Convergence of the office markets in capital cities of the Visegrád Group countries

29 August 2023, ERSA 2023 62nd Congress in Alicante, Spain on Urban Challenges and Sustainable Technological Revolution

by Krzysztof Nowak, Malgorzata Snarska, and Jana Prilucikova

Outline

1. Introduction
2. Threefold Aims of the Research
3. Research Questions
4. V4 Office Market Overview
5. Methodology
6. Results and Discussion
7. Q&A

Research Team

Krzysztof Nowak

University of Rzeszów, Poland

Małgorzata Snarska

Cracow University of Economics, Poland

Jana Prilucikova

Tomas Bata University in Zlín, Czech Republic

Áron Horváth

Eltinga, Budapest, Hungary

Research topic and motivation

Office market convergence in Visegrad Group (V4) capital cities (Czech Republic, Hungary, Poland, Slovakia)

Understanding regional economic dynamics

Contributing to academic knowledge and providing implications for policy-makers and business

Threefold Aims of the Research

1 ECM Suitability Verification

Assess alignment of V4 office markets with Error Correction Models. Study responsiveness to short-term deviations from equilibrium.

2 Unified Market Characteristics Exploration

Investigate if individual V4 markets can be treated as a unified market.Utilize panel data to identify shared trends and dynamics.

3 Convergence Investigation

Examine the potential for convergence within individual V4 office markets.Identify potential reduction in disparities over time.

Research Questions

ECM Suitability Verification

Do the office markets in capital cities of the Visegrad Group countries conform to the Error Correction Models (ECM) framework?

Unified Market Characteristics Exploration

Can the office markets in capitals of the Visegrad Group countries be considered as a single, integrated market?

Convergence Investigation

Is there evidence of convergence among the office markets in capitals of the Visegrad Group countries?

Office Market Overview

Prague

In the Czech Republic, the capacity of the office market is about 3.8 million square meters of office space.

Budapest

In Budapest, the area of the office market is about 4.2 million m²

Warsaw

In Warsaw, the capacity of the office market is about 6.3 million square meters of office space

Bratislava

In Slovakia, the capacity of the office market is about 2.0 million square meters of office space

Key Office Market Characteristics

Total office stock

The cumulative contemporary office space, measured in thousands square meters (m², sqm), serves as a indicator of market growth and responsiveness (in the model refers to ***SU***, supply variable, “**stock**“).

Office vacancy rate

The proportion of unoccupied offices to total available office space (%) is a key indicator of market dynamics, economic adaptability, and office property appeal to potential tenants (v, “**vacancy rate**“).

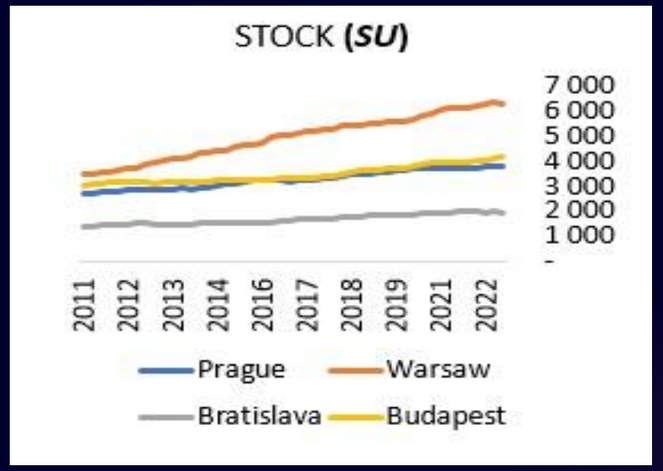
Prime office rent

The cost of renting prime office spaces, measured in euros per sqm per month, indicates market attractiveness and responsiveness (R ,“**rent**“).

Employed persons

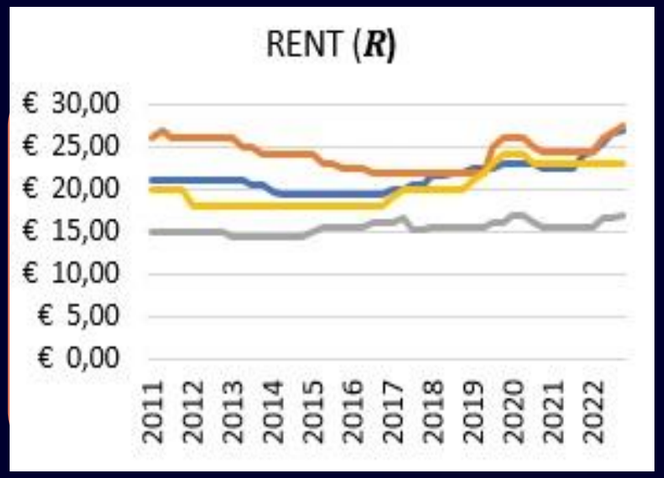
The total persons employed (in thousands) in the capital city, reflects its workforce and economic role as a hub for jobs and growth (E, demand variable, “**employment**“).

Unveilling office market trends

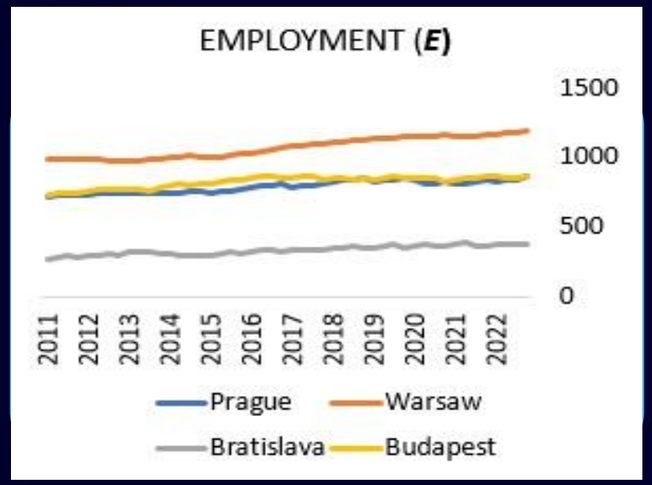


Total office stock

Office vacancy rate



Prime office rent



Employed persons

Research methodology

Panel data analysis

A panel data model is established, incorporating data from all the four office markets. This approach enables the exploration of interdependencies and shared trends across the markets.

1

Individual market assessment

Error Correction Models (ECMs) are constructed for each city's office market.These models capture the dynamic relationships between variables and assess how quickly deviations from equilibrium are corrected.

2

3

Convergence ratios estimation

Convergence ratios are calculated to gauge the degree of convergence in rents or relevant indicators across the four office markets.

Research question 1

Do the office markets in capital cities of the Visegrad Group countries conform to the Error Correction Model (ECM) framework?

Error correction model

$$\log R_t = \log \gamma_0 + \gamma_1 \log E_t + \gamma_2 \log(1 - v_t) + \gamma_3 \log SU_t + e_t$$

$$\Delta \log R_t = \alpha_0 + \alpha_1 \Delta \log E_t + \alpha_2 \Delta \log(1 - v_t) + \alpha_3 \Delta \log SU_t + \alpha_4 u_{t-1} + \eta_t$$

Where: R – rent, E – demand variable (employment), v – vacancy rate, SU – supply variable (office stock), u - residuals from the long term equation.

(source: Hendershott, MacGregor & Tse, 2002)

ECM Results 1 – the long-term equations

BRATISLAVA	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	.8197459	.6608259	1.24	Intercept	.4340591	.6183598	0.70	Intercept	.2299784	.5973921	0.38
LNTotalStock	.1149619	.1228543	0.94	LNOcuppiedStock	.286921	.0915509	3.13***	LNTotalStock	.142613	.1076095	1.33
LNEmployment	.149773	.1516632	0.99	LNEmployment	.0718656	.1227918	0.59	LNOccupationRate	.5316934	.1376777	3.86***
.	.	.	.	.	.	.	.	LNEmployment	.0767005	.1338929	0.57
R^2	0.4060			0.5030				0.5564			

BUDAPEST	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	3.040902	.9599433	3.17***	Intercept	5.185542	.9488783	5.46***	Intercept	7.347084	1.966848	3.74***
LNTotalStock	1.152085	.107581	10.71***	LNOcuppiedStock	1.083586	.0725819	14.93***	LNTotalStock	1.026214	.085448	12.01***
LNEmployment	.4994717	.1996028	2.50**	LNEmployment	1.619744	.2069197	7.83***	LNOccupationRate	1.371201	.2407318	5.70***
.	.	.	.	.	.	.	.	LNEmployment	1.866258	.2846621	6.56***
R^2	0.7840			0.8712				0.8757			

PRAGUE	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	4.613713	1.177678	3.92***	Intercept	1.734392	.9712556	1.79*	Intercept	.2260221	1.602349	0.14
LNTotalStock	.615881	.2196054	2.80***	LNOcuppiedStock	.8386091	.1755381	4.78***	LNTotalStock	.7095923	.1925674	3.68***
LNEmployment	.2346624	.4426817	0.53	LNEmployment	1.153517	.4568703	2.52**	LNOccupationRate	1.242487	.3162481	3.93***
.	.	.	.	.	.	.	.	LNEmployment	1.150862	.4502803	2.56**
R^2	0.4855			0.5989				0.6191			

WARSAW	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	2.646762	.9898461	2.67**	Intercept	2.54263	1.227008	2.07**	Intercept	4.278766	1.167541	3.66***
LNTotalStock	.6238846	.1652116	3.78***	LNOcuppiedStock	.6934078	.3044657	2.28**	LNTotalStock	.0744833	.3341248	0.22
LNEmployment	1.454056	.4445748	3.27***	LNEmployment	1.611019	.7871691	2.05**	LNOccupationRate	1.501231	.6336213	2.37**
.	.	.	.	.	.	.	.	LNEmployment	.2973239	.8518721	0.35
R^2	0.2585			0.1245				0.3424			

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

ECM Results 2 – the basic short-term equations 1

BRATISLAVA	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	.0030049	.004293	0.70	Intercept	.0005502	.0039632	0.14	Intercept	.0026842	.003993	0.67
LNTotalStockC	.1337644	.2801952	0.48	LNOcuppiedStockC	.3258545	.2237575	1.46	LNTotalStockC	.0887979	.2604117	0.34
LNEmploymentC	.0553506	.1163122	0.48	LNEmploymentC	.0743551	.1136548	0.65	LNOccupationRateC	.7489215	.2893877	2.59**
ResidualsM1L	.2451651	.1151569	2.13**	ResidualsM2L	.3275941	.1214161	2.70**	LNEmploymentC	.0748144	.1093135	0.68**
.	.	.	.	.	.	.	.	ResidualsM3L	.3136261	.124282	2.52
R^2	0.1185			0.1609				0.2437			

BUDAPEST	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	.0051369	.0050562	1.02	Intercept	.0000968	.0048012	0.02	Intercept	.0029033	.0049624	0.59
LNTotalStockC	.2732462	.4710659	0.58	LNOcuppiedStockC	.370033	.330775	1.12	LNTotalStockC	.120274	.4374335	0.27
LNEmploymentC	.0656671	.3368285	0.19	LNEmploymentC	.1308544	.3343564	0.39	LNOccupationRateC	.7497697	.3968673	1.89*
ResidualsM1L	.0670982	.0812694	0.83	ResidualsM2L	.1835926	.1006892	1.82*	LNEmploymentC	.2795875	.3351732	0.83
.	.	.	.	.	.	.	.	ResidualsM3L	.190543	.1001049	1.90*
R^2	0.0331			0.0877				0.1557			

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

ECM Results 3 – the basic short-term equations 2

PRAGUE	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	.0036929	.0035657	1.04	Intercept	.0016405	.0033423	0.49	Intercept	.0027008	.0034942	0.77
LNTotalStockC	.1417458	.3054293	0.46	LNOccupiedStockC	.4264305	.2477834	1.72*	LNTotalStockC	.2568502	.3012262	0.85
LNEmploymentC	.176258	.2166368	0.81	LNEmploymentC	.0681132	.2203252	0.31	LNOccupationRateC	.6768878	.3473539	1.95*
ResidualsM1L	.0116848	.0536454	0.22	ResidualsM2L	.0393475	.0638275	0.62	LNEmploymentC	.0424852	.2207859	0.19
.	.	.	.	.	.	.	.	ResidualsM3L	.0518154	.0679136	0.76
R^2	0.0249			0.0853				0.1079			

WARSAW	Model 1			Model 2				Model 3			
Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t	Variable	Coefficient	Std. Err	t
Intercept	.0136235	.0078579	1.73*	Intercept	.0059693	.0084278	0.71	Intercept	.0117942	.0083104	1.42
LNTotalStockC	.925767	.4367443	2.12**	LNOccupiedStockC	.4265445	.5648365	0.76	LNTotalStockC	.7128126	.5369681	1.33
LNEmploymentC	.2677549	.7140423	0.37	LNEmploymentC	.0431968	.7594123	0.06	LNOccupationRateC	.4568179	.6222973	0.73
ResidualsM1L	.1192742	.0750816	1.59	ResidualsM2L	.1136869	.081882	1.39	LNEmploymentC	.3602868	.7284583	0.49
.	.	.	.	.	.	.	.	ResidualsM3L	.1111484	.0873508	1.27
R^2	0.1422			0.0463				0.1540			

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

ECM Results 3 – the modified short-term equations

	Model 3 (Bratislava)				Model 3 (Budapest)		
Variable	Coefficient	Std. Err	t	**Variable**	Coefficient	Std. Err	t
Intercept	.0038603	.0031726	1.22	**Intercept**	.0325824	.0097778	3.33***
COVLNTotalStockC	-1.390129	.5692944	-2.44**	**LNTotalStockC**	-.4502258	.4121329	-1.09
LNOccupationRateC	.6327807	.2677367	2.36**	**LNOccupationRateC**	1.072069	.3703363	2.89***
COVLNEmploymentC	.4920565	.2668254	1.84*	**COVLNEmploymentC**	-.3693631	.5263725	-0.70
ResidualsL	-.213169	.1236488	-1.72*	**ResidualsL**	-.1919049	.0892057	-2.15**
-	-	-	-	**VacancyL**	-.240687	.0662429	-3.63***
R^2	0.3516			R^2	0.3667		
	Model 1 (Prague)				**Model 1 (Warsaw)**		
Variable	Coefficient	Std. Err	t	**Variable**	Coefficient	Std. Err	t
Intercept	.0224228	.0077665	2.89***	**Intercept**	-.0038443	.0048624	-0.79
COVLNTotalStockC	.6580379	.7384487	0.89	**COVLNTotalStockC**	-2.107517	.8531946	2.47**
COVLNEmploymentC	.6252662	.3409084	1.83*	**COVLNEmploymentC**	-1.567856	1.504638	-1.04
ResidualsL	-.104621	.0548706	-1.91*	**ResidualsL**	-.1976931	.0825684	-2.39**
COVLNRRentCL2	.5748307	.218658	2.63**	**VacancyL**	.3907035	.1353676	2.89***
VacancyL	-.1941697	.0732268	-2.65**	-	-	-	-
R^2	0.3606			R^2	0.2302		

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Research question 2

Can the office markets in capitals of the Visegrad Group countries be considered as a single, integrated market?

Synchronisation of office markets in V4 group

Pedroni (1999) tests for cointegration - The seven test statistics allow heterogeneity in the panel, both in the short-run dynamics as well as in the long-run slope and intercept coefficients. Unlike regular time-series analysis, this tool does not consider normalization or the exact number of cointegrating relationships. Instead, the hypothesis test is simply the degree of evidence, or lack thereof, for cointegration in the panel among two or more variables. In our analysis only tests, for which statistics were reliably calculated are presented. Three separate models have been calculated, they differ by the explanatory variables. The results of the Pedroni cointegration procedure for the office market variables in the Visegrad Group capitals can be interpreted in terms of synchronization, comovement, and codependence among the variables.

Panel VAR of a form:

$$Y_{it} = Y_{it-1}A_1 + X_{it}B + u_i + e_{it}$$

where Y_{it} is a vector of dependent variables, X_{it} is a matrix of exogenous covariates (or ECM errors) and $u_i$and e_{it} are vectors of dependent variable specific panel fixed effects and idiosyncratic errors

long run analysis (demeaned variables from model 3) – fixed effects PVAR estimation, groupped by City and date (192 obs. 4 groups) short run analysis (demeaned first differences of variables from model 3) – fixed effects PVAR estimation, groupped by City and date (192 obs. 4 groups)

Cointegration analysis

Statistic	Model 1: Prents","OStock","Emp"			Model 2: Prents","TStock","Emp"			**Model 3: Prents","Tstock","ORate","Emp"**		
	empirical	standard.	P-value	empirical	standard.	P-value	**empirical**	**standard.**	**P-value**
nipanel	0,0000	-2,7574	0,0089	0,0000	-2,7574	0,0089	**0,0000**	**-3,0206**	**0,0042**
rhogroup	-20,0641	3,0482	0,0038	-12,3353	3,8692	0,0002	**-19,7915**	**3,5715**	**0,0007**
tgroupnonpar	-5,0383	2,6851	0,0108	-3,5139	4,7239	0,0000	**-5,1792**	**3,3961**	**0,0012**
tgrouppar	-4,9684	2,7786	0,0084	-3,3248	4,9769	0,0000	**-4,9425**	**3,7126**	**0,0004**

Panel VAR results

		Levels - long run equation				First differences - short run without ECM			
		Explained variables				Explained variables			
Explanatory variables	Parameters	demeaned_Prents	demeaned_Tstock	demeaned_ORate	demeaned_Emp	demeaned_Prents	demeaned_Tstock	demeaned_ORate	demeaned_Emp
demeaned_lag1_Prents	estimate	0,9263	0,0096	-0,0378	-0,0477	0,203	-0,0282	0,0261	-0,0102
	stand.error	0,0283	0,0144	0,0119	0,0222	0,0759	0,0352	0,0322	0,0574
	t-stat	32,7314	0,6667	-3,1765	-2,1486	2,6746	-0,8011	0,8106	-0,1777
	p-value	0,0000	0,5058	0,0017	0,0329	0,0081	0,4240	0,4186	0,8591
demeaned_lag1_Tstock	estimate	0,0366	0,9786	-0,0068	0,0992	-0,3121	-0,0287	-0,0132	-0,1488
	stand.error	0,0268	0,0136	0,0112	0,0210	0,1696	0,0787	0,0719	0,1283
	t-stat	1,3657	71,9559	-0,6071	4,7238	-1,8402	-0,3647	-0,1836	-1,1598
	p-value	0,1736	0,0000	0,5445	0,0000	0,0673	0,7158	0,8545	0,2476
demeaned_lag1_ORate	estimate	0,1424	0,0398	0,9839	0,1009	-0,178	-0,0549	0,1256	0,1577
	stand.error	0,0550	0,0279	0,0230	0,0430	0,1845	0,0857	0,0782	0,1396
	t-stat	2,5891	1,4265	42,7783	2,3465	-0,9648	-0,6406	1,6061	1,1297
	p-value	0,0104	0,1553	0,0000	0,0200	0,3359	0,5225	0,1099	0,2600
demeaned_lag1_Emp	estimate	0,0081	0,0112	0,0298	0,7741	-0,0261	0,0045	0,0342	-0,3369
	stand.error	0,0532	0,0270	0,0222	0,0416	0,0916	0,0426	0,0388	0,0693
	t-stat	0,1523	0,4148	1,3423	18,6082	-0,2849	0,1056	0,8814	-4,8615
	p-value	0,8791	0,6787	0,1811	0,0000	0,7760	0,9160	0,3792	0,0000

Discussion of synchronization results

•**Comovement and codependence:** The consistent absence of cointegration at the panel level (as indicated by the "nipanel" statistic) suggests that, overall, there isn't strong evidence of a long-term equilibrium relationship across the entire set of variables in each model. However, the presence of potential cointegration among subsets of variables (as indicated by the negative "rhogroup" statistics) suggests that certain combinations of variables exhibit synchronization and comovement tendencies over the long term. This synchronization and comovement among specific variables could indicate codependence, where the behavior of certain variables is interconnected and collectively influenced by common factors or forces. These relationships might not be evident when looking at the entire panel but become apparent when examining subsets of variables.

•**Long run synchronization:** The coefficients for the lagged levels of the variables capture the long-term relationships among the variables after accounting for any short-term dynamics. "demeaned_lag1_Prents" has a coefficient of 0.9263, which is statistically significant at the 0.01 level. This suggests that a one-unit increase in the lagged level of "Prents" leads to an increase of 0.9263 units in the level of itself in the long run. Similarly, "demeaned_lag1_Tstock," "demeaned_lag1_ORate," and "demeaned_lag1_Emp" have coefficients close to 1, indicating strong positive relationships with their own lagged levels in the long run. In addition to the above, "demeaned_lag1_ORate" and "demeaned_lag1_Emp" have statistically significant coefficients indicating a long-term relationship between these variables and "Prents". However, one could expect that the impact Employment as well as of Occupation Rate on rent would be positive.

•**Short run synchronization**: The coefficients for the lagged first differences of the variables indicate the short-term dynamics and interactions among the variables. "demeaned_lag1_Prents" has a coefficient of 0.2030, which is statistically significant at the 0.01 level. This suggests that a one-unit increase in the lagged first difference of "Prents" leads to an increase of 0.2030 units in the first difference of itself. The other lagged first differences do not appear to be statistically significant at conventional significance levels.

Research question 3

Is there evidence of convergence among the office markets in capitals of the Visegrad Group countries?

Convergence ratios estimation

Beta convergence - the constant over time negative correlation betwen the level of rents Y_{it} and its growth rate. It means that regions with initially lower level of rents will catch up the better developed markets. The analysis is based on the dynamic model of a form

$$\log\left(\frac{Y\_it}{Y_{it-1}}\right) = \alpha_0 - \alpha_1 \log Y_{it-1} + u_i + e_{it} \rightarrow \beta = -\log(1-\alpha_1),$$

where u_i - group effects, e_{it} - error term

Sigma convergence - refers to a reduction in the dispersion of levels of rents across office markets $\sigma_t^2 = \frac{1}{N}\sum_i \left(\log(y_{it}) - \overline{\log(y_{it})}\right)^2$

Gamma convergence – relates to intermobility within rents distribution:

$$\gamma_t = \frac{\sigma^2(\sum_i R(y_{it}))}{\sigma^2((T+1)\cdot R(y_{io}))}$$

where Kendall's $R(y_{it})$ rank of rent level in the i-th market in year t, $R(y_{i0})$ – Kendalls' rank of rent level in the i-th market in year 0 (first period of analysis)

Convergence ratios results

	Sigma	Beta	Gamma
Bratislava	0.04328162	-5.232798e-15	-2.264839e-16
Budapest	0.1082355	-1.487064e-14	-1.609531e-15
Prague	0.08367568	-1.768579e-14	-1.47987e-15
Warsaw	0.07051279	0.03774033	0.002661176
Overall	0.18205	1.116977e-16	2.033458e-17

Convergence analysis

A lower **sigma value** indicates that rents are becoming more equal across regions. In this context, we can observe that Bratislava has the lowest sigma value, which means that there's relatively less rent inequality in this city compared to the others. The overall sigma value is higher, suggesting that there's still significant rent inequality across all the cities combined, despite some reduction in inequality over time.

A negative **beta value** suggests that regions with lower rents initially are growing faster, while a positive value suggests the opposite. In this case, Bratislava, Budapest, and Prague have very small and negative beta values, indicating that these cities are not following the typical beta convergence pattern. Warsaw, on the other hand, has a positive beta value, implying that it's experiencing growth in rents faster than what would be expected based on initial rent levels.

Gamma convergence combines both sigma and beta convergence. It gives an overall picture of whether there's convergence in both rent levels and growth rates of rent. **Negative gamma values** suggest that regions with lower rents are growing faster, contributing to overall convergence. In this case, Bratislava, Budapest, and Prague have negative gamma values close to zero, indicating limited convergence. Warsaw has a positive gamma value, suggesting some level of convergence due to its positive beta value, although the effect is still relatively small.

Further remarks

•Overall, based on these results, it seems that there is some reduction in rent inequality (sigma convergence) across the cities, but the growth rates are not following the typical beta convergence pattern for most cities.

•Warsaw's rent growth is contributing to a moderate level of overall convergence according to gamma convergence. The sigma convergence analysis indicates the degree of rent inequality reduction among the office markets. The values suggest that rent disparities are gradually decreasing over time in each city.

•Bratislava has the lowest sigma value, implying a relatively higher degree of rent equality, followed by Warsaw, Prague, and Budapest. However, the overall sigma value, while positive, is still relatively high, suggesting that despite individual reductions in inequality, there remains significant variation in rents across the Visegrad Group cities.

•The beta convergence analysis focuses on the growth rates of rent across the four markets. Bratislava, Budapest, and Prague exhibit extremely small and negative beta values, which suggest that these cities do not conform to the typical pattern of poorer regions growing faster than richer regions. Instead, they seem to experience negligible growth rate differences based on initial rent levels. Conversely, Warsaw's positive beta value signifies that it is growing at a rate higher than expected from its initial rent level. This observation could be attributed to Warsaw's unique economic conditions and attractiveness to investors.

•The gamma convergence analysis combines both rent levels and growth rates. For Bratislava, Budapest, and Prague, the negative gamma values suggest that despite their individual growth patterns, the overall convergence effect is limited. These cities seem to experience slow changes in rent levels and growth rates. Warsaw's positive gamma value, while small, indicates some convergence due to its unique growth trajectory

Main findings

Market stability

The office markets in capital cities of the Visegrad Group countries do conform to the Error Correction Model (ECM) framework. However, exogenous factors together with characteristics of the markets may influence the relationships depicted by the ECM approach.

Synchronization

According to the VAR and VECM results the office markets in capitals of the Visegrad Group countries can be considered as a single, integrated market. However, the influence of aforementioned factors is also visible.

Convergence

There is no clear convergence in rent and rent growth on the office markets within the Visegrad Group capital cities.

Thank you for your attention

Questions and comments are welcome