and investors' perceptions regarding expectations of the risk-income relation. It should be pointed out that one effect of globalisation is increasing transparency in local office markets, which means easier access for foreign investors and greater confidence on their part (Eichholtz et al., 2011). However, it also results in accumulating convergence that can limit the ability of investors to

build appropriately diversified portfolios (Lee, 2017). Oertel et al. (2020), on the other hand, found that the relative attractiveness (i.e. risk premia) of office real estate markets affects cross-border capital inflows.

Asymmetric, non-linear relationships between the cap/yield rate and factors affecting it are another topic that shows up in the literature, with many papers presenting various approaches (e.g. Bruneau & Cherfouh, 2018; Beracha et al., 2019; Nowak, 2024).

Some studies work on the market-dominant cap/yield rate and some on the data from office building sale transactions. The latter are far fewer in number due to the frequent scarcity and inaccessibility of data, especially in emerging markets. For this reason, we used time series of the prevailing yield rates in the four office markets. Many papers are based on the Gordon growth model (Peyton, 2009) or the Capital Asset Pricing Model (Jud & Winkler, 1995; McDonald & Dermisi, 2009). In this article, the list of determinants of the yield rates fits into the Gordon growth model, which equates the yield rate to the sum of the risk-free interest rate and the risk premium, minus cash flow growth.

Table 1 presents indicators of particular elements of the Gordon growth model. The risk-free interest rates are delineated by interest on government bonds. There are four types of risk premium: monetary, indicated by M3, HICP and exchange rates; alternative investments, conveyed by stock indices; country-specific, captured by GDP growth rate; and local market, embodied by Vacant space / Net absorption. Last, but not least, cash-flow growth is embodied by rent growth rate.

Individual elements of the Gordon growth model can be local, national, regional or international in nature. The four office markets function within small, open economies, where monetary spill-overs, capital flows and outside impacts from advanced economies are visible. The Visegrád Group countries are closely interconnected at the historical and geographical levels, and are close when it comes to level of economic development and demographic trends. Hungary, the Czech Republic, and Poland are EU members, while Slovakia is also a member of the EMU. Contiguity and distance (Lepers, 2024) dictate including the EMU as a CRE capital in-flow source. Moreover, at each of the four markets, the euro remains the currency of settlements. The USA is a worldwide capital provider, and this also spans commercial real estate markets.

Table 1. The independent variables in ARDL and NARDL models

Types of variables according to the Gordon growth model	Variables characteristics	Economic areas' sets of variables			
		The National	The V4	The EMU	The USA
Risk-free interest rates	Government bonds interest (10-yr)	SK, HU, CZ, PL	Average in V4 countries	EMU	USA
Monetary (risk premium)	M3 monetary aggregate	EMU, HU, CZ, PL	-	EMU	USA
	HICP inflation rate	SK, HU, CZ, PL	Average in V4 countries	EMU	USA
	Exchange rates	-	-	National currency/EUR	National currency/USD
Alternative investments (risk premium)	Stock indices	SAX, BUX, PX, WIG20	CETOP	DAX	S&P 500
Country specific (risk premium)	GDP growth rate qoq	SK, HU, CZ, PL	Average in V4 countries	EMU	USA
Office market characteristics (risk premium)	Vacancy/net absorption*	Bratislava, Budapest, Prague, Warsaw	Bratislava, Budapest, Prague, Warsaw	Bratislava, Budapest, Prague, Warsaw	Bratislava, Budapest, Prague, Warsaw
Cash flow growth	Rent growth rate				

*In Budapest, due to data accessibility issues, the time series represent vacancy divided by gross take-up.

Source: own elaboration, from the following sources: the time series reflecting the characteristics of the office markets (i.e. yield rate, prime rent, vacant space and net absorption/gross take-up) were obtained from Colliers International Poland; yields of 10-year government bonds were from fred.stlouisfed.org, sdw.ecb.europa.eu, and www.investing.com; stock indices were from bsse.sk, bse.hu, investing.com, and marketwatch.com; M3 and GDP were from fred.stlouisfed.org; HICP was from ec.europa.eu; and exchange rates were from fred.stlouisfed.org, mnb.hu, cnb.cz, and nbp.pl.

Application of time series of the four economic areas — national, V4 (regional), the EMU (continental) and the USA (international) — is also legitimised by the hard data. According to Colliers (Jędrak et al., 2023), in CEE-6, the main sources of CRE capital flows in 2022 were region-domestic capital (38%), European (21.5%) and American (20.5%). This is pretty much confirmed by Cushman & Wakefield (2025). However, that report also points out differences when it comes to the predominant origin of capital. In Czech Republic, Hungary and Slovakia, the key role is played by CEE capital, while in Poland, Western European capital accounts for the highest investment volume. However, the sources of capital have been changing with time. Before and at the beginning of the Covid-19 pandemic, cross-border investors from Western Europe and the USA exhibited stronger commitment to the region, but in last few years, one can observe the national and regional investments being more visible (Savills, 2020; Cushman & Wakefield, 2025). We also acknowledge the need to examine the impact of indicators representing the four different economic areas.

The above literature analysis shows that explanatory variables can be local, national or international in character. With this in mind, we widened the scope of the study to include regional data. There are four main groups of factors: the local market situation; monetary conditions; the capital market; and the economic situation. Furthermore, the time series employed in the study covers the period of the Covid-19 pandemic and the Russian aggression on Ukraine, which may imply nonlinear relationships. In order to address the three scopes of issues, the following research questions were formulated:

Research question 1: Which of the following economic areas' sets of variables i.e. the National, the V4, the EMU, and the USA, best explain the fluctuations of the yield rates in the four office markets?

Research question 2: Which variables representing the consecutive groups of factors — i.e., monetary influence, capital market factors, economic situation, and local market factors — have the strongest impact on yield rates?

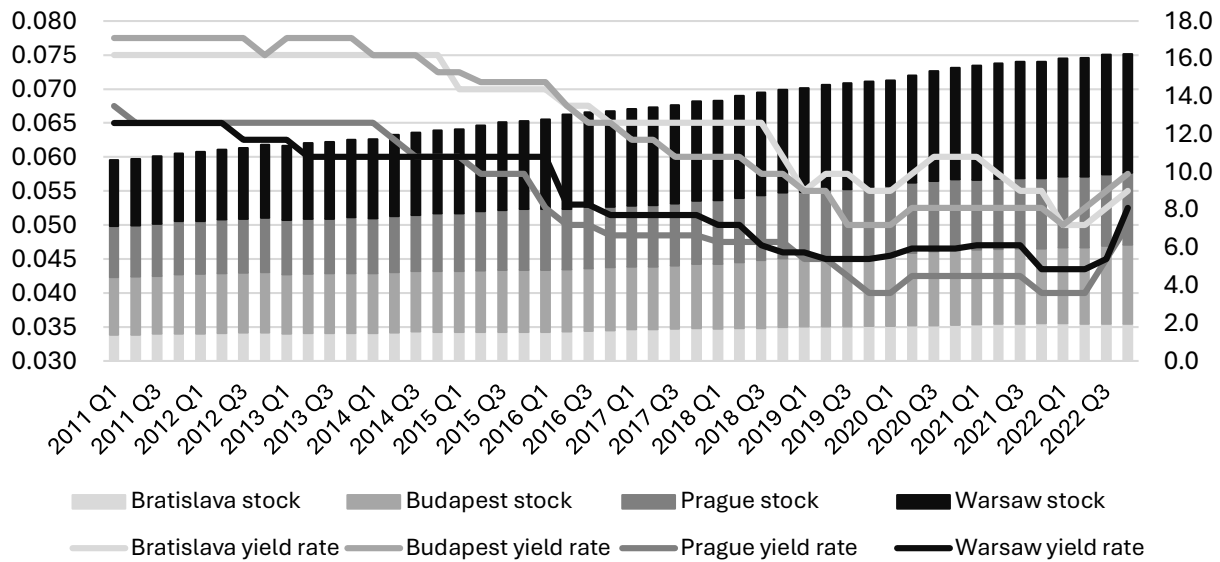


Figure 1. The yield rates (left axis) and total office stock (right axis, in M/Sqm.) on the office markets in Bratislava, Budapest, Prague and Warsaw, Q1 2011 to Q4 2022.
Source: own elaboration on data provided by Colliers International Polska

Research question 3: Do the explanatory variables also impact the yield rates in an asymmetric manner?

3. Data

The study is based on quarterly data for the period Q1 2011 to Q4 2022. Data availability is always problematic on private markets like the office market. As a result, studies based on single-cycle data time ranges using a similar methodological approach are not uncommon — e.g. Gupta et al. (2020), Mintah et al. (2020), Liow (2006), and Wong et al. (2023). The variables being explained in the study are the yield rates in the office markets in Bratislava, Budapest, Prague and Warsaw. The dependent variable in each city is the gross market-dominant initial prime yield rate in particular periods for prime buildings that have been commercialised and that have been the subject of sale transactions. The yield rate represents the relationship between the net operating income (NOI) and the price paid by the buyer of the building, as provided by Colliers International Poland. Neither tenant incentives nor transaction costs are factored into the rent and purchase prices.

Figure 1 plots a time series of the four office yield rates, which can be divided into three sub-periods representing three different tendencies. The first encompasses the time period from Q1 2011 until mid-2014, and depicts fairly stable yield rates with only slight reductions. The period from mid-2014 until

Q1 2020 has an evident decreasing trend. Finally, the last part of the graph, from 2020 onward, ends the declining trend and brings with it moderate increases. Bialkowski et al. (2023) and Devaney et al. (2019) stated that the greater the amount of the total office stock in the market, the lower the yield rates. The total stock of office space is the lowest in Bratislava and the highest in Warsaw, and the yield rate in the first city is, in fact, higher than in the second. However, most of the time, the lowest yield rate was recorded in Prague.

Table 2 illustrates the descriptive statistics of the variables used in the final models. It should be borne in mind that the time series used in the study represent nominal data. This is because one of the key issues in the study was the verification of the impact of inflation itself on the yield rates.

4. Methodology

As far as the econometric methods are concerned, many studies on office cap/yield rates or returns utilize the Vector Autoregression approach (Coën et al., 2018), the Error Correction Model (Nowak, 2024), or the Vector Error Correction Model (Larriba & Linneman, 2021) within the OLS framework. The ARDL approach has been used in several studies regarding the real estate market (Liow, 2006; Lee, 2013; Gupta et al., 2020), bearing in mind that studies regarding solely the office market are a rarity. The same is true for NARDL

Table 2. Descriptive statistics of time series employed in the final models

Time series	Yield rate	Yield rate	Yield rate	Yield rate	Gover- nment Bonds (10-yr)	Gover- nment Bonds (10-yr)	Gover- nment Bonds (10-yr)	Gover- nment Bonds (10-yr)	M3 ag- regate	HICP inflation	HICP inflation	HICP inflation
Variable code	BRY	BUY	PRY	WAY	B10C	B10V4	B10E	B10U	M3C	HICPC	HICPV4	HICPE
Area	Bratislava	Budapest	Prague	Warsaw	Czechia	Visegrad group	EMU	USA	Czechia	Czechia	Visegrad group	EMU
Unit	%	%	%	%	%	%	%	%	Points (2015 = 100)	Rate of change	Rate of change	Rate of change
Min.	0.050	0.050	0.040	0.044	0.0025	0.0096	-0.0009	0.0065	79.60	-0.0079	-0.0079	-0.0069
Max.	0.075	0.078	0.068	0.065	0.0538	0.0630	0.0449	0.0383	175.46	0.0797	0.0534	0.0363
Mean	0.066	0.065	0.053	0.054	0.0200	0.0293	0.0169	0.0218	120.39	0.0082	0.0087	0.0050
S.D.	0.008	0.010	0.009	0.007	0.0127	0.0154	0.0127	0.0068	29.73	0.0144	0.0126	0.0075
Time series	HICP inflation	Stock index	Stock index	GDP	GDP	GDP	GDP	Exchange rate	Exchange rate	Vacant stock/ Net Absorp- tion*	Vacant stock/ Net Absorp- tion*	Vacant stock/ Net Absorp- tion*
Variable code	HICPU	CETOP1	SNPI	GDPC	GDPV4	GDPE	GDPU	PLNUSD	USDEUR	BRVSNA	PRVSNA	WAVSNA
Area	USA	Central Europe	USA	Czechia	Visegrad group	EU	USA	Poland/ USA	USA/EMU	Bratislava	Prague	Warsaw
Unit	Rate of change	Points	Points	Growth rate	Growth rate	Growth rate	Growth rate	PLN	USD	Sqm.	Sqm.	Sqm.
Min.	-0.0199	1,478.33	1,131.42	-8.736	-9.956	-11.395	-7.891	2.752	0.978	1.813	-622.36	-83.70
Max.	0.0374	2,515.03	4,766.18	7.376	8.875	12.140	7.759	4.953	1.452	18.607	185.28	523.58
Mean	0.0058	1,926.66	2,511.14	0.477	0.641	0.293	0.573	3.660	1.194	7.756	-1.85	15.34
S.D.	0.0119	241.73	945.58	1.872	2.041	2.507	1.685	0.440	0.110	3.946	96.92	78.20
Time series	Rent growth rate	Rent growth rate	Rent growth rate	Rent growth rate	-	-	-	-	-	-	-	-
Variable code	BRRGR	BURGR	PRRGR	WARGR	-	-	-	-	-	-	-	-
Area	Bratislava	Budapest	Prague	Warsaw	-	-	-	-	-	-	-	-
Unit	Growth rate	Growth rate	Growth rate	Growth rate	-	-	-	-	-	-	-	-
Min.	-0.070	-0.100	-0.035	-0.042	-	-	-	-	-	-	-	-
Max.	0.065	0.056	0.067	0.136	-	-	-	-	-	-	-	-
Mean	0.003	0.003	0.006	0.002	-	-	-	-	-	-	-	-
S.D.	0.023	0.023	0.018	0.028	-	-	-	-	-	-	-	-

Source: own elaboration. Note: due to space limitations, Table 2 provides only descriptive statistics of the time series used in the final models. Descriptive statistics of the all-time series applied in the study are available upon request

*The values of VSNA may differ significantly as a result of quarterly oscillations in absorption.

(Rehman et. al. 2020; Mehta et al., 2023; Gluszak & Trojanek, 2024). There have been a few papers on the commercial real estate market in Australia that implement the ARDL approach in determining cap rates (Wong et al., 2023) or total returns (Mintah et al., 2020). Wang and Hartzell (2021) applied ARDL to a study of housing and commercial real estate returns in Hong Kong. Regardless, the ARDL framework is not a dominant research method when it comes to the office market, but there are advantages to its use.

The ARDL modelling approach proposed by Pesaran and Shin (1999) makes it possible to verify both short-term and long-term dependencies, as does the Error-Correction Model (ECM) approach initiated by Engle and Granger (1987). However, an advantage of the ARDL over the ECM is that the former can be based on time series that are mixed or those that are stationary at $I(0)$ or $I(1)$, potentially widening the range of time series that can be used in the study. Equation (1) shows the basic form of the error-correction ARDL approach.

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^p \beta_i \Delta Y_{t-i} + \sum_{j=0}^q \gamma_j \Delta X_{t-j} + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + u_t \quad (1)$$

The ARDL and the NARDL are based on the bounds testing approach developed by Pesaran et al. (2001) and Shin et al. (2014). The NARDL makes it possible to examine nonlinear relationships between yield rates and explanatory variables, as it decomposes independent variables into positive and negative partial sums. This is shown in equation (2). In that way, one can verify whether there are asymmetric long-run and short-run dependencies on positive and negative changes of explanatory variables.

$$\Delta Y_t = \alpha + \sum_{i=1}^{p-1} \beta_i \Delta Y_{t-i} + \sum_{j=0}^{q-1} \gamma_j^+ \Delta X_{t-j}^+ + \sum_{j=0}^{q-1} \gamma_j^- \Delta X_{t-j}^- + \delta_1 Y_{t-1} + \delta_2^+ X_{t-1}^+ + \delta_2^- X_{t-1}^- + u_t \quad (2)$$

Where: $\Delta Y_t, \Delta Y_{t-i}, \Delta Y_{t-1}$ = differenced and level dependent variables; $\Delta X_{t-j}, X_{t-1}$ = differenced and level explanatory variables; $\Delta X_{t-j}^+, \Delta X_{t-j}^-, X_{t-1}^+, X_{t-1}^-$ = differenced, level, positive and negative partial sums of explanatory variables; α_0, α = constants; δ_1 = a coefficient reflecting the speed of the adjustment process; $\beta_i, \gamma_j, \gamma_j^+, \gamma_j^-$ = coefficients indicating the short-run relationship between the dependent and explanatory variables; $\delta_2, \delta_2^+, \delta_2^-$ = coefficients indicating the long-run relationship

between the dependent and explanatory variables; and u_t = error term.

The first step of the study procedure was to determine the time series' order of stationarity using the ADF test. A correlation matrix was then formulated. For each economic area in each city, a list of independent variables of the models was formed using variables stationary at order [0] or [1], as well as ones that did not exhibit a statistically significant correlation with a magnitude of 0.5 or higher. For a given economic area, the detection of a correlation resulted in several versions of the model with various lists of independent variables, as one of the two correlated variables was dropped. Next, the models were formulated within the ARDL error-correction formula, with the number of lags determined by Akaike's information criterion (AIC) — though this was constrained by the number of lags allowed by the Stata software based on the number of degrees of freedom.

Then, cointegration among the variables was verified using the Bounds test. If the test indicated cointegration, the long-run relationship in the model was also considered proven (in addition to the short-run), and the error-correction form of the model was anticipated as the final one. If there was no cointegration, the model was re-run on first-differenced variables, i.e. indicating only the short-run relationship.

The following post-estimation tests were used to assure the econometric fit of the final version of each ARDL model: the Breusch-Godfrey test (autocorrelation); the White test together with the Breusch-Pagan test (heteroscedasticity); the Jarque-Bera test and the Shapiro-Wilk test (residuals' normality). Models with inappropriate post-estimation test results were dismissed, and the final ARDL model for each city was picked using the best model based on the adj. R^2 . In the case of two close adj. R^2 results, the number of statistically significant variables was considered conclusive.

Afterwards, the NARDL models were defined based on the list of variables used in the regular ARDL models, though variables with detected collinearity were omitted. The aim here was to determine models conveying asymmetric relationships within an error-correction framework, so models with rejected cointegration were dropped. Similarly, models were dismissed if they yielded inappropriate results from the Portmanteau test (serial correlation), the Breusch-Pagan test (heteroscedasticity), the Ramsey RESET

Table 3. Results of the ADF stationarity test of time series employed in the final ARDL and NARDL models

BRATISLAVA – the V4 dataset (ARDL)								
Variable		BRY	B10V4	HICPV4	CETOP1	GDPV4	BRVSNA	BRRGR
Levels	Test statistic	-0.864	-2.281	-2.486	-3.246**	-5.985***	-2.417	-4.611***
First differences	Test statistic	-5.010***	-2.848*	-7.630***	-5.566***	-	-6.661***	-
BUDAPEST – the EMU dataset (ARDL)								
Variable		BUY	B10E	HICPE	GDPE	BURGR	-	-
Levels	Test statistic	-1.141	-2.078	-2.664*	-6.690***	-3.588**	-	-
First differences	Test statistic	-3.131**	-3.683***	-6.960***	-	-6.284***	-	-
PRAGUE – the NATIONAL dataset (ARDL)								
Variable		PRY	B10C	M3C	HICPC	GDPC	PRVSNA	PRRGR
Levels	Test statistic	-1.481	-0.897	0.360	-3.926	-5.883***	-4.564***	-1.996
First differences	Test statistic	-2.988**	-3.565**	-4.499***	-6.677***	-	-	-7.200***
WARSAW – the USA dataset (ARDL)								
Variable		WAY	B10U	HICPU	PLNUSD	GDPU	WAVSNA	WARGR
Levels	Test statistic	-1.018	-2.165	-4.566***	-1.096	-6.499***	-4.524***	-3.513
First differences	Test statistic	-2.524**	-3.285**	-	-5.656***	-	-	-6.799***
BRATISLAVA – the USA dataset (NARDL)								
Variable		BRY	HICPU	USDEUR	SNPI	GDPU	BRVSNA	BRRGR
Levels	Test statistic	-4.566***	-4.566***	-1.864	-1.631	-6.499***	-2.417	-4.611***
First differences	Test statistic	-	-	-4.358***	-5.273***	-	-6.661***	-

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Source: own elaboration Note: The ADF test was conducted with 1 lag; the WAY test was performed with no constant; tests on first differences were run when there was a lack of stationarity at $p = 0.01$ on the level time series.

test (general specification), and/or the Jarque-Bera test (normality). Finally, the Wald test was performed on both the long-run and short-run variables to confirm the asymmetric dependency. The study was performed using Stata software.

5. Results

5.1. The ARDL Models

According to results of the ADF test, shown in Table 3, all the time series applied in the following models were stationary at order [0] or [1]. The models were formulated as to avoid including variables that were

statistically significantly correlated with a magnitude of 0.5 or higher. This approach resulted in a few different iterations of the models for each dataset and each city. Due to space constraints, the results of the ARDL models present only the final models for each office market.

Based on the aforementioned selection criteria (postestimation tests, adj. R^2 , number of statistically significant variables) the final models for each city were as follows: Bratislava on the V4 dataset, Budapest on the EMU dataset, Prague on the National dataset, and Warsaw on the USA dataset. Table 4 shows the results of the Bounds tests. Cointegration was detected only in the case of the office market in Budapest. This means that the final model for the city takes into

Table 4. Results of the Bounds cointegration test (Case 3)

BRATISLAVA – the V4 dataset						
p levels of critical values	10%		5%		1%	
Lower and upper bounds	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-statistics	2.364	2.284	3.728	2.760	4.412	6.059
t-statistics	-0.491	-2.427	-3.896	-2.805	-4.358	-5.304
BUDAPEST – the EMU dataset						
p levels of critical values	10%		5%		1%	
Lower and upper bounds	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-statistics	9.379***	2.598	3.883	3.150	4.606	6.308
t-statistics	-5.382***	-2.508	-3.619	-2.864	-4.032	-4.866
PRAGUE – the NATIONAL dataset						
p levels of critical values	10%		5%		1%	
Lower and upper bounds	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-statistics	7.606	2.328	3.658	2.794	4.299	5.821
t-statistics	-1.813	-2.493	-3.973	-2.854	-4.413	-5.306
WARSAW – the USA dataset						
p levels of critical values	10%		5%		1%	
Lower and upper bounds	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
F-statistics	6.283	2.291	3.717	2.765	4.393	6.020
t-statistics	-0.519	-2.438	-3.909	-2.813	-4.367	-5.304

***rejection of the null hypothesis of no long-run relationship at levels at $p < 0.01$. Source: own elaboration

account variables on levels in addition to variables on differences — i.e., it expresses relationships in both the long-term and short-term. In contrast, the final models for the other three cities were formulated only on the differenced time series — i.e., they only depict short-term relationships.

The final models for each of the office markets are presented in Table 5. The adj. R^2 of the four equations ranges from 0.5002 to 0.7098. As far as the results for Bratislava are concerned, statistically significant lags of variable representing government bonds' interest DB10V4, taken together, negatively impacted the yield rate with a magnitude of -0.33, as did rent growth rate DBRRGR and its three lags (-0.15). A 1% increase in change of the CETOP stock index resulted in a -0.02% decrease of the yield rate in Bratislava. On the other hand, a positive impact was seen from four lags of V4 inflation DHICPV4 (0.87), GDP growth rate DGDVP4 and its two lags (0.002), as well as two lags of relation of vacant stock to net absorption DBRVSN4 (0.0006).

In the case of Budapest, the adjustment variable BUYL1 (lagged yield rate) is negative, which indicates that the model is not of an explosive pattern. In other words, there was a long-run convergence, as 0.19 of the previous variation of the yield rate is corrected in the current period. The GDP growth rate in the EMU was statistically insignificant. A 1% increase in interest rate of 10-year government bonds B10E, the EMU inflation rate HICPE, and the rent growth rate BURGR created, respectively, a 0.88% yield rate increase, and decreases of 0.50% and 0.35%. The lags of the differenced yield rate DBUYL1 were also negative (-0.69). Interestingly, the impact of the other short-run variables was the opposite of the long-run — i.e., inflation rate DHICPE (0.08), and rent growth rate DBURGR and its lag, were positive (0.04).

When it comes to the office market in Prague, the continuation of this trend is visible, as the impact of the lagged dependent variable DPRYL1 is positive (0.55). The joint influence of the statistically significant lags of government bonds' interest DB10C on the yield

Table 5. The final ARDL models explaining the yield rate on each of the office markets.

BRATISLAVA – The V4 dataset			BUDAPEST – The EMU dataset			PRAGUE – The National dataset			WARSAW – The USA dataset		
Independent variables	Coefficient	Std. Err.	Independent variables	Coefficient	Std. Err.	Independent variables	Coefficient	Std. Err.	Independent variables	Coefficient	Std. Err.
Intercept	-0.0009***	0.0003	Adjustment variable			Intercept	0.0001	0.0005	Intercept	-0.0002	0.0002
DBRYL1	0.1824	0.1775	BUYL1	-0.1949***	0.0362	DPRYL1	0.5501***	0.1713	DWAYL1	0.2289	0.1621
DB10V4	-0.0182	0.1103	Long-run variables			DB10C	-0.0498	0.0598	DWAYL2	0.3239*	0.1811
DB10V4L1	-0.2948**	0.1003	B10E	0.8843***	0.1105	DB10CL1	0.0558	0.0524	DB10U	-0.0552	0.0761
DB10V4L2	-0.1117	0.0814	HICPE	-0.5047***	0.1480	DB10CL2	0.1241**	0.0535	DB10UL1	0.1674**	0.0749
DB10V4L3	0.2436**	0.0872	GDPE	0.0004	0.0004	DB10CL3	-0.1933***	0.0591	DHICPU	-0.0306*	0.0172
DB10V4L4	-0.2822**	0.0993	BURGR	-0.3462***	0.0919	DM3C	0.0305	0.0284	DHICPUL1	-0.0617***	0.0173
DHICPV4	-0.0693	0.0679	Short-run variables			DM3CL1	-0.0501*	0.0269	DPLNUSD	0.0012	0.0013
DHICPV4L1	0.2485***	0.0747	DBUYL1	-0.3789***	0.1323	DHICPC	-0.0518**	0.0189	DPLNUSD1	0.0001	0.0014
DHICPV4L2	0.1277*	0.0645	DBUYL2	-0.1405	0.1457	DHICPCL1	0.0155	0.0236	DPLNUSD2	-0.0012	0.0015
DHICPV4L3	0.2561***	0.0803	DBUYL3	-0.3115*	0.1582	DHICPCL2	0.0534**	0.0248	DPLNUSD3	0.0034**	0.0014
DHICPV4L4	0.2384***	0.0585	DHICPE	0.0763**	0.0363	DHICPCL3	0.0296	0.0275	DGDPU	0.0009***	0.0002
DCETOP1	-0.0218***	0.0041	DBURGR	0.0212*	0.0124	DHICPCL4	0.0849***	0.0272	DWAVSNA	7.80e-06**	3.07e-06
DCETOP1L1	0.0053	0.0039	DBURGRL1	0.0223**	0.0094	DGDPC	0.0001**	0.0001	DWAVSNA1	-3.50e-06	2.87e-06
DCETOP1L2	-0.0016	0.0030	Intercept	0.0098***	0.0021	DPRVSNA	2.44e-06*	1.23e-06	DWAVSNA2	0.00001***	2.80e-06
DCETOP1L3	0.0023	0.0031	-	-	-	DPRRGR	-0.0091	0.0119	DWARGR	0.0089	0.0079
DCETOP1L4	-0.0038	0.0025	-	-	-	DPRRGRL1	0.0249*	0.0131	DWARGRL1	0.0044	0.0088
DGDPV4	0.0007***	0.0002	-	-	-	-	-	-	DWARGRL2	0.0552***	0.0127
DGDPV4L1	0.0006**	0.0002	-	-	-	-	-	-	DWARGRL3	-0.0488***	0.0142
DGDPV4L2	0.0005**	0.0002	-	-	-	-	-	-	DWARGRL4	0.0274***	0.0093
DGDPV4L3	0.0002	0.0001	-	-	-	-	-	-	-	-	-
DBRVSNA	-0.0001	0.0001	-	-	-	-	-	-	-	-	-
DBRVSNA1	-0.0001	0.0001	-	-	-	-	-	-	-	-	-
DBRVSNA2	0.0003***	0.0001	-	-	-	-	-	-	-	-	-
DBRVSNA3	0.0003***	0.0001	-	-	-	-	-	-	-	-	-
DBRVSNA4	-0.0001	0.0001	-	-	-	-	-	-	-	-	-
DBRRGR	-0.0195*	0.0096	-	-	-	-	-	-	-	-	-
DBRRGRL1	-0.0182	0.0134	-	-	-	-	-	-	-	-	-
DBRRGRL2	-0.0315**	0.0141	-	-	-	-	-	-	-	-	-
DBRRGRL3	-0.0512***	0.0129	-	-	-	-	-	-	-	-	-
DBRRGRL4	-0.0500***	0.0104	-	-	-	-	-	-	-	-	-
Adj. R ²	0.7098		Adj. R ²	0.5008		Adj. R ²	0.6708		Adj. R ²	0.5002	

*p < 0.1; **p < 0.05; ***p < 0.01. Source: own elaboration Note: Time series of M3C, CETOP1 and SNPI were applied in the study in the log form; the variables represent yield rates (BRY, BUY, PRY, WAY); government 10-yr bonds (B10C, B10V4, B10E, B10U); M3 money aggregate (M3C); HICP inflation (HICPC, HICPV4, HICPE, HICPU); stock index (CETOP1); GDP (GDPC, GDPV4, GDPE, GDPU); Exchange rate (PLNUSD); vacant stock/net Absorption indicators (BRVSNA, PRVSNA, WAVSNA); and rent growth rate (BRRGR, BURGR, PRRGR, WARGR). “D” at the beginning of variables’ codes stands for “first-differenced time series.” “L” at the end of the variables’ codes stands for “lagged time series.”

Table 6. Results of the Breusch-Godfrey autocorrelation test on the final ARDL models

Number of lags	BRATISLAVA		BUDAPEST		PRAGUE		WARSAW	
	chi2	Prob > chi2	chi2	Prob > chi2	chi2	Prob > chi2	chi2	Prob > chi2
1	0.097	0.7557*	0.317	0.5733*	0.441	0.5067*	0.845	0.3581*
2	0.389	0.8233*	0.321	0.8516*	0.691	0.7077*	1.840	0.3985*
3	1.693	0.6386*	0.409	0.9384*	2.460	0.4825*	2.943	0.4004*
4	1.836	0.7658*	1.294	0.8624*	2.562	0.6335*	5.481	0.2414*

*p > 0.1; **p > 0.05; ***p > 0.01. Source: own elaboration

Table 7. Results of the White and the Breusch-Pagan heteroscedasticity tests on the final ARDL models

The White test for heteroscedasticity							
BRATISLAVA		BUDAPEST		PRAGUE		WARSAW	
chi2(41)	Prob > chi2	chi2(42)	Prob > chi2	chi2(41)	Prob > chi2	chi2(41)	Prob > chi2
42.00	0.4274*	43.00	0.4282*	42.00	0.4274*	42.00	0.4274*
The Breusch-Pagan test for heteroscedasticity							
BRATISLAVA		BUDAPEST		PRAGUE		WARSAW	
F(30, 11)	Prob > F	F(11, 31)	Prob > F	F(16, 25)	Prob > F	F(19, 22)	Prob > F
1.59	0.2112*	0.39	0.9509*	0.75	0.7238*	0.67	0.8083*

*p > 0.1; **p > 0.05; ***p > 0.01. Source: own elaboration

rate was negative (-0.07), as was monetary aggregate DM3CL1 (-0.05). In turn, the change of the inflation rate DHICPC and its two lags worked collectively on the yield rate in a positive direction (0.09). The impacts of the other significant variables — GDP growth rate DGDPC (0.0001), relation of vacant stock to net absorption DPRVSNA (2.44e-06), and rent growth rate DPRRGRL1 (0.02) — were also positive.

In the Warsaw office market, only the changes in inflation rate DHICPU and its lag affected the yield rate in a negative manner (-0.09). All the remaining statistically significant variables or groups (differenced variables and/or their lags) represented positive effects: those expressing changes in interest on 10-year government bonds DB10UL1 (0.17); exchange rate DPLNUSDL3 (0.003); GDP growth rate DGDPU (0.0009); pace of office space absorption DWAVSNA and its lag (0.00002); and three lags of changes in the rent growth rate DWARGR taken together (0.034). The second lag of the differenced dependent variable was also positive (0.32).

The results of the post-estimation tests — the Breusch-Godfrey test (autocorrelation), the White and Breusch-Pagan tests (heteroscedasticity), as well

as the Jarque-Bera test and the Shapiro-Wilk test (residuals' normality) — are presented in Tables 6, 7 and 8, respectively. The results allow for interpretation of the four models.

Table 9 presents answers to the first two research questions. In the first case, the heterogeneous findings indicate that factors from different economic areas determined the yield rates in the four office markets. It is noteworthy that the office market in Bratislava did not exhibit a close relationship with the EMU variables, despite being monetarily integrated. Also, regardless of the course of the impact, inflation rates, together with government bond interest rates, were found to impact the yield rates with the highest magnitude.

5.2. The NARDL Model

As far as the NARDL models are concerned, cointegration was detected only for the office market in Bratislava based on the USA dataset. The results of this model are presented in Table 10.

Table 8. Results of the Jarque-Bera and the Shapiro-Wilk normality tests for residuals of the final ARDL models

The Jarque-Bera normality test							
BRATISLAVA		BUDAPEST		PRAGUE		WARSAW	
Chi(2)	Prob > chi2	Chi(2)	Prob > chi2	Chi(2)	Prob > chi2	Chi(2)	Prob > chi2
1.024	0.5994*	1.587	0.4523*	1.775	0.4117*	3.104	0.2118*
The Shapiro-Wilk normality test							
BRATISLAVA		BUDAPEST		PRAGUE		WARSAW	
z	Prob > z	z	Prob > z	z	Prob > z	z	Prob > z
0.831	0.20287*	0.666	0.25276*	0.750	0.22665*	0.987	0.16187*

*p > 0.1; **p > 0.05; ***p > 0.01. Source: own elaboration

Table 9. Answers to the first two research questions

Research question	BRATISLAVA	BUDAPEST	PRAGUE	WARSAW
Which of the following economic areas' sets of variables — i.e. the National, the V4, the EMU, or the USA — best explain fluctuations in the yield rates for the four office markets?	The V4	The EMU	The National	The USA
Which variables representing the consecutive groups of factors — i.e. monetary influence, capital market factors, economic situation, or local market factors — have a dominant impact on the yield rates?	The monetary factor – changes in the inflation rate (DHICPV4)	Long-term impact: The capital market factor – interest of government bonds (B10E); Short-term impact: The monetary factor – changes in the inflation rate (DHICPE)	The monetary factor – changes in the inflation rate (DHICPC)	The capital market factor – changes in interest from government bonds (DB10UL1)

Source: own elaboration

The post-estimation tests presented in Table 10 — the Portmanteau test (autocorrelation), the Breusch-Pagan test (heteroscedasticity), the Ramsey RESET test (model specification) and the Jarque-Bera test (normality) — allow for interpretation of the results. The adjustment variable BRYL1 is statistically significant and negative (-1.76). However, the short-run changes in the yield rate are not significant. For each variable, at least one coefficient is statistically significant, taking into consideration the time series expressing long-term influence, as well as those expressing short-term impact.

Table 11 proves the asymmetric relationships between the yield rate and the explanatory variables. A statistically significant long-run asymmetry is indicated for all six endogenous variables, while in the short run, and is acknowledged for the S&P index and rent growth rate. This is reflected precisely in the Wald tests, except with inflation rate. When it comes

to long-run asymmetry effects, apart from GDP, increases of all variables were statistically significant. Moreover, the coefficients of the inflation rate HICPU, the S&P index SNPI and rent growth rate BRRGR were negative. The decreases in GDP were found to have positive significant impacts on the yield rate, and pace of space absorption BRVSNA was found to have significant negative impact. The results substantiate an affirmative answer to the third research question, as we found nonlinear, asymmetric relationships between the yield rate and the independent variables.

Figure 2 plots the dynamic effects on the yield rate of the positive and negative changes in the explanatory variables. All the graphs have a fairly stochastic shape. The asymmetry line shifted the most (relative to 0) with the inflation rate, rent growth rate and EUR/USD exchange rate, and shifted the least with GDP and the variable representing the pace of space absorption. Therefore, the findings of the dynamic multipliers for

Table 10. The final NARDL model explaining the yield rate on the office market in Bratislava with the USA dataset

BRATISLAVA – The USA dataset		
Independent variables	Coefficient	Std. Err.
Constant	0.1399**	0.0331
BRYL1	-1.7601**	0.4249
HICPUL1 ⁺	-0.4858*	0.1881
HICPUL1 ⁻	-0.0364	0.1276
USDEUR ⁺	0.2266**	0.0749
USDEUR ⁻	-0.0114	0.0199
SNPIL1 ⁺	-0.0923***	0.0166
SNPIL1 ⁻	-0.0133	0.0136
GDPUL1 ⁺	-0.0014	0.0016
GDPUL1 ⁻	-0.0045*	0.0020
BRVSNAL1 ⁺	0.0021**	0.0007
BRVSNAL1 ⁻	0.0008*	0.0003
BRRGRL1 ⁺	-0.2651*	0.1008
BRRGRL1 ⁻	-0.0368	0.0485
ΔBRYL1	0.6558	0.3742
ΔBRYL2	-0.2981	0.1903
ΔHICPU ⁺	-0.2202*	0.0833
ΔHICPUL1 ⁺	0.1738	0.1169
ΔHICPU ⁻	-0.0677	0.0795
ΔHICPUL1 ⁻	-0.0044***	0.0713
ΔUSDEUR ⁺	0.0980*	0.0387
ΔUSDEURL1 ⁺	-0.0932	0.0541
ΔUSDEUR ⁻	-0.0405	0.0272
ΔUSDEURL1 ⁻	-0.0375*	0.0151
ΔSNPI ⁺	-0.0599**	0.0172
ΔSNPIL1 ⁺	-0.0160	0.0182
ΔSNPI ⁻	0.0013	0.0124
ΔSNPIL1 ⁻	0.0201	0.0171
ΔGDPU ⁺	-0.0002	0.0009
ΔGDPU ⁻	-0.0007	0.0004
ΔGDPUL1 ⁺	0.0007	0.0008
ΔGDPUL1 ⁻	-0.0007	0.0004
ΔGDPUL1 ⁻	0.0020**	0.0006
ΔBRVSNA ⁺	0.0010**	0.0004
ΔBRVSNAL1 ⁺	-0.0004	0.0003
ΔBRVSNA ⁻	0.00001	0.0004
ΔBRVSNAL1 ⁻	-0.0005*	0.0002
ΔBRRGR ⁺	-0.1524*	0.0602

Continued **Table 10.** The final NARDL model explaining the yield rate on the office market in Bratislava with the USA dataset

BRATISLAVA – The USA dataset						
Independent variables		Coefficient		Std. Err.		
ΔBRRGRL1 ⁺		0.0296		0.0265		
ΔBRRGR [·]		0.0343		0.0280		
ΔBRRGRL1 [·]		0.0276		0.0235		
Adj. R ²		0.6686				
Tests		Stat.		p-value		
Portmanteau test (chi2)		19.06*		0.5178		
Breusch-Pagan test (chi2)		0.4469*		0.5038		
Ramsey RESET test (F)		47.98*		0.1056		
Jarque-Bera test (chi2)		1.426*		0.4901		
Bounds cointegration test						
p levels of critical values		10%		5%		1%
Lower and upper bounds [^]		I(0)	I(1)	I(0)	I(1)	I(0)
F-statistics	3.5008*	2.12	3.23	2.45	3.61	3.15
t-statistics	-4.1429*	-2.57	-4.04	-2.86	-4.38	-3.43

*p < 0.1; **p < 0.05; ***p < 0.01. [^]The critical values of lower and upper bounds come from Pesaran et al. (2001). Source: own elaboration Note: SNPI time series was applied in the study in the log form; “Δ” at the beginning of variables’ codes stands for “first-differenced time series”; “L” at the end of the variables’ code stands for “lagged time series”; and the superscripts “+” and “-” refer to positive and negative cumulative sums, respectively.

Table 11. Results of long-run and short-run asymmetry, long-run positive and negative effects, and the Wald test

Independent variables	Long-run asymmetry	Short-run asymmetry	Wald test long-run asymmetry	Wald test short-run asymmetry
	F-stat	F-stat	F-stat	F-stat
HICPU	4.746*	0.0112	3.99	0.01
USDEUR	11.12**	2.271	7.02*	2.27
SNPI	35.51***	8.562**	16.12**	8.56**
GDP	89.53***	1.215	18.36**	1.22
BRVSNA	7.605*	2.903	7.42*	2.90
BRRGR	11.24**	10.26**	6.01*	10.26**
Long-run asymmetry positive and negative effects				
Independent variables	Long-run effect⁺		Long-run effect⁻	
	Coefficient	F-stat	Coefficient	F-stat
HICPU	-0.276**	11.65	0.021	0.0838
USDEUR	0.129**	17.64	0.006	0.3333
SNPI	-0.052***	34.37	0.008	0.8072
GDP	-0.001	0.7935	0.003*	6.595
BRVSNA	0.001**	13.4	-0.000**	8.726
BRRGR	-0.151**	10.66	0.021	0.5401

*p < 0.1; **p < 0.05; ***p < 0.01. Source: own elaboration

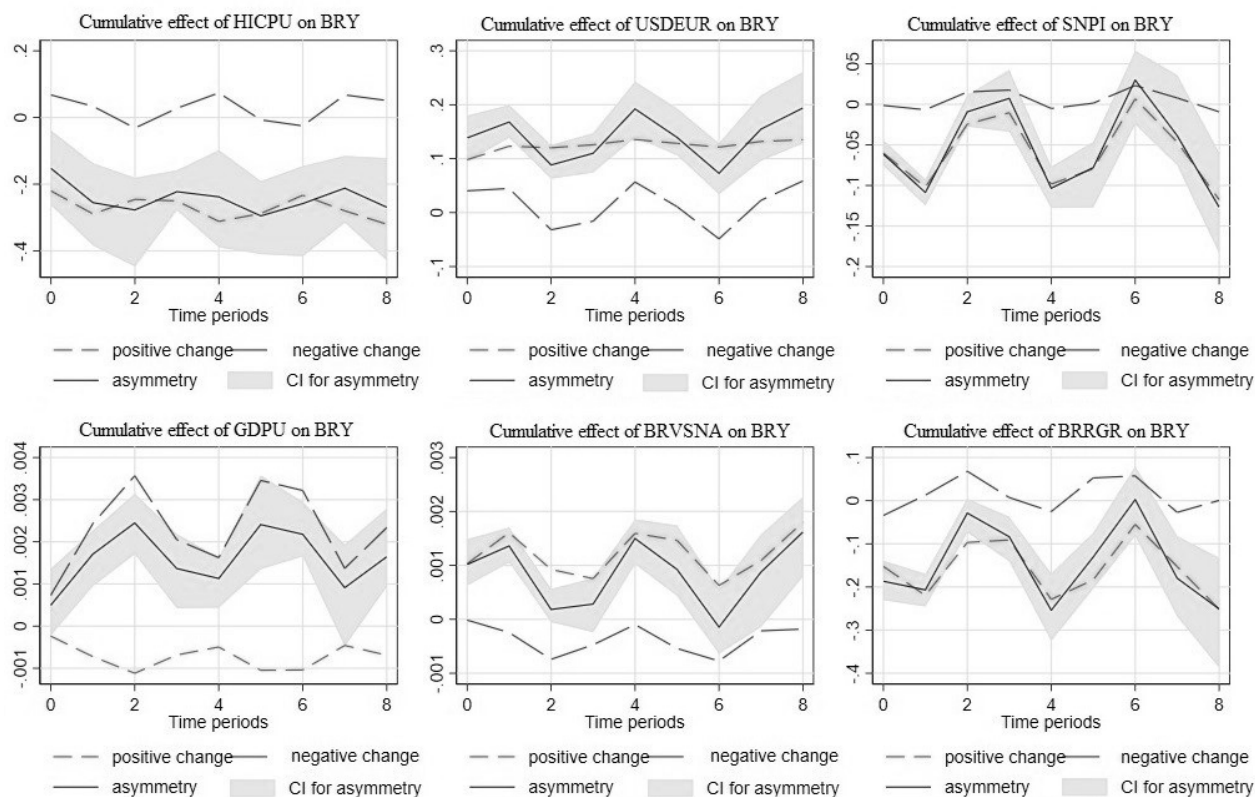


Figure 2. The cumulative effects of explanatory variables on yield rate in the office market in Bratislava
Source: own elaboration

the inflation rate, rent growth rate and EUR/USD are consistent with the previous results; in both the model (Table 10) and in the long-run positive effects (Table 11), the coefficients of the variables are of the highest magnitude.

6. Discussion

6.1. The ARDL Models

The impact of particular variables does depend on the circumstances. Usually, economic circumstances exert the strongest influence, but in this case, it is particularly easy to see the effects of geopolitical developments in the period covered by the time series. The study is based on the time span of Q1 2011 to Q4 2022. This was a period of low interest rates — a sort of legacy of the global financial crisis, which had translated into a compression of the yield rate on the office market worldwide. A period of extremely low interest rates also took place from 2020 until mid-2022. The negative real interest rates back then were unusual, especially for developing countries like those in the

Visegrád Group. The Covid-19 pandemic also resulted in an increase in office yield rate as a consequence of a rapid reduction in demand for office buildings. As a result, the market values of such buildings decreased, thus lifting the yield rates.

Newell and Marzuki (2023) argued the Covid-19 pandemic caused a decline in global real estate capital flows in 2020, followed by a recovery in 2021. The reported decline in 2022 was an effect of “inflation concerns, geopolitical tensions, economic growth concerns, increased cost of debt issues and supply chain issues” (p. 553). It was also the first year of the war in Ukraine and a moment of a radical tightening in monetary policy by central banks. Three of the four countries in question (Slovakia, Hungary and Poland) directly border Ukraine, and this may have affected foreign financial investors’ perceptions of the commercial real-estate markets in those countries, especially at the beginning of the conflict.

Here, the emphasis is set on interpreting particular variables’ course of impact of on yield rates in the context of advancing commercial real estate markets, globalisation and cross-border capital flows. McAllister and Nanda (2015; 2016) found a negative

effect from foreign investment on cap rates in studies of 38 metro areas in the USA and 28 key cities in Europe. They stated that this effect is especially visible in dynamic global cities because foreign investors prefer investments in premium real estate locations and assets. Oikarinen and Falkenbach (2017) also demonstrated that foreign investor participation had a negative impact on the cap rate of the Helsinki CBD office market. This effect may also apply to commercial real estate markets in small open economies, which depend to a large measure on foreign capital. Applied here, monetary and capital market factors refer to investment conditions that affect the decisions of foreign investors, and thus financial in- and outflows, making liquidity an outcome of globalisation. However, the interpretation of individual variables employed may vary depending on which economic area they represent.

There are three types of variables representing monetary factors: the M3 aggregate, HICP inflation rate, and exchange rate. The first one is represented by the lagged one-period changes in the M3 aggregate of the CZK that applied negatively to the yield rate in Prague (in the other three office markets, monetary aggregates were excluded from the final models because of statistically significant correlations). This confirms the relationships indicated in the literature. Kim et al. (2019) found that monetary variables based on M2 negatively influenced office yields in six major Asian office market centres. Bruneau and Cherfouh (2018) also found M2 to have a negative impact on UK office yields. Nevertheless, when nonlinearity was introduced into the model, they obtained ambiguous results. The concept behind the negative relationship implies that growing monetary liquidity boosts real estate prices and reduces yield rates. It is worth recalling the aforementioned Colliers (Jędrak et al., 2023) and Cushman & Wakefield (2025) reports, which indicate a substantial share of Czech capital domestically, as well as in the CEE region, when it comes to CRE purchase transactions. This specificity sounds like a preponderant component here. The negative impact of national monetary liquidity on the office yield rate in Prague then emerges as an effect of national investment volume, reinforced by international capital flows.

The second monetary factor is the HICP inflation rate, the growth of which should generate expectations for higher nominal yield rates in a given market. This was substantiated by Bialkowski et al. (2023), who reported that inflation had a positive impact on office

cap rates in their extensive study of 89 large cities in 33 countries. De Wit and Van Dijk (2003) observed the positive influence of inflation on office total returns for 46 districts in Asia, Europe, and the USA. However, the relationship is not as straightforward when the inflation rates derive from diverse economic areas. Inflation variables had a positive impact in Bratislava and Prague, as well as in the short-term part of the Budapest equation. In Warsaw and in the long-term part of the Budapest equation, however, the influence was actually negative. The non-homogeneous results could be because the models for Bratislava and Prague are based on regional (V4) and national data, respectively, while the models for Budapest and Warsaw are based on the EMU and the USA datasets, respectively. In this instance, local/regional inflation rates generated business conditions that contributed to changes in rents for a particular office market. For example, a higher inflation rate in Slovakia might mean an increase in nominal rents, which brings the yield rate up. Then again, the impact of the USA HICP rate and the long-term EMU HICP rate reflect global monetary liquidity, and affect properties' prices more than their rents. In such cases, external capital flows can have an impact on office properties' prices by stimulating demand for office buildings.

In this context, Coën et al. (2022) reported a positive relationship between the global money supply and office prices based on a study of 16 main office markets in Europe. In this way, greater liquidity in the EMU and the USA pulls the yield rate down by increasing its denominator. The difference in the course of the EMU HICP impacts on the yield rate in Budapest in the short-term and in the long-term is attributable to the spillover of EMU monetary conditions. The statistically significant correlation between the HICP rate in Hungary and in the EMU exceeds 0.72. This may indicate that, in the short-term view, the EMU HICP may work on yield rate in the same way as the national/V4 HICP rate in Prague and Bratislava. Nevertheless, in the long term, the global monetary liquidity effect prevails.

According to Coën and Lefebvre (2022) who looked at British and German office markets after the GFC, there were significant differences in how the main currencies' exchange rates influenced the prices of properties. The results obtained here are also not intuitive, as the PLN/USD exchange rate was found to have a positive impact on the yield rate in Warsaw. First, a larger amount of PLN paid for one USD will make the Polish office market cheaper for US

investors, considering the fact that there is statistically significant negative correlation between PLN/USD and USD/EUR of more than 0.92. This could translate into higher demand for office buildings in Warsaw, dragging the yield rate down.

On the contrary, the weakening of the PLN against the USD may be a result of tightening monetary policy in the USA — through, for example, an interest-rate increase from the Fed, which could lead to an out-flow of foreign capital from emerging markets to the USA. This implies positive relationships between the PLN/USD and the yield rate. In addition, one should bear in mind that, notwithstanding the rents in euros, there are still some expenses in PLN that must be borne by building owners. A decreasing PLN means that there are more euros left from rents after taxes and wages are paid in PLN.

When it comes to the capital market factors, variables reflecting the interest on 10-year government bonds in Bratislava and Prague were found to have negative collective impacts. The CETOP stock exchange index was also found to negatively influence the office market in Bratislava. This is in line with Kim et al. (2019)'s finding in the major Asian office markets that expanded liquidity in financial markets tends to reduce office yields due to a positive effect on commercial real estate value. Quan and Titman (1997) indicated a strong positive relationship between real estate values and stock prices (i.e. a negative relationship with yield rates) in office-market data for cities across 17 countries in Asia and Europe, as well as the USA. In contrast, the bond variables in Warsaw and in the long-term part of the equation in Budapest have positive coefficients. This is in line with Wong et al. (2023), who found positive relationships between bond rates and cap rates in Australia. Once again, the rationale for these results can be found in the financial in- and out-flows.

Improving the investment attractiveness of the region — reflected by the increasing bond interest, as well as increasing regional stock indices — leads to more foreign capital flowing into the V4 countries. In this case, part of the capital is invested in the regional capital markets and part in the commercial real estate markets. The in-flow of foreign capital into the office market increases the values of office properties, which, *ceteris paribus*, should cause a yield-rate drop. This applies to the models of Bratislava (based on V4 data) and Prague (based on national data). In turn, an increase in government bond interest in the EMU and

the USA can cause capital to be pulled back toward markets that are treated as global safe havens. This may mean reduced investment liquidity worldwide. Hence, the out-flow of foreign capital from the V4 countries means less demand for office buildings, which translates into falling property prices and growing yield rates. This is mirrored by the results for the office markets in Budapest and Warsaw, which depend on the EMU and USA data.

As expected, the variables representing GDP qoq growth rate led yield rates in Bratislava, Prague and Warsaw in a positive direction. Hence, improving economic sentiment in the V4, Czech Republic and the USA had a positive impact on their respective cities' office markets. *Inter alia*, Wang and Hartzell (2021) found a positive impact of the GDP on office, housing, retail and factory property returns in Hong Kong. Mintah et al. (2020) also proved that real GDP had a positive impact, however varied in magnitude, on total returns on office markets in Sydney and Melbourne. However, one can also find contradictory results indicating a negative influence of GDP on office total returns — e.g., Akinsomi et al. (2018).

There are two variables that measure the impact of the prosperity of the local office market on the yield rate: the VSNA and RGR. With the first, which can be referred to as the pace of space absorption, there are statistically significant and positive coefficients in Bratislava, Prague and Warsaw. On the contrary, however, Sivitanidou and Sivitanides (1999) obtained a negative sign for the analogous variable in their study of several metropolitan areas in the USA. Other authors reported varied results referring to a vacancy-only impact on cap rates. Wong et al. (2023) reported that the vacancy rate had a negative impact on cap rates in Melbourne and Sydney. However, Bialkowski et al. (2023) insisted that cap rates rise as vacancy rates increase. The pace of space absorption is kind of a tricky variable. An increase in the DVSNA — induced by an increase in vacant space and/or a decline in absorption — should mean a downturn in the office market, and result in a reduction in rental income. This should, in turn, cause a decrease in the yield rate. Nevertheless, the reduction in rent should apply mostly to new lease agreements, as existing tenants are bound by previously-concluded contracts. Hence, the decline in the rent income is limited. This process also only works if one assumes that the prices of the office properties are stable, but the denominator of the yield rate can also vary. Market deterioration thus can also lead to less demand for office buildings,

which can translate to lower prices and, in effect, an increase in the yield rate. The results of this study indicate that the second process prevailed in the office markets in Bratislava, Prague and Warsaw. In other words, in these three office markets, positive DVSNA coefficients imply that during a downturn, decline of property prices can be of a higher magnitude than decreases in rent cash flow.

According to the Gordon growth model, the coefficients of rent growth rates should be negative, and this is commonly reported in the literature (Sivitanidou & Sivitanides, 1999; Clayton et al., 2009; Chervachidze & Wheaton, 2013; Wong et al., 2023). However, in this study, this was only seen in Bratislava and in the long-run part of the equation for Budapest. However, in Prague and Warsaw, but also in the short-run part of Budapest model, the impact was positive. The intuitive interpretation links these results to the distinction between the long- and short-term. One may infer that the short-term positive impact of rent increases is from the rise not yet being reflected in the office buildings' prices. In the long-term part of the equation for Budapest, however, rent growth was recorded by investors, which caused building prices to increase. In this case, the prices increase faster than the rents, as the impact of this variable is negative. The concepts of investor rationality and office building overvaluation are quite well-researched in the literature (Hendershott, 1996, 2000; Sivitanides et al., 2001; Hendershott & MacGregor, 2005; Cincinelli et al., 2024). This scenario is proven by the cases of Prague, Warsaw (both models based on the differentiated time series referring to the short-term) and especially Budapest (short- and long-term variables). Only Bratislava, where the short-term impact of rent changes is negative, does not fit this pattern.

In the case of Budapest, the negative coefficient of an adjustment variable is a fulfillment of the cointegrated ARDL model assumption, and the lagged one-period differenced yield rate is negative. The non-negative coefficients of the lagged changes in the yield rates in Prague and Warsaw can be attributed to trend persistence within the three sub-periods mentioned earlier in the Data section. The continuation of each out of three tendencies was surely also an effect of the economic situation (low interest rates), the Covid-19 pandemic, and the war in Ukraine.

6.2. The NARDL Model

The asymmetric impact of the explanatory variables on yield rates has already been a topic of interest in a few studies. Bruneau and Cherfouh (2018) used the VECM and the STR models to study the UK office market, and concluded that in both the linear and non-linear models, money supply was a key factor. Beracha et al. (2019) used the Markov-switching regression on the commercial real estate market in the USA and reported that the impact of explanatory fundamental and non-fundamental determinants of *ex ante* commercial real estate risk premiums was of an asymmetrical character. Nowak (2024) examined the yield rate in Warsaw's office market using the ECM and the Markov-switching regression, and also found asymmetric relationships.

The results of the NARDL model shown in Table 10 should be interpreted alongside the results shown in Table 11, which work as a sort of asymmetry check. One can observe the dominant impact of the inflation rate, as the coefficients of its variables in the model are of the highest magnitude in both the long and the short run ($HICPUL1+$ and $\Delta HICPU+$). This is also the case for the long-run asymmetry positive effects. The negative impact of long-run increases of the inflation rate $HICPU$ in the model (Table 10) is also validated, in part, by the negative coefficient of the long-run asymmetry positive effects (Table 11) and by the statistically significant long-run asymmetry (Table 11). This is in line with Warsaw's ARDL model, which was also formulated on the USA dataset. However, the negative short-term coefficients of the inflation rate are not proven in Table 11. Similarly, the positive influence of long-run gains in the USD/EUR exchange rate is evidenced by such long-run effects, together with the long-run asymmetry and the Wald test. One consequence of the EUR strengthening against the USD is that office buildings in Bratislava become more expensive to US investors, which may cause an out-flow of money and a fall in office-building prices. It also means there are more USD on each EUR gained on rent. Both of these factors indicate a growing yield rate.

The statistically significant variables $SNPI$ and $BRRGR$ function asymmetrically, as evidenced by both the long- and short-run numbers in Table 11. The S&P increases implicate declines in the yield rate, unlike the US government bonds in the ARDL model for Warsaw; both of these represent capital market factors. One intuitive reason for such an outcome

may be a difference in the workings of interest-rate increases on US government bonds and stock-market quotes. The first can be treated as a process that pulls capital back to a safe haven. The second may be an indication of a mild monetary policy that pushes US capital not only into the stock market, but also abroad; this also means yield rates fall. When it comes to the rent growth rate, the negative impact of an increment in the long-term can be assigned to the aforementioned tendency toward overvaluation of office buildings. This is consistent with most of the literature, and also reflected by the negative coefficient of the short-run variable.

The results for the GDP variables are ambiguous. In the model, long-run decreases reduce the yield rate; however, Table 11 indicates that the long-run negative effects have a positive influence. The results in Tables 10 and 11 — variables representing the interplay of the vacancy rate and the net absorption — are within the same line when it comes to the BRVSNA increases in the long-term. The long-run coefficients of BRVSNA declines behave positively in the model, but the other way around according to the effects presented in the Table 11. The asymmetric relationships are also embedded in the definition of the dependent variable — which, once more, is a gross yield rate that excludes tenant incentives and transaction costs. In that case, in a downturn on the market, potential buyers may use their stronger bargaining position to bring properties' prices lower as a compensation for their expected transaction costs and longer rent-free periods. This would lead to an oversized increase in the gross yield rate.

7. Conclusions

The literature analysis indicated that liquidity and globalisation are two major factors impacting office markets nowadays. In this context, the study proves the importance of cross-border capital flows for the office markets in Bratislava, Budapest, Prague and Warsaw. Following this line of reasoning, we proved that different conditions of scale — i.e. national, regional, continental and global — can affect the yield rates in a particular office market.

The study provided answers to our three research questions. Regarding the first research question, we proved that in each of the four markets, the variable sets representing different economic areas (the V4

for Bratislava; the EMU for Budapest; the National for Prague; and the USA for Warsaw) best explained the fluctuations in the yield rates. In this respect, the markets behave in a non-unanimous manner. In the case of the second research question, it has been demonstrated it is the monetary factor and the capital market factor that most greatly impacted the yield rates (inflation rate in Bratislava; interest from government bonds in long term and inflation rate in the short term in Budapest; inflation rate in Prague; and interest from government bonds in Warsaw). Finally, as for the third research question, there are apparent asymmetric relationships indicated between the yield rate and the independent variables in Bratislava.

We interpreted these results while taking into consideration the peculiarities of the study. The four office markets are, to a large extent, dependent on cross-border capital flows, and function within small open economies. In this case, rent is determined mostly in the local or national market, while the price of office space is believed to be set largely in the international market. Accordingly, the interpretation of the ARDL models' findings differs across economic areas depending on the origin of the variables influencing the yield rate. This is the case for inflation rates and interest on government bonds.

The results also show a distinction between the long-term and short-term impact of some variables. Recall that the model for Budapest includes both long-run and short-run relationships, while the models on the three other office markets represent only short-term dependencies. This has created varied outcomes with regard to inflation rates, interest on government bonds and rent growth rates. The NARDL model on the USA dataset confirmed the presence of non-linear relationships, especially when it came to the influence of the inflation rate, S&P stock index, and rent growth rate on the yield rate in Bratislava.

This study proves that when seeking capital allocation in the office markets of V4 capital cities, one should be aware of the fact that there are four levels of factors — national, regional, continental and international — that drive yield rates. Moreover, our findings suggest that there should be special attention paid to inflation rates and interest on government bonds. These implications are relevant to real-estate market practitioners, investors and academics.

There is a vast research gap when it comes to the CRE markets in the CEE. The paper is but one attempt to bridge this gap. Research areas are limited

primarily by the availability of data. The lack of data within public statistics means that one must solely rely on data from commercial institutions. Unfortunately, this means time series are limited, which is why this study could only examine a single business cycle. The next step in the study of the office markets in the CEE would be a spatial analysis, but the lack of available transactional data on prices, rents, the number of transactions made by foreign investors, and detailed characteristics of buildings (such as tenant mix) is an obstacle. This makes it difficult to drill down to the level of specific buildings. However, some private projects are underway that may soon help close the research gap in the CEE region.

Disclosure statement

The author reports there are no competing interests to declare.

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