Paradigm

VACANCY RATE AND RENT ON THE OFFICE MARKET IN POLAND - IN SEARCH OF ASYMMETRY

Krzysztof Adam Nowak*[1], Michał Głuszak[2]

[1] *Departament of Financial Markets and Consumer Finance, University of Rzeszow, al. Tadeusza Rejtana 16C, 35-310 Rzeszów, Poland, e-mail: krnowak@ur.edu.pl, ORCID: 0000-0003-0543-1670*

[2] *Departament of of Real Estate and Investment Economics, Krakow University of Economics, ul. Rakowicka 27, 31-510 Kraków, Poland, e-mail: gluszakm@uek.krakow.pl, ORCID: 000-0001-7614-229X*

* *Corresponding author*

ARTICLE INFO

Keywords:

asymmetric adjustment, office market, vacancy rate, rent

JEL Classification:

R30, R33

ABSTRACT

A growing body of empirical evidence suggests that adjustments on the office market are not symmetric. The theoretical framework provides various justifications for the presence of frictions, especially in the case of rent and vacancy rate. In this paper, we investigate the asymmetric reactions of rent and vacancy rate to the demand and supply shocks in the nine major office markets in Poland. In the course of the study we seek answers to two research questions. First, we investigate if the direction (positive or negative) as well as type (demand or supply) of the shocks produce asymmetry in the adjustments of vacancy rate and rent. Secondly, we examine if market conditions and distinction between the long-term and short-term perspective can generate asymmetry in vacancy rate and rent responses to the shocks.
We use quarterly time series starting in 2011 / 2018 in the case of mature markets and markets in the early stage of development, respectively. Our data end in the end/mid- of 2024. In the study, the nonlinear autoregressive distributed lag (NARDL) model is applied. The paper contributes to the discussion regarding nonlinear adjustments on the office markets in Central and Eastern Europe.

Citation: Nowak, K.A., & Gluszak, M. (2025). Vacancy rate and rent on the office market in Poland - In search of asymmetry. *Real Estate Management and Valuation*, *33*(4), 96-109. https://doi.org/10.2478/remav-2025-0038

1. Introduction

An increasing volume of research literature addresses the nonlinearities within the office market. The results suggests the presence of asymmetric adjustments, particularly concerning rent and vacancy rates. This paper examines the asymmetric responses of rent and vacancy rates within the nine regional office markets in Poland to demand and supply shocks.

The phenomenon of sluggish or incomplete market adjustment has captured significant attention from economists at both the theoretical and empirical levels, sparking intense debate and driving robust research efforts over recent decades. Although even early economists like Marshall or Fisher noted considerable frictions in the market adjustment mechanism, the concept of the downward rigidity of prices (wages) was first systematically introduced and integrated into broader macroeconomic theory by Keynes in his famous monograph "The General Theory of Employment, Interest and Money" (1936). Since then, price stickiness has been explained through different mechanisms, including menu costs (Ball et al., 1994), fairness and norms (Kahneman et al., 1986) or imperfect competition (Blanchard & Kiyotaki, 1987). The phenomenon of price stickiness has undergone extensive empirical scrutiny, with a significant body of research focused on wages (Fallick et al., 2022; Schaefer & Singleton, 2022), stocks (Chen, 2007) and commodities (Chen & Sun, 2021), and daily products (Giulietti et al., 2020). It is safe to say, that the presence of asymmetries in dynamics of various markets is well-documented by consistent empirical evidence.

Unbalanced adjustment of the real estate market to exogenous shocks has not been fully addressed in economic literature until the late 1990s. As demonstrated by Genesove and Mayer (1997), sluggish real estate price adjustment in downturn can be attributed to behavioral effects. The authors directly linked sticky prices to the loss aversion of real estate owners (Genesove & Mayer, 1997, 2001). On the other hand, asymmetries in property market responses to exogenous shocks may result from the durability of buildings (brick and mortar argument), as claimed by Glaeser and Gyourko (2005). To date, asymmetrical dynamics is a well-documented phenomenon in the case of the housing market. There is convincing empirical evidence that house prices and rents do not react swiftly and consistently to the exogenous shocks (Erlandsen & Juelsrud, 2023). Asymmetries may arise from both demand (Katrakilidis & Trachanas, 2012; Yuming Li, 2015; Simo-Kengne et al., 2013; Tsai, 2013) and supply shocks (Głuszak & Trojanek, 2024; Yaoyao Li et al., 2022; Yii et al., 2022). Additionally, differences in house price adjustment may be linked with the timing of the exogenous shock. House prices seem to adjust differently in market downturns and upturns (Fan, 2022; Yuming Li, 2015; Tsai, 2013). The research suggest that sticky pricing reduces convergence across housing markets (Fan, 2022), and has important housing policy implications (Katrakilidis & Trachanas, 2012).

In line with housing research, a substantial body of evidence on asymmetric adjustments is based on office market dynamics. In late 2000s, Brounen and Jennen (2009) reported that office rents in the US reacted significantly stronger to positive demand shocks when vacancy rates are below the long-term average. These findings were confirmed by McCartney (2012), based on his investigation of office market dynamics in Dublin (Ireland). Several other studies compared the asymmetric response to positive and negative supply and demand shocks and found that profound rigidities occur and market fluctuations are inherently asymmetrical (Chau & Wong, 2016; Farrelly et al., 2014; Hendershott et al., 2010; Matsuo et al., 2023; Nowak et al., 2020). Additionally, there is solid evidence that the office market may exhibit different adjustment patterns compared to other real estate segments. Ibanez and Pennington-Cross (2013) revealed, based on 34 regional commercial real estate markets in the US, that there are significant differences in both the long and the short run rent dynamics subject to demand and supply shocks between office, industrial, retail and flex space markets. Results demonstrated that office markets were the slowest to adjust back towards equilibrium (Ibanez & Pennington-Cross, 2013).

Due to search costs and the fixed duration of lease contracts, there are substantial frictions when it comes to the adjustment of occupied space on the office market subject to changing demand and supply (Nowak, 2020). Empirical evidence suggests that changes in vacancy rates may also exhibit significant asymmetries. Gholipour et al. (2022) confirmed differences in vacancy rate adjustment to both global and local uncertainty shocks between four quality segments of office market in Australia differing in terms of quality (A to D grades). Another recent study shows that rent and vacancy rate adjustment depends largely on the direction of change in supply and demand, as well as the market regime (Matsuo et al., 2023). Another Japanese study revealed that a shift in the preferences of tenants may lead to significant shifts in the demand for low and high-quality offices (Matsuo et al., 2024). As the result, rents and vacancies in different office market segments may respond differently to aggregate demand and supply shocks. Matsuo et al. (2024) attribute those asymmetries to the corporate relocations to high-end office buildings (a mechanism they call “flight to quality”).

The goal of the paper is to assess the adjustment of rents and vacancies to various exogenous shocks. To do so, we seek answers to two research questions. First, we investigate if the direction (positive or negative) as well as type (demand or supply) of the shocks produce asymmetry in the adjustments of the vacancy rate and rent. Secondly, we examine if market conditions and distinction between the long-term and short-term perspective can generate asymmetry in the vacancy rate and rent responses to the shocks.

In the empirical part, we apply the nonlinear autoregressive distributed lag (NARDL) model, and use quarterly time series from 2011 (in the case of mature markets) or 2018 (in the case of markets in the early stage of development) to the end of 2024 and mid-2024, respectively.

The paper narrows the gap in the economic literature related to the asymmetric properties of office market dynamics in two interlinked ways. Firstly, with the exception of Nowak et al. (2020) and Nowak (2021), there is limited evidence of asymmetric adjustments in the case of dynamically growing and changing regional office markets in Poland (or CEE for that matter), which differ substantially from their mature counterparts in the US and UK. The paper contributes to the discussion regarding nonlinear adjustments on the office markets in Central and Eastern Europe.

Secondly, although there is a substantial body of evidence regarding the asymmetric changes of office rents, the dynamics of vacancy rates remain relatively understudied. We provide additional empirical evidence that helps to understand those complex interlinkages.

2. Material and methods

There is a lack of public data on commercial real estate market in Poland what with no doubts causes the research gap in this area. The study is conducted with the use of the quarterly office data provided by Colliers Polska Sp. z o.o. (Colliers, 2025). To the best of our knowledge, this is the first comprehensive study which is devoted to nine main office markets in Poland. Table 1 presents basic statistics of the nine office markets in the last quarter of the data. Based on the total stock, the markets can be divided into four groups. The first separate group consists only of Warsaw, which is the most developed, liquid and diverse market in Poland, as well as in Central and Eastern Europe (CEE). Another batch is formed by cities with total stock of over 1M sq. m, i.e. Krakow, Wroclaw and Trojmiasto. The third cluster contains office markets with a few hundred k of sq. m – Katowice, Poznan and Lodz. The last set includes Lublin and Szczecin which are still markets pretty much at their infancy. The time range of data for Warsaw, Krakow, Wroclaw and Trojmiasto embrace the period from Q1 2011 to Q4 2024. While the time series for other cities involve the period from Q1 2018 to Q2 2024.

In our study, we target nine office markets however, the final models are provided only in the case of five cities. This is due to the fact that we present only credible models which were positively verified by postestimation econometric tests. The below figures are dedicated to the office markets which were considered in the final models. Figures 1 and 2 plot variations of stock, demand and vacancy rate, rent min. and rent max. in Krakow, Wroclaw and Trojmiasto. Figures 3 and 4 are devoted to the cities from the third batch of the office markets - Katowice and Poznan.

Table 1

Main office markets in Poland as at end of the analysis period*

Office market (city)	Total stock (sq. m)	Demand (sq. m)	Vacancy rate (%)	Rent Min (euro/sq. m/mth)	Rent Max (euro/sq. m/mth)
Warsaw	6 293 298	244 146	10.6	12.5	28.5
Krakow	1 831 438	98 324	19.0	13.5	19.5
Wroclaw	1 375 863	50 546	19.3	14.5	17.0
Trojmiasto	1 067 026	25 217	12.5	14.0	16.0
Katowice	751 120	13 606	20.8	13.0	17.0
Poznan	674 228	6 647	13.9	15.0	18.0
Lodz	645 462	16 846	23.3	13.0	14.0
Lublin	220 857	1 148	12.3	12.0	14.3
Szczecin	187 248	1 152	6.3	12.0	15.0

*Note: *Q4 2024 in the case of Warsaw, Krakow, Wroclaw, Trojmiasto, and Q2 2024 in the case of other cities.*

Source: Colliers Polska Sp. z o.o.

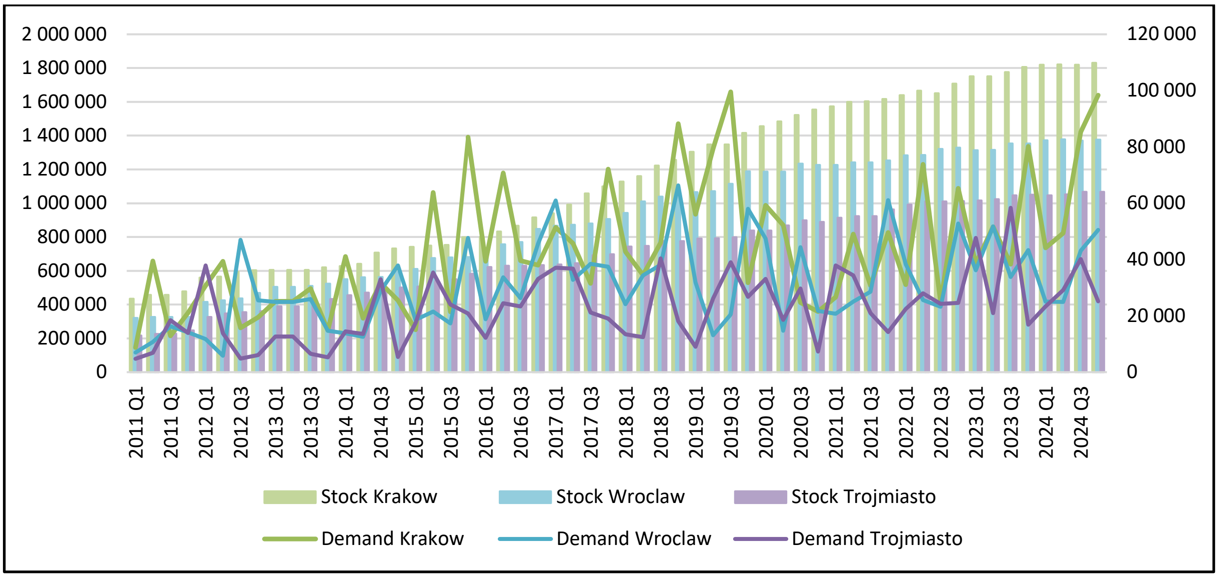

Fig. 1. Fluctuations of stock and demand in Krakow, Wroclaw and Trojmiasto. *Source*: own elaboration on data provided by Colliers Polska Sp. z o.o.

eISSN: 2300-5289

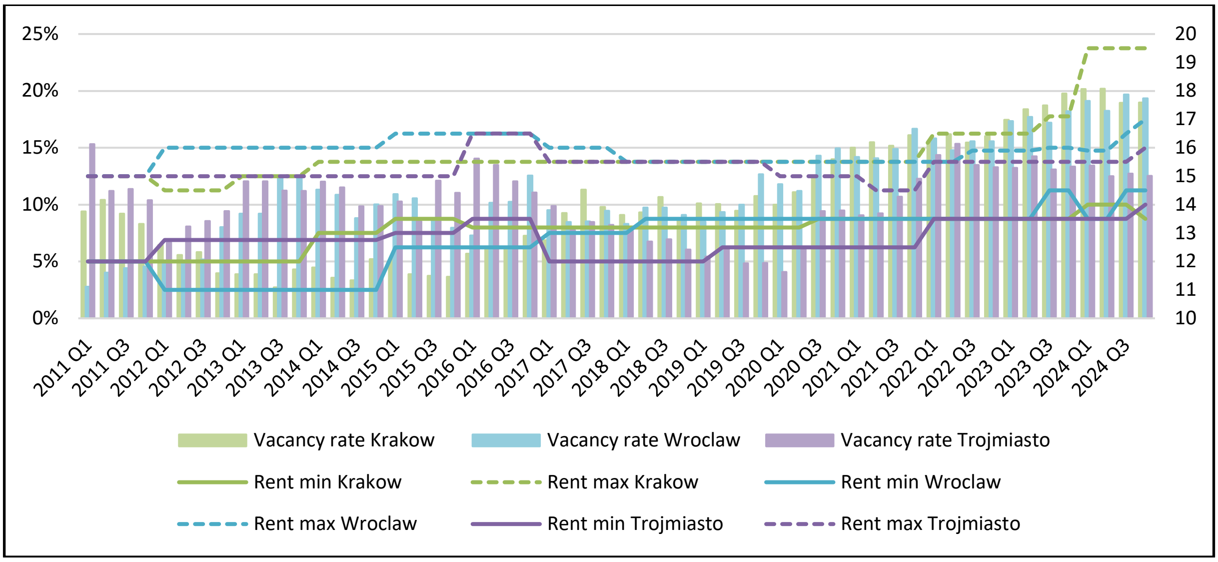

Fig. 2. Fluctuations of vacancy rate, rent min, rent max in Krakow, Wroclaw and Trojmiasto. *Source*: Own elaboration on data provided by Colliers.

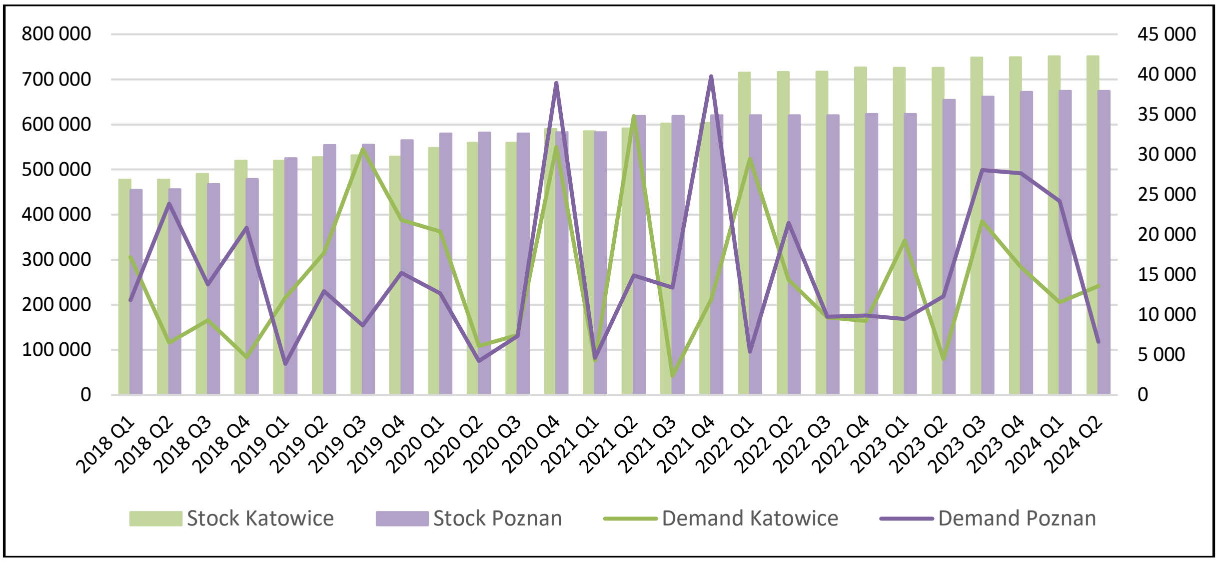

Fig. 3. Fluctuations of stock and demand in Katowice and Poznan. *Source*: Own elaboration on data provided by Colliers Polska.

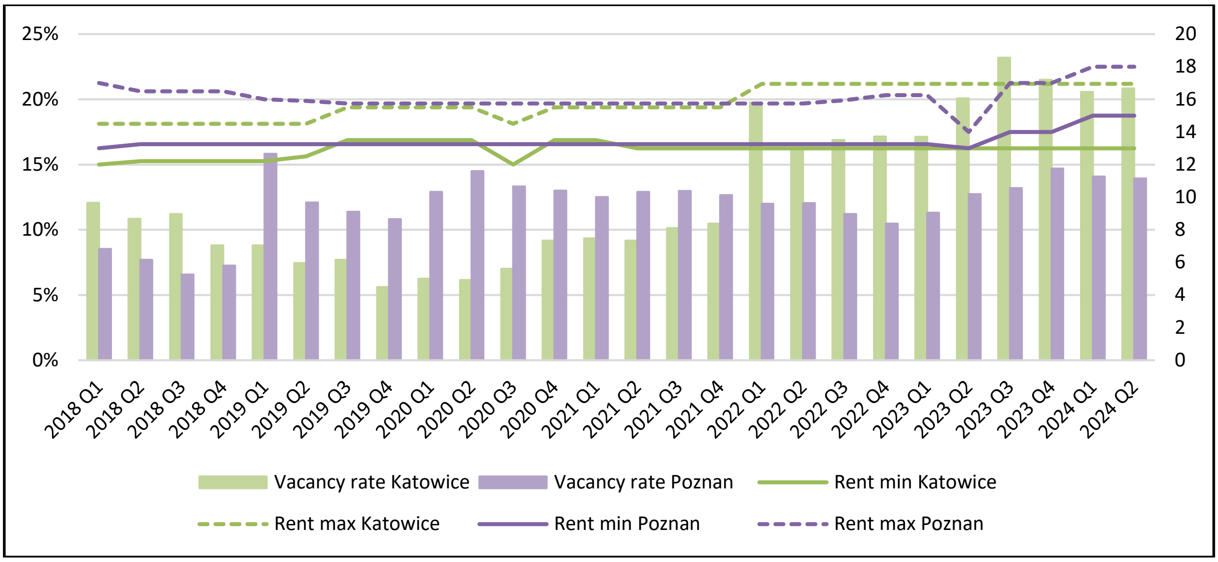

Fig. 4. Fluctuations of vacancy rate, rent min, rent max in Katowice and Poznan. *Source*: Own elaboration on data provided by Colliers Polska.

eISSN: 2300-5289 | Received 2025-06-23 | Revised 2025-10-25 | Accepted 2025-11-14

We investigate vacancy rate as well as rent min. and rent max. adjustments to supply and demand shocks. Asymmetric fluctuations of vacancy rate and rent may be triggered by the perception of landlords. For instance, growing market stock may cause a massive increase in vacancies and no response in rent. In this case, landlords may believe that it would be more profitable in the long-term to wait the period of high vacancy out, rather than reduce rent (Grenadier, 1995). Moreover, since tenants are obliged by previously signed contracts, the impact of changes in stock and demand may not be immediately mirrored by variations in the vacancy rate and rent.

We decided to include two rent time series representing market minimum and maximum instead of one dominant market rent. The endeavour was carried out in order to verify possible asymmetric effects as one ought to expect distinct reactions of min. and max. rent under supply and demand pressure. We use asking rent, which - due to transaction rent data availability issue - is common in studies regarding the office market. Similar data were used by Matsuo et al. (2024), Matsuo et al. (2023), Ibanez and Pennington-Cross (2013), Ke and White (2013) and McCartney (2012).

In many studies regarding the workings of office market space, the supply variable is reflected by time series of new supply or market stock. We stick to the last as new supply may stay at zero in some periods, which brings on problems in the case of a log form of time series. The demand variable is often defined as the number of employees in the FIRE sectors (i.e., finance, insurance and real estate), business service sectors or others which are believed to be featured by the high percentage of office workers (e.g. Farrelly et al., 2014; Matsuo et al., 2023). Notwithstanding, we decided to go with a direct demand indicator, i.e. the number of sq. m leased in particular quarters. The time series is derivative of the employment data. Moreover, when it comes to the exact definitions of the employment type expressing demand for office space, there is a lack of such public data in Poland on the city level for the whole time span of the study. Table 2 provides descriptive statistics of data applied in the study.

Table 2

Descriptive statistics of data employed in the study

Office market (city)	Statistics	Total stock (sq. m)	Demand (sq. m)	Vacancy rate (%)	Rent Min (euro/sq. m/mth)	Rent Max (euro/sq. m/mth)	Obs.
Krakow	Mean	1133509	43649	10.218	13.073	15.807	56
	Sd.	472121	22856	5.297	0.606	1.174	
	Min.	434082	8732	2.713	12	14.5	
	Max.	1831438	99559	20.184	14	19.5	
Wroclaw	Mean	910047	30714	11.344	12.741	15.855	56
	Sd.	354910	14848	4.297	1.0871	0.439	
	Min.	321284	5826	2.782	11	15	
	Max.	1378382	66336	19.671	14.5	17	
Trojmiasto	Mean	698227	22457	10.319	12.768	15.304	56
	Sd.	262454	11989	2.869	0.576	0.454	
	Min.	216426	4743	4.083	12	14.5	
	Max.	1067026	58371	15.325	14	16.5	
Katowice	Mean	616630	14910	12.824	12.896	15.788	26
	Sd.	99453	9106	5.629	0.491	1.017	
	Min.	477372	2392	5.619	12	14.5	
	Max.	751119	34795	23.2	13.5	16.95	
Poznan	Mean	587164	15455	11.947	13.423	16.148	26
	Sd.	65920	9942	2.299	0.514	0.802	
	Min.	454916	3881	6.556	13	14	
	Max.	674228	39760	15.828	15	18	

Source: Own elaboration on data provided by Colliers Polska.

Studies aimed to trace asymmetric dependencies on the office market are most often based on the Error-correction model (ECM) proposed by Hendershott et al. (2002a; 2002b). Some authors tried to adapt techniques including nonlinearity in the market adjustments. In that manner, Füss et al. (2012) used the regime-switching approach to verify asymmetry in the adjustment process of rental prices in the industrial, retail and office sectors in the UK. In the study, we deploy the NARDL model, which is a desirable method, since it allows for the verification of asymmetric long- and short-term dependencies in the case of both, positive and negative shocks. In this model, the explanatory variables on level time series as well as on differenced time series are split into positive and negative fluctuations, which work as references to positive and negative shocks, respectively. This approach had already been used in research regarding the housing market in Poland (Głuszak & Trojanek, 2024). However, to the best of our knowledge, it was not used on rent and vacancy rate adjustments in the CRE market. The model is depicted by the Equation (1).

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

where:

ΔY_t	- dependent variable,
Y_{t-1}	- adjustment variable, lagged dependent variable on level time series,
ΔY_{t-i}	- lagged dependent variable on differenced time series,
X_{t-1}^{+}, X_{t-1}^{-}	- positive and negative fluctuations of independent variables on level time series,
ΔX_{t-j}^{+}, ΔX_{t-j}^{-}	- positive and negative fluctuations of independent variables on differenced time series,
α	- intercept,
δ_1	- a coefficient reflecting the speed of the adjustment,
$\beta_i, \gamma_j^{+}, \gamma_j^{-}$	- coefficients indicating short-run relationships,
δ_2^{+}, δ_2^{-}	- coefficients indicating long-run relationships,
u_t	- error term.

The first step in the study was to check the stationarity of the time series. The advantage of the NARDL over the ECM is that it allows to exploit both time series stationary at levels and at first differences. Next, the models were determined within the NARDL framework. Another step was a verification of results of the Bounds cointegration test according to the approach provided by Pesaran et al. (2001). Then, we examined the quality of the models with a use of postestimation tests: Portmanteau test (autocorrelation), Breusch-Pagan test (heteroskedasticity), Ramsey RESET test (general specification), Jarque-Bera test (residuals' normal distribution). The models with no cointegration and inappropriate results of postestimation tests were dismissed. This rule of thumb ensures the econometric fit of the final models. Lastly, we checked results of the long-run and short-run asymmetry also by conducting the Wald tests, and interpreted the Long-run effect^{+} and Long-run effect^{-} in the models. In the study, we use quarterly time series in the log form. The models have been specified in the STATA software.

The study is divided into two segments. The first one is to answer the question of whether there is evidence of asymmetric adjustments caused by the direction and type of the shocks. In this part of the study, we formulated basic models in which the regular variables are. stock and demand, determined vacancy rate, min. rent and max. rent (the three being dependent variables). This translates to three models formed for each of the nine cities. In the second part of the study we included market conditions in the explanatory variables specification. We divided the stock and demand time series based on the relation of the vacancy rate to the natural vacancy rate (average vacancy rate over the course of the study) and min. rent and max. rent in relation to the their mean values. In the second phase of the study, four models were built for each of the nine office markets (in two, the vacancy rate served as the dependent variable). In the paper, we present results regarding only the models that passed the verification with five postestimation econometric tests.

3. Results

In this section, we provide results of the three basic NARDL models (first stage of the study) and two DV NARDL models (second part of the study) which have passed verification with econometric tests. As far as the basic NARDL models are concerned, cointegration via the Bounds test was detected in the case of Krakow, Poznan and Katowice. The results below concern the three office markets. Table 3 presents the results of the ADF stationarity test for variables used in the basic models on the three office markets. The time series are stationary at order [0] or [1], which allows them to be used in models within the NARDL framework.

Table 3

Results of the ADF stationarity test of time series employed in the basic NARDL models

City (office market)	Time series	Variable	Test statistic at levels	Test statistic at first differences
Krakow	Vacancy	VR	-0.541	-6.185***
	Stock	ST	-2.299	-4.292***

	Demand	DE	-2.275	-8.850***
Poznan	Vacancy	VR	-2.775*	-4.977***
	Stock	ST	-2.636*	-2.873*
	Demand	DE	-3.635**	-
Katowice	Vacancy	VR	-0.304	-2.783*
	Stock	ST	-0.950	-3.889***
	Demand	DE	-3.674**	-

*Note: *p < 0.1; **p < 0.05; ***p < 0.01. The ADF test conducted with 1 lag. Test on first differences was run in the case of the lack of stationarity at p 0.05 on the level time series.*

Source: own elaboration.

Table 4 presents results of basic NARDL models on the office markets in Krakow, Poznan and Trojmiasto in which the vacancy rate works as a dependent variable. The adjustment variables VRL1 are statistically significant and negative in all three cases. Also, one variable representing lagged short-run changes of vacancy rate is significant on each market. However, the direction of the impact is not unanimous, i.e. negative in Krakow and Katowice, but positive in Poznan. When it comes to statistically significant variables indicating long-run positive and negative changes of stock and demand, results for Poznan and Katowice, and Katowice alone, respectively indicate the expected positive impact of stock increments (8.1680; 2.8084) and the negative impact of demand increases (-0.1582) on the vacancy rate. However, decrease of stock and demand in Krakow (24.7015; -0.2881) and Katowice (52.1426; -0.2255) contradict stylized facts. Namely, decreasing stock should reduce vacancy, while decreasing demand should enhance it, but here these produce the opposite results. This may serve as an indication of possible asymmetric relationships in the long-run adjustments on the office market. The huge magnitudes of $STL1^-$ may be a reflection of the fact that there are only a few periods in which stock was actually falling. As far as short-run adjustments are concerned, statistically significant variables delineating positive and negative changes of stock are in line with expectations, i.e. they follow stylized facts. There is one exception however. In Katowice, ΔST^- brings on increases in vacancy rate (15.8320). The situation is quite different in the case of demand short-run variables. Basically, the results do not align with expectations, as declines of demand produce decreases in vacancy rate and increases in demand (Katowice) induce rises in vacancy rate. Symmetric adjustment can be observed in one case, i.e. in Krakow, where $\Delta DEL1^-$ has a positive effect on vacancy rate (0.1782).

On the whole, in the models 1, 2 and 3 in the long term one can find an indication of impact of the direction of the shocks. Increases of stock and demand effect in symmetric adjustments, while decreases of stock and demand produce asymmetric relationships. When it comes to short-term relationships, the distinction is with regard to type of the shock. The positive and negative changes of stock provoke symmetric outcomes, whereas declines as well as increases of demand generate asymmetric reactions of vacancy rate. This is generally true apart from one coefficient in both cases.

The adjusted R^2 in the three models is pretty high as it stays within 0.5419 and 0.9381 boundaries. Results of the Table 5 confirm the correct shapes of the models, as there is no indication of autocorrelation and heteroskedasticity, the general specifications are accurate, and residuals follow normal distribution. Finally, the Bounds tests prove cointegration.

Table 4

The basic NARDL models on the office markets of Krakow, Poznan and Katowice

Independent variables	Model 1 - Krakow		Model 2 - Poznan		Model 3 - Katowice	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Constant	-2.1080***	0.3404	-7.0665***	0.9087	-2.5057***	0.2782
VRL1	-0.5785***	0.0948	-2.5283***	0.3276	-0.7375***	0.0946
$STL1^+$	-0.5488	0.4323	8.1680***	1.1243	2.8084***	0.7435
$STL1^-$	24.7015*	13.2106	31.7287	33.4539	52.1426***	13.8744
$DEL1^+$	-0.1087	0.0768	0.0015	0.0636	-0.1582**	0.0472
$DEL1^-$	-0.2881***	0.0952	0.1279	0.0636	-0.2255**	0.0702
ΔVRL1	-0.1510	0.1233	0.7074**	0.1858	-0.3129*	0.1367
ΔVRL2	-0.3644***	0.1179	-	-	0.0778	0.0917
ΔVRL3	-0.1714	0.1274	-	-	-	-
ΔST^+	2.1390**	0.9355	5.3771***	0.8214	4.3289***	0.6597
$\Delta STL1^+$	2.2434***	0.7304	0.9243	1.0266	1.2292**	0.4982
$\Delta STL2^+$	1.5661**	0.7543	3.0937**	0.9004	-	-

ΔST^-	23.8238	16.4199	-66.9371*	27.3262	15.8320*	7.9435
$\Delta STL1^-$	-19.2059	16.3491	-156.4074**	38.1669	-19.4175	10.8931
$\Delta STL2^-$	-1.7930	16.3155	-99.1135**	32.9692	-	-
ΔDE^+	-0.1022	0.0631	-0.0417	0.0630	0.0513	0.0343
$\Delta DEL1^+$	-0.0578	0.0977	-0.0669	0.0622	0.0953**	0.0336
$\Delta DEL2^+$	-0.1131	0.0758	0.0211	0.0539	-	-
ΔDE^-	-0.1505*	0.0862	-0.0899*	0.0366	-0.1559***	0.0374
$\Delta DEL1^-$	0.1782*	0.0906	-0.1707**	0.0604	0.0158	0.0541
$\Delta DEL2^-$	0.0945	0.0769	-0.1193**	0.0414	-	-
Adj. R^2	0.5419		0.9197		0.9381	

*Note: *p < 0.1; **p < 0.05; ***p < 0.01. "Δ" stands for first-differenced time series. "L" at the end of the variables' name stands for lagged time series. The superscripts "+" and "-" refer to positive and negative cumulative sums, respectively.*

Source: own elaboration.

Table 5

Results of autocorrelation, heteroskedasticity, model specification, normality and cointegration tests for the basic NARDL models

Tests		Krakow	Poznan	Katowice
		Stat.	Stat.	Stat.
Portmanteau test (chi2)		16.82*	17.58***	5.442*
Breusch-Pagan test (chi2)		0.2088*	0.0286*	0.6386*
Ramsey RESET test (F)		3.015***	0.5667*	0.2425*
Jarque-Bera test (chi2)		1.462*	4.55*	2.495*
Bounds cointegration test^	F-statistics	10.9527***	12.8197***	23.6408***
	t-statistics	-6.1040***	-7.7179***	-7.7925***

*Note: *p > 0.1; **p > 0.05; ***p > 0.01. ^Statistical significance verified against the critical values of lower and upper bounds from Pesaran et al. (2001).*

Source: own elaboration.

Table 6

Results of long-run and short-run asymmetry, long-run positive and negative effects, the Wald tests of the basic NARDL models

Independent variables		Long-run asymmetry	Short-run asymmetry	Long-run effect$^+$	Long-run effect$^-$	Wald test long-run asymmetry	Wald test short-run asymmetry
		F-stat	F-stat	Coefficient	Coefficient	F-stat	F-stat
Krakow	ST	2.807	0.0114	-0.949	-42.699	3.46*	0.01
	DE	9.674***	5.133**	-0.188	0.498***	12.63***	5.13**
Poznan	ST	0.4822	24.16***	3.231***	-12.550	0.49	24.16***
	DE	29.47***	5.6*	0.001	-0.051	18.30**	5.60*
Katowice	ST	21.97***	0.6554	3.808**	-70.697***	12.80***	0.66
	DE	3.562	10.9**	-0.214***	0.306***	2.63	10.90**

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

Based on Table 6, one can draw general conclusions of an evidence of long-run and short-run asymmetry in the case of the demand variable in Krakow. Tests also imply short-run asymmetry as well as long-run and short-run asymmetry in the case of stock and demand variables on the office market in Poznan. When it comes to Katowice, there is long-run asymmetry detected in the case of the stock variable, and a short-run for the demand variable. However, significant coefficients in Long-run effect+ and Long-run effect- suggest symmetric relationships.

Table 7 presents results of DV NARDL models which are based on split time series. In the case of the office market in Wroclaw, the minimum rent serves as the dependent variable. In model 4, the explanatory variables were formed by dividing the basic demand and supply time series into two parts. The first represents the values for periods where the vacancy rate is higher than the natural vacancy rate and zero otherwise. The second part includes values for periods where the vacancy rate is lower than natural vacancy and zero otherwise. In the case of Wroclaw, the adjustment variable RMINL1 is negative and significant. There are no statistically significant variables embodying long-term impact on the dependent variable. Short-run changes of the dependent variable lagging by two periods are negative. The cumulative impact of $\Delta STVRHL1^+$ and $\Delta STVRHL3^+$ on min. rent is positive (0.4519), which means that the increase of stock produce min. rent growth, even though the market vacancy rate is above the natural vacancy rate. Interestingly, the $\Delta STVRLL1^-$ coefficient (1.6815) argues that min. rent increases, also in the case of decreasing stock, with market vacancy being lower than natural vacancy rate. There are signs of positive $\Delta DEVRHL3^+$ and negative $\Delta DEVRHL3^-$ impacts of demand fluctuations on min. rent (0.1262, -0.0712) on the office market in Wroclaw. The results here are symmetric.

In the DV NARDL model for Trojmiasto, the vacancy rate works as the dependent variable. This time, the independent variables were formed as splits of basic demand and stock time series based on the maximum rent market level. Hence, the first variable includes values for periods with the maximum rent being higher than the average maximum rent and zero otherwise, whereas the second is based on values for periods with maximum rent being lower than the average maximum rent, and zero otherwise. The adjustment variable VRL1 is again negative and significant, which fits into the ARDL approach as a non-explosive pattern. All the long-term variables have a negative effect, while the short-term variables have a positive effect on the vacancy rate. Surprisingly, when it comes to the long-run impact variable $STRMAXHL1^{+}$ is negative (-11.7892), which means that stock increases reduce vacancy rate, despite the fact that the market max. rent is above its average level. As expected, $STRMAXLL1^{-}$ representing declining stock accompanied by max. rent below average, works in the same way (-12.2745). In the case of maximum rent being above the time span average, increases ($DERMAXHL1^{+}$) as well as decreases ($DERMAXHL1^{-}$) in demand imply vacancy rate falls (-1.2551; -1.4393). As far as the short-term is concerned, stock expansion and high max. Rent, i.e. both $\Delta STRMAXHL1^{+}$ and $\Delta STRMAXHL2^{+}$, indicate a rise of vacancy rate (8.6752; 4.4090). Simultaneously, declining stock accompanied by relatively low max. rent ($\Delta STRMAXLL1^{-}$, $\Delta STRMAXLL2^{-}$) also triggers a vacancy rate boost (9.1036; 4.5500). Curiously enough, the impact of the variables $\Delta DERMAXHL1^{+}$, $\Delta DERMAXHL2^{+}$, $\Delta DERMAXHL3^{+}$ is positive (cumulatively 1.9298). Also, the total impact of $\Delta DERMAXH^{-}$ and its lags is positive (1.2426), i.e. deteriorating demand together with high max. rent results in developing vacancy. Finally, $\Delta DERMAXLL1^{-}$ and $\Delta DERMAXLL2^{-}$ are positive and thus, as expected, lower demand accompanied by max. rent below the average results in a higher vacancy rate (0.5583; 0.4401).

Table 7

The DV NARDL models on the office markets in Wroclaw and Trojmiasto

Independent variables	Model 4 - Wroclaw		Independent variables	Model 5 - Trojmiasto	
	Dependent variable	RMIN (Min. rent)		Dependent variable	VR (Vacancy rate)
	Coefficient	Std. Error		Coefficient	Std. Error
Constant	1.620001***	0.2957141	Constant	-5.038825**	1.597846
RMINL1	-0.6678769***	0.1421054	VRLNL1	-2.466531***	0.6479558
$STVRHL1^{+}$	-1.713109	1.585728	$STRMAXHL1^{+}$	-11.78924***	2.99178
$STVRHL1^{-}$	-0.0694757	0.4026458	$STRMAXHL1^{-}$	0.2371299	1.077027
$STVRLL1^{+}$	-0.0349637	0.4784721	$STRMAXLL1^{+}$	-0.2538719	1.153203
$STVRLL1^{-}$	-1.639039	1.558921	$STRMAXLL1^{-}$	-12.27447***	2.991203
$DEVRHL1^{+}$	0.1244152	0.0771543	$DERMAXHL1^{+}$	-1.255053***	0.2976162
$DEVRHL1^{-}$	0.0154249	0.1064117	$DERMAXHL1^{-}$	-1.439259***	0.3213066
$DEVRLL1^{+}$	0.0112676	0.045407	$DERMAXLL1^{+}$	-0.5097632	0.3623582
$DEVRLL1^{-}$	0.0451972	0.0455804	$DERMAXLL1^{-}$	-0.671783	0.4040352
$\Delta RMINL1$	-0.3268563	0.1827764	$\Delta VRL1$	0.5623632	0.4231194
$\Delta RMINL2$	-0.3548731*	0.187487	$\Delta VRL2$	0.1526195	0.1852051
$\Delta STVRH^{+}$	-0.4867043	0.4695437	$\Delta STRMAXH^{+}$	0.0786997	1.312461
$\Delta STVRHL1^{+}$	1.678613*	0.8498064	$\Delta STRMAXHL1^{+}$	8.675233***	2.443551
$\Delta STVRHL2^{+}$	0.2802441	0.5320328	$\Delta STRMAXHL2^{+}$	4.409024**	1.789286
$\Delta STVRHL3^{+}$	-1.226686*	0.6324728	$\Delta STRMAXHL3^{+}$	1.143565	1.178391
$\Delta STVRH^{-}$	-0.3416813	0.3492917	$\Delta STRMAXH^{-}$	-0.1983982	1.517762
$\Delta STVRHL1^{-}$	-0.1100267	0.3342606	$\Delta STRMAXHL1^{-}$	-0.7432367	1.353654
$\Delta STVRHL2^{-}$	0.1339876	0.3089367	$\Delta STRMAXHL2^{-}$	-0.3476563	0.6842768
$\Delta STVRHL3^{-}$	0.3137202	0.2338433	$\Delta STRMAXHL3^{-}$	-0.718085	0.7513476
$\Delta STVRL^{+}$	-0.2718342	0.3458659	$\Delta STRMAXL^{+}$	-0.2457351	1.567463
$\Delta STVRLL1^{+}$	-0.0717822	0.3416003	$\Delta STRMAXLL1^{+}$	-0.4474888	1.331798
$\Delta STVRLL2^{+}$	0.1414606	0.29045	$\Delta STRMAXLL2^{+}$	-0.0300652	0.6564754
$\Delta STVRLL3^{+}$	0.2493119	0.2402447	$\Delta STRMAXLL3^{+}$	-0.5802349	0.8327409
$\Delta STVRL^{-}$	-0.462382	0.4528304	$\Delta STRMAXL^{-}$	0.0631241	1.290746
$\Delta STVRLL1^{-}$	1.681518*	0.8572287	$\Delta STRMAXLL1^{-}$	9.10359***	2.508077
$\Delta STVRLL2^{-}$	0.3114632	0.526721	$\Delta STRMAXLL2^{-}$	4.550016**	1.83524
$\Delta STVRLL3^{-}$	-1.158427	0.623553	$\Delta STRMAXLL3^{-}$	1.197989	1.143669
$\Delta DEVRH^{+}$	0.072645	0.0428242	$\Delta DERMAXH^{+}$	0.0053549	0.0599134
$\Delta DEVRHL1^{+}$	-0.026727	0.0863604	$\Delta DERMAXHL1^{+}$	1.105752***	0.271978
$\Delta DEVRHL2^{+}$	0.0317495	0.0595224	$\Delta DERMAXHL2^{+}$	0.6029571**	0.2204406

eISSN: 2300-5289

ΔDEVRHL3+	0.1261563**	0.0446442	ΔDERMAXHL3+	0.221065*	0.1137088
ΔDEVRH-	0.059106	0.0554545	ΔDERMAXH-	-0.2312612**	0.0789269
ΔDEVRHL1-	0.0653114	0.0570972	ΔDERMAXHL1-	0.7663445**	0.2330442
ΔDEVRHL2-	0.0407849	0.0564645	ΔDERMAXHL2-	0.509995***	0.1230756
ΔDEVRHL3-	-0.0712253**	0.0285049	ΔDERMAXHL3-	0.1974807**	0.0796251
ΔDEVRL+	-0.0321916	0.0294331	ΔDERMAXL+	-0.134476	0.10038
ΔDEVRLL1+	-0.0120946	0.0366203	ΔDERMAXLL1+	0.2077076	0.2679722
ΔDEVRLL2+	0.0181492	0.0135315	ΔDERMAXLL2+	0.013256	0.2340183
ΔDEVRLL3+	0.0038143	0.0131134	ΔDERMAXLL3+	-0.0054777	0.1758687
ΔDEVRL-	0.0387175	0.0244622	ΔDERMAXL-	0.0027269	0.1289818
ΔDEVRLL1-	-0.0531895	0.0358093	ΔDERMAXLL1-	0.5582529**	0.2353947
ΔDEVRLL2-	-0.0319844	0.0434619	ΔDERMAXLL2-	0.4400967**	0.1670895
ΔDEVRLL3-	0.0247485	0.0225156	ΔDERMAXLL3-	0.1577343	0.127226
Adj. R^2	0.7525		Adj. R^2	0.8863	

*Note: *p < 0.1; **p < 0.05; ***p < 0.01. "Δ" stands for first-differenced time series. "L" at the end of the variables' name stands for lagged time series. The superscripts "+" and "-" refer to positive and negative cumulative sums, respectively.*

Source: own elaboration.

Table 8

Results of autocorrelation, heteroskedasticity, model specification, normality and cointegration tests for the DV NARDL models

Tests		Wroclaw	Trojmiasto
		Stat.	Stat.
Portmanteau test (chi2)		28.74*	28.89*
Breusch-Pagan test (chi2)		1.314*	0.001442*
Ramsey RESET test (F)		1.735*	5.616***
Jarque-Bera test (chi2)		1.267*	2.691*
Bounds cointegration test^	F-statistics	9.7436***	4.6456**
	t-statistics	-4.6999***	-3.8066*

Note: *p > 0.1; **p > 0.05; ***p > 0.01. ^Statistical significance verified against the critical values of lower and upper bounds from Pesaran et al. (2001).

Source: own elaboration.

The Adjusted R^2 in models 4 and 5 is quite high. Moreover, tests stored in Table 8 confirm the econometric fit of the models in relation to autocorrelation, heteroskedasticity, specification and normal distribution.

Table 9 provides no proof of long-run and short-run asymmetry in the case of the office market in Wroclaw, Model 4. However, when it comes to Model 5, the results are more explicit. Long-run and short-run asymmetry is detected for all explanatory variables except the long-term impact of demand on the vacancy rate, with max. rent lower than its average value. This is also confirmed by the Wald tests. The aforementioned long-term effect of max. rent being above the average is acknowledged here, as negative impacts of the long-run effect+ of stock and demand are indicated. Nevertheless, when it comes to the long-run effect,- the results for STRMAXL, DERMAXH and DERMAXL imply vacancy rate growth.

Table 9

Results of long-run and short-run asymmetry, long-run positive and negative effects, the Wald tests for the DV NARDL models

Independent variables		Long-run asymmetry	Short-run asymmetry	Long-run effect+	Long-run effect-	Wald test long-run asymmetry	Wald test short-run asymmetry
		F-stat	F-stat	Coefficient	Coefficient	F-stat	F-stat
Model 4 Wroclaw	STVRH	1.561	0.03268	-2.565	0.104	1.86	0.03
	STVRL	1.745	0.06642	-0.052	2.454	2.10	0.07
	DEVRH	1.704	0.1417	0.186	-0.023	2.07	0.14
	DEVRL	0.2272	0.0000409	0.017	-0.068	0.22	0.00
Model 5 Trojmiasto	STRMAXH	187.3***	14.94***	-4.780***	-0.096	12.83***	14.94***
	STRMAXL	141.3***	14.23***	-0.103	4.976***	12.39***	14.23***
	DERMAXH	18.6***	6.592**	-0.509***	0.584***	12.47***	6.59**
	DERMAXL	0.933	3.659*	-0.207	0.272*	0.93	3.66*

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

eISSN: 2300-5289 | Received 2025-06-23 | Revised 2025-10-25 | Accepted 2025-11-14

4. Interpretation and discussion of the results

The findings based on models 1, 2 and 3 provide a positive answer to the first research question. First, the course of the impact of the shocks may influence vacancy rate adjustments. When it comes to the long-term, stock increases (Poznan, Katowice) and increments of demand (Katowice) produce symmetric reactions, and thus positive and negative responses of vacancy rate respectively. On the other hand, declines of stock and demand (Krakow and Katowice) generate asymmetric outcomes – increase and decrease of vacancy rate. As far as short-term adjustments are concerned, the type of the shock is crucial, as there are visible differences of the vacancy rate's reactions to the stock and demand fluctuations. In general, despite the direction, changes of stock induce symmetric vacancy rate variations (except for ΔST^- in Katowice). At the same time, there are non-linear vacancy rate responses to the ups and downs of demand (except for $\Delta DEL1^-$ in Krakow).

The results of DV models acknowledge positive answers to the second research question. The short-term relationships derived by model 4 indicate a rise of min. rent caused by an increase of stock (cumulative coefficients of $\Delta STVRHL1^+$ and $\Delta STVRHL3^+$) accompanied by a relatively high vacancy rate. The possible reason for this is the fact that, for the new office buildings entering the market – even in the times of a relatively high vacancy rate, landlords place the lower boundary of the rent range of a building on a higher than average market level. This drags the market level of min. rent up. This can be considered as kind of a novelty effect in the office market in Wroclaw, as brand new office space is simply expected to be better adapted to tenants' requirements and therefore more costly. On the other hand, a positive influence of $\Delta STVRLL1^-$ denotes the effect of the flight to quality process. The market stock may decline because of two reasons – first, because of the owner's decision to withdraw the office buildings from the market; second, because of a market analyst's decision to dismiss the particular buildings from the set of modern office space on the market. Both cases are caused by an inadequate, too low standard of office buildings, which usually translates into lower attention from tenants, higher vacancy rates and thus lower rent. This is why the disappearance of such buildings from the market stock is reflected in min. rent lift.

Min. rent in Wroclaw reacts to the changes of demand variables in a symmetric manner. However, one might expect that an increase in demand in the case of a high vacancy rate ($\Delta DEVRHL3^+$) should drive the vacancy to fall first, before the rent can rise. Again, this may not be the truth if we split the market rent into minimum and maximum rental rates. Despite the fact that dominant market rent may stay unchanged, expanding demand may result in increased min. rent. Under these circumstances, offices with relatively low rent may be the first to see the effects of improving economic conditions in the industry, to wit - an increase in occupancy and min. rent. This can also be proved in another way, by the variable $\Delta DEVRHL3^-$. Shrinking demand at high vacancy rates may first take its toll on buildings offering lower quality office space, pulling the min. rent down. As in an unfavourable economic situation, the flight to quality (Matsuo et al., 2024) can be more visible - older buildings in non-central locations may need to struggle for customers with min. rent reductions.

The results of Model 5 indicate that the time perspective may factor into market adjustments, which fits into the second research question. One can find an indication of differences in the direction of the impact of the max. rent level in the long-term and in the short-term in Trojmiasto. In the long-run, the max. rent being higher than average in the analyzed period is a symptom of prosperity. In this context, lasting high max. rents are confirmation of a strong market and put intense pressure on vacancies. Thus, declining vacancy rate is a natural state in such conditions. In this case, the ups and downs of demand result in falling vacancy ($DERMAXHL1^+$, $DERMAXHL1^-$) and even additional stock is swiftly absorbed by the market ($STRMAXHL1^+$). A negative impact of $STRMAXLL1^-$ can be attributed to the symmetric effect of market downturn.

The perspective on the high-level max. rent in the short-term is quite different. In the short-run, it can be considered as evidence of market disequilibrium which expectedly causes the vacancy rate to grow in the case of increasing stock ($\Delta STRMAXHL1^+$, $\Delta STRMAXHL2^+$) as well as falling demand ($\Delta DERMAXH^-$ and its lags). Another case is growing vacancy rate in the case of falling stock and low max. rent ($\Delta STRMAXLL1^-$, $\Delta STRMAXLL2^-$). Intuitively, one would expect vacancy rate to fall amid sinking stock and relatively low max. rent. However, in the short-run these conditions can be an exemplification of a market downturn at which low rents and fading stock do not last long enough to change the direction of vacancy rates. Unfavourable market terms may result in aforementioned withdrawals of older office buildings from the market, changing intended use of buildings being at the relatively early stage of construction e.g. from the office to the residential site (Colliers, 2024) and postponing the market new office buildings'on entrance . All of this matches the picture of declining stock and low max. rents ,causing vacancy to grow.

The positive workings of rising demand at high max. rents on vacancy rate (ΔDERMAXHL1^{+}, ΔDERMAXHL2^{+}, ΔDERMAXHL3^{+}) mean that there are many tenants who do not extend leasing agreements because of too high max. rent. One shall bear in mind that, in each period on the market, there is a particular number of agreements that expire. If the rent in the current period is too high, the tenants may be less interested in renewals. This may result in positive demand and negative net absorption at the same time. This is possible because the demand time series represents the amount of space leased in new agreements, while net absorption represents demand after deduction of space that has been vacated. The variables ΔDERMAXLL1^{-} and ΔDERMAXLL2^{-} cause a symmetric expansion of vacancy.

Last but not least, it is worth noting that, in the long-run, decreasing stock in the case of max. rent being lower than average, causes the vacancy rate to fall (STRMAXLL1^{-}), while in the short-term the influence is positive (ΔSTRMAXLL1^{-}, ΔSTRMAXLL2^{-})) This fits into the mould, as the short-run perspective works here as aforementioned evidence of a downturn. In turn, from the long-run angle, there are enough periods of such market conditions for one to actually observe the expected reduction in the vacancy rate, the last being a sign of slowly restoring market prosperity.

Our study provide indications of asymmetric rental (min. rent) adjustments (model 4) depending on the direction and type of the shocks as well as accompanying market conditions. This is in line with the literature to date. Englund et al. (2008), Hendershott, Lizieri and MacGregor (2010) and Matsuo et al. (2023) insist that the impact of the shocks depends on their direction and market conditions. Similarly, Brounen and Jennen (2009), Farrelly et al. (2014) and McCartney (2012) also report the importance of the current market situation. The critical role of market conditions is also described in a few Polish studies (Nowak et al., 2020 - office market in Warsaw; Nowak, 2021 - office markets in Krakow, Wroclaw, Poznan and Warsaw).

In most studies, vacancy rate is used to formulate supply and demand variables. There are far fewer publications touching vacancy rates as the dependent variable, as in the case of models 1, 2, 3 and 5. Matsuo et al. (2023) found evidence of asymmetric responses of vacancy rate depending on the course of changes of explanatory variables and market conditions. Hendershott et al. (2010) put this to test, but did not find evidence of statistically significant asymmetries. Englund et al. (2008) depict the vacancy asymmetry indirectly, by implementing the concept of hidden vacancy. There is a lack of studies on the vacancy rate in Poland as well as throughout CEE.

We also stress the distinction of long-term and short-term adjustments. This was signaled by Adams and Füss (2012) with regard to the impact of occupied stock. However, within the ECM framework, one can only test the non-linear relationships in the short-run. The NARDL overcome these limitations though. Hence, we report apparent differences in vacancy rate adjustments in the long and short term. Nonetheless, we cannot prove such evidence for minimum rent.

To sum up, the primary value added of the paper is twofold; first, it lies in the comprehensive verification of vacancy rate adjustments; second, it comes with a distinction between the long- and short-term perspective. Moreover, we have split the market rent into two minimum and maximum rates. Although there is only a final model explaining min. rent in force, this division allows us to better understand the impacts of particular shocks on the vacancy rate. Albeit the presence of papers regarding asymmetry on housing market in Poland (Brzezicka, et al., 2022; Głuszak & Trojanek, 2024), there is a lack of such on CRE markets. Our study is an attempt to bridge the research gap on this topic in CEE.

The limitations of the study are with reference to the time series. Due to the lack of public statistics and problematic availability of data the time series cover approximately one economic cycle (the four primary office markets) or shorter (the second tier cities). Then again, this is common in CEE, though this obstacle can be overcome with time. We also used asking min. and max. rent time series, by which one can imagine a market tendency of rigid face rents and, at the same time, increasing periods free of rent, in the case of a market downturn. This phenomenon should be investigated in the future by using transaction data, the lack of which, at present, makes it infeasible.

5. Conclusions

The paper is dedicated to the verification of asymmetric adjustments of vacancy rate and rent in nine office markets in Poland. We apply the NARDL approach on quarterly data and address topics that were not thoroughly studied hitherto - time perspective influence on office market dependences and vacancy rate adjustments.

The study proves asymmetry in vacancy rate and minimum market rent adjustments. First, we provide evidence of the time perspective impacting relationships among vacancy rate and stock and demand explanatory variables. The impact on vacancy rate is quite different in the long and short term.

Moreover, we acknowledge results of previous studies regarding non-linear responses of rent (minimum rent) which vary with reference to the direction, type of shocks and current market conditions. Moreover, we also indicate such relations when it comes to the vacancy rate (models 1, 2, 3, 5). These have rarely been the subject of research on vacancy rate so far.

We contribute to the empirical work on the CRE market in CEE, studies on which have been a rarity to date. Our findings produce implications for market practitioners - investors, developers, landlords and tenants - on market adjustments, which can affect the results of their market decisions.

Funding Sources

Michal Gluszak acknowledges that the research was co-financial from the subsidy granted to the Krakow University of Economics (Project no 076/EEN/2024/POT).

References

Adams, Z., & Füss, R. (2012). Disentangling the short and long-run effects of occupied stock in the rental adjustment process. *The Journal of Real Estate Finance and Economics, 44*(4), 570–590. https://doi.org/10.1007/s11146-010-9250-7

Ball, L., & Mankiw, N. G. (1994). Asymmetric price adjustment and economic fluctuations. *Economic Journal (London), 104*(423), 247–261. https://doi.org/10.2307/2234746

Blanchard, O. J., & Kiyotaki, N. (1987). Monopolistic competition and the effects of aggregate demand. *The American Economic Review, 77*(4), 647–666. www.jstor.org

Brounen, D. & Jennen, M. (2009). Asymmetric properties of office rent adjustment. *J Real Estate Finan Econ, 39*, 336–358. https://doi.org/10.1007/s11146-009-9188-9

Brzezicka, J., Łaszek, J., Olszewski, K., & Wisniewski, R. (2022). The missing asymmetry in the Polish house price cycle: An analysis of the behaviour of house prices in 17 major cities. *Journal of Housing and the Built Environment, 37*(2), 1029–1056. https://doi.org/10.1007/s10901-021-09861-w

Chau, K. W., & Wong, S. K. (2016). Information asymmetry and the rent and vacancy rate dynamics in the office market. *The Journal of Real Estate Finance and Economics, 53*(2), 162–183. https://doi.org/10.1007/s11146-015-9510-7

Chen, H., & Sun, Z. (2021). International crude oil price, regulation and asymmetric response of China's gasoline price. *Energy Economics, 94*, 105049. https://doi.org/https://doi.org/10.1016/j.eneco.2020.105049 https://doi.org/10.1016/j.eneco.2020.105049

Chen, S. S. (2007). Does monetary policy have asymmetric effects on stock returns? *Journal of Money, Credit and Banking, 39*(2–3), 667–688. https://doi.org/https://doi.org/10.1111/j.0022-2879.2007.00040.x https://doi.org/10.1111/j.0022-2879.2007.00040.x

Colliers. (2024). *Market Insight Polska H1 2024*.

Colliers. (2025). Quarterly data provided to the Authors on vacancy rate, min. rent, max. rent, demand and stock in nine major office markets in Poland.

Englund, P., Gunnelin, Å., Hendershott, P. H., & Söderberg, B. (2008). Adjustment in property space markets: Taking long-term leases and transaction costs seriously. *Real Estate Economics, 36*(1), 81–109. https://doi.org/10.1111/j.1540-6229.2008.00208.x

Erlandsen, S. K., & Juelsrud, R. E. (2023). Downward nominal house price rigidity: Evidence from three centuries of data on housing transactions. *Economics Letters, 225*, 111038. https://doi.org/https://doi.org/10.1016/j.econlet.2023.111038 https://doi.org/10.1016/j.econlet.2023.111038

Fallick, B., Villar, D., & Wascher, W. (2022). Downward nominal wage rigidity in the United States in times of economic distress and low inflation. *Labour Economics, 78*, 102246. https://doi.org/https://doi.org/10.1016/j.labeco.2022.102246 https://doi.org/10.1016/j.labeco.2022.102246

Fan, Y. (2022). Demand shocks and price stickiness in housing market dynamics. *Economic Modelling, 110*, 105820. https://doi.org/https://doi.org/10.1016/j.econmod.2022.105820 https://doi.org/10.1016/j.econmod.2022.105820

Farrelly, K., Gluszak, M., & Matysiak, G. (2014). *Panel modelling of European office market rent dynamics and asymmetries*. In 21st Annual European Real Estate Society Conference. Bukareszt. Retrieved from http://eres.scix.net/cgi-bin/works/Show?eres2014_78

Füss, R., Stein, M., & Zietz, J. (2012). A regime switching approach to modeling rental prices of UK real estate sectors. *Real Estate Economics, 40*(2), 317–350. https://doi.org/10.1111/j.1540-6229.2011.00316.x

Genesove, D., & Mayer, C. (1997). Equity and time to sale in the real estate market. *The American Economic Review, 87*(3), 255–269. http://www.jstor.org/stable/2951345

Genesove, D., & Mayer, C. (2001). Loss aversion and seller behavior: Evidence from the housing market. *The Quarterly Journal of Economics, 116*(4), 1233–1260. https://doi.org/doi:10.1162/003355301753265561 https://doi.org/10.1162/003355301753265561

Gholipour, H. F., Arjomandi, A., Farzanegan, M. R., & Yam, S. (2022). Global and local economic uncertainties and office vacancy in Australia: A sub-class analysis. *Applied Economics, 54*(47), 5393–5411. https://doi.org/10.1080/00036846.2022.2044998

Giulietti, M., Otero, J., & Waterson, M. (2020). Rigidities and adjustments of daily prices to costs: Evidence from supermarket data. *Journal of Economic Dynamics & Control, 116*, 103927. https://doi.org/https://doi.org/10.1016/j.jedc.2020.103927 https://doi.org/10.1016/j.jedc.2020.103927

Glaeser, E. L., & Gyourko, J. (2005). Urban decline and durable housing. *Journal of Political Economy, 113*(2), 345–375. https://doi.org/10.1086/427465

Głuszak, M., & Trojanek, R. (2024). Supply, demand and asymmetric adjustment of house prices in Poland. *Real Estate Management and Valuation, 32*(2), 31–45. https://doi.org/http://dx.doi.org/10.2478/remav-2024-0013

Grenadier, S. R. (1995). The persistence of real estate cycles. *The Journal of Real Estate Finance and Economics, 10*, 95–119. https://doi.org/10.1007/BF01096984

Hendershott, P. H., Lizieri, C. M., & MacGregor, B. D. (2010). Asymmetric adjustment in the city of London office market. *The Journal of Real Estate Finance and Economics, 41*(1), 80–101. https://doi.org/10.1007/s11146-009-9199-6

Hendershott, P. H., MacGregor, B. D., & Tse, R. Y. (2002a). Estimation of the rental adjustment process. *Real Estate Economics, 30*(2), 165–183. https://doi.org/10.1111/1540-6229.00036

Hendershott, P. H., MacGregor, B. D., & White, M. (2002b). Explaining real commercial rents using an error correction model with panel data. *The Journal of Real Estate Finance and Economics, 24*(1-2), 59–87. https://doi.org/10.1023/A:1013930304732

Ibanez, M. R., & Pennington-Cross, A. (2013). Commercial property rent dynamics in U.S. metropolitan areas: An examination of office, industrial, flex and retail space. *The Journal of Real Estate Finance and Economics, 46*(2), 232–259. https://doi.org/10.1007/s11146-011-9347-7

Kahneman, D., Knetsch, J. L., & Thaler, R. (1986). Fairness as a constraint on profit seeking: Entitlements in the market. *The American Economic Review, 76*(4), 728–741. http://www.jstor.org/stable/1806070

Katrakilidis, C., & Trachanas, E. (2012). What drives housing price dynamics in Greece: New evidence from asymmetric ARDL cointegration. *Economic Modelling, 29*(4), 1064–1069. https://doi.org/https://doi.org/10.1016/j.econmod.2012.03.029 https://doi.org/10.1016/j.econmod.2012.03.029

Ke, Q., & White, M. (2013). A tale of two Chinese cities: The dynamics of Beijing and Shanghai office markets. *Journal of Real Estate Portfolio Management, 19*(1), 31–47. https://doi.org/10.1080/10835547.2013.12089940

Li, Y. (2015). The asymmetric house price dynamics: Evidence from the California market. *Regional Science and Urban Economics, 52*, 1–12. https://doi.org/10.1016/j.regsciurbeco.2015.02.002

Li, Y. Qi, Y., Liu, L., Hou, Y., Fu, S., Yao, J., & Zhu, D. (2022). Effect of increasing the rental housing supply on house prices: Evidence from China's large and medium-sized cities. *Land Use Policy, 123*, 106420. https://doi.org/https://doi.org/10.1016/j.landusepol.2022.106420

Matsuo, K., Tsutsumi, M., & Imazeki, T. (2023). Asymmetric dynamics of rent and vacancy rates in the Tokyo office market. *International Real Estate Review, 26*(1), 1–41. https://doi.org/10.53383/100355

Matsuo, K., Tsutsumi, M., Imazeki, T., & Kudoh, T. (2024). The impact of the flight to quality on office rents and vacancy rates in Tokyo. *Real Estate Management and Valuation, 32*(3), 77–86. https://doi.org/10.2478/remav-2024-0026

McCartney, J. (2012). Short and long-run rent adjustment in the Dublin office market. *Journal of Property Research, 29*(3), 201–226. https://doi.org/10.1080/09599916.2012.689990

Nowak, K. (2020). Hidden Vacancy rate as a part of office market dynamics in selected polish cities. *Real Estate Management and Valuation, 28*(1), 1–12. https://doi.org/10.2478/remav-2020-0001

Nowak, K. (2021). *Dynamika rynku powierzchni biurowej. (*The dynamics of office market). Wydawnictwo Uniwersytetu Rzeszowskiego.

Nowak, K., Gluszak, M., & Belniak, S. (2020). Dynamics and asymmetric rent adjustments in the office market in Warsaw. *International Journal of Strategic Property Management, 24*(6), 428–440. https://doi.org/https://doi.org/10.3846/ijspm.2020.13647 https://doi.org/10.3846/ijspm.2020.13647

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics, 16*(3), 289–326. https://doi.org/10.1002/jae.616

Schaefer, D., & Singleton, C. (2022). *The extent of downward nominal wage rigidity: New evidence from payroll data.* Review of Economic Dynamics. https://doi.org/https://doi.org/10.1016/j.red.2022.11.006

Simo-Kengne, B. D., Balcilar, M., Gupta, R., Reid, M., & Aye, G. C. (2013). Is the relationship between monetary policy and house prices asymmetric across bull and bear markets in South Africa? Evidence from a Markov-switching vector autoregressive model. *Economic Modelling, 32*(1), 161–171. https://doi.org/10.1016/j.econmod.2013.02.006

Tsai, I.-C. (2013). The asymmetric impacts of monetary policy on housing prices: A viewpoint of housing price rigidity. *Economic Modelling, 31*, 405–413. https://doi.org/https://doi.org/10.1016/j.econmod.2012.12.012 https://doi.org/10.1016/j.econmod.2012.12.012

Yii, K.-J., Tan, C.-T., Ho, W.-K., Kwan, X.-H., Nerissa, F.-T. S., Tan, Y.-Y., & Wong, K.-H. (2022). Land availability and housing price in China: Empirical evidence from nonlinear autoregressive distributed lag (NARDL). *Land Use Policy, 113*, 105888. https://doi.org/https://doi.org/10.1016/j.landusepol.2021.105888 https://doi.org/10.1016/j.landusepol.2021.105888