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HOUSING INVESTMENT IN POLAND AS INFLATION HEDGE IN LOW AND HIGH INFLATION. THRESHOLD COINTEGRATION ANALYSIS

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ARTICLE INFO

Keywords:

inflation hedging, exchange rate, real estate, low and high inflation

JEL Classification:

G11, R30, R31, R39

ABSTRACT

This study examines the efficiency of housing real estate investments in Poland as an inflation hedge, with a particular focus on the influence of exchange rate and inflation measured by the HICP index on housing property prices. Aim: to determine whether housing real estate investment can be inflation hedge in both low and high inflation environments. Methodology: The analysis applies threshold cointegration techniques to identify regimes of high and low inflation and assess the long-term and short-term relationships between the variables. Findings: The results suggest that the variables used in the study can be effectively analyzed using threshold cointegration analysis. The findings indicate that investment in housing real estate can serve as a strong capital hedge, particularly during periods of low inflation. Implications: The study provides important insights for examining the relationship between housing real estate investments, inflation, and exchange rates. The analysis allows for the identification of distinct regimes of high and low inflation, which can have significant implications for understanding the dynamic relationships between the inflation, exchange rate and real estate prices. The results suggest that real estate can be a valuable asset in a diversified portfolio, particularly during periods of low inflation, as it can serve as a hedge against loss of value. Originality/value: The research delves into the nuances of the relationship between inflation and housing real estate, examining the potential for housing real estate to serve as an effective hedge against inflation and the exchange rate as a factor that may influence its performance in low and high inflationary contexts.

Citation: Karp, P. & Wolski, R. (2025). Housing investment in Poland as inflation hedge in low and high inflation. Threshold cointegration analysis. *Real Estate Management and Valuation*, *33*(2), 23-38. https://doi.org/10.2478/remav-2025-0013

1. Introduction

Real estate investment has long been considered a reliable strategy for securing capital in the face of economic uncertainty. Although investors primarily look at inflation hedging assets during periods of high inflation, many studies show that it is in the long term that capital hedging assets are easier to find. However, when considering the long term, one cannot fail to notice that inflation has higher and lower levels. This is why the paper aims to determine whether housing real estate investments in Poland can be an inflation hedge in both low and high inflation environments. To utilizing a threshold cointegration analysis to elucidate the underlying mechanisms that govern this relationship. The existing literature on the subject has highlighted the importance of understanding the intricate interplay between housing real estate investment and inflation, with some studies suggesting that the relationship may not be linear and may exhibit nonlinearities or thresholds that differ based on the level of inflation. (Rubens et al., 1989; Wolski, 2023) Building upon this foundation, the research paper delve deeper into the nuances of this relationship, examining the potential for housing real estate to serve as an effective hedge against inflation and the factors that may influence its performance in various inflationary contexts.

In order to achieve the research aim, the authors formulated the main research hypothesis: Investments in housing real estate in Poland can be successfully

used as a hedge against inflation.

In the course of the research work, three auxiliary hypotheses were formulated:

1. the exchange rate of PLN/EUR affects housing real estate prices,
2. in periods of low and high inflation, housing real estate investments hedge against inflation in a different manner.

2. Literature overview

The prevailing economic and political uncertainties have prompted investors to actively pursue diversified asset allocation strategies as a means of mitigating risk and optimizing returns. Periods of high inflation have also led investors to gravitate towards asset classes commonly associated with capital protection against the adverse impacts of inflationary processes, such as real estate (Lintner, 1975). The literature on the subject is very extensive, and it is impossible to present all the research in the field of hedging inflation.

One of the pioneering studies on the topic was conducted by Fama and Schwert (1977), which demonstrated that U.S. residential real estate investments could serve as a hedge against inflation. The researchers examined the relationship between house prices and both expected and unexpected inflation, considering data from 1953 to 1971 on a quarterly and monthly basis. The findings indicated that residential real estate investments effectively shielded against the anticipated component of inflation, but not the unanticipated element. Subsequent research delved deeper into the interplay between real estate, interest rates, and inflation. Studies have revealed a statistically significant positive correlation between stock returns and future changes in interest rates and inflation rates, suggesting that real estate investment trusts (REITs), which are particularly sensitive to interest rate and inflation dynamics, may provide superior forecasting capabilities compared to broad market indices (Titman & Warga, 1989). Additionally, the inherent illiquidity and pricing biases in the real estate market had been found to introduce upward biases in estimated returns and downward biases in perceived risks, particularly when the marketing period is highly uncertain relative to the holding period (Titman & Warga,1989; Lin & Vandell, 2007). The studies cited and the research problems that were identified, coupled with periods of rising inflation levels, resulted in what can almost be considered eruption of research into the inflation hedge role of real estate. It is not possible to cite all the papers, hence the authors have conducted a selective review to outline the background to the work carried out over the years, including the purpose of the research, the databases analyzed, the markets in which the research was conducted, the research methods used and the results obtained. The authors decided to present a selection of, in their opinion, the most interesting items from the topic under study. The overview has been done chronologically.

Starting from 1989 Rubens et al. aimed to investigate the inflation-hedging effectiveness of real estate. The authors used historical data from 1976-1987 to analyze the relationship between real estate returns and inflation. They employed a multi-factor error correction model for their analysis. The results of their study suggest that while real estate may not be a perfect hedge against inflation, it can offer some protection against unexpected inflation in the short term. In the same year the study by Chatrath & Liang (1998) examined if REITs can be considered a hedge against inflation over the long term. The authors used various REIT indices and the Consumer Price Index data from 1972-1995. They utilize regression analysis and Johansen tests for cointegration to analyze the relationship between REIT returns and inflation. The findings show limited evidence for REITs acting as a short-term inflation hedge. However, the Johansen tests suggest REITs might offer a long-term inflation hedge, indicating that REITs and general price levels move together over extended periods.

Bond & Seiler (1998) examined the inflation-hedging effectiveness of residential real estate. They used data from 1969-1994 and employed an Added Variable Regression Method to analyze the relationship between residential real estate returns and inflation. Their findings indicated that residential real estate was a significant hedge against both expected and unexpected inflation.

The research of National & Low (2000) aimed to determine if real estate was a better hedge against inflation compared to financial assets in Singapore. Authors used the Consumer Price Index as an indicator of inflation in Singapore. They also mentioned using econometric analysis. Specifically, they referred to testing the hypothesis that real estate assets were better hedges against inflation than financial assets. This involves analysis of the relationship between asset prices (both real estate and financial) and inflation. The study found that real estate, particularly industrial property, provided a

better hedge against both expected and unexpected inflation compared to stocks and securitized real estate in Singapore. It also suggested that a portfolio with higher exposure to industrial real estate was better at protecting against inflation risk.

Chu and Sing (2004) aimed to investigate the inflation hedging characteristics of the Chinese real estate market. The authors used a data set comprising monthly returns of real estate: residential, office, and commercial property in four major Chinese cities - Beijing, Shanghai, Chengdu, and Shenzhen. Additionally, they used data on expected inflation, unexpected inflation, real GDP growth, and real stock returns. The methodology employed involves using Ordinary Least Squares regressions to determine the relationship between real estate returns and inflation, controlling for other economic factors. The results of the study contradict findings in other countries - real estate in the studied Chinese cities does not exhibit significant hedging against both expected and unexpected inflation, with the exception of Chengdu, where real estate returns showed a significant but negative hedge against expected inflation.

In the USA, Adrangi et al. (2004) examined the relationship between Real Estate Investment Trust returns and inflation to determine if REITs can be considered a reliable hedge against inflation. The authors used both traditional regression tests and cointegration tests to analyze the long-term relationship between REIT returns, inflation rates, and real economic activity. They also employed Chow tests to assess the stability of the relationship between REIT returns and inflation over different periods. The study found a negative correlation between real REIT returns and the inflation rate, suggesting that REIT investments may not provide a safe haven during periods of inflation. This finding held true in both the long and short term. Additionally, the study found no strong evidence to support the proxy hypothesis, which posits that the negative relationship between REITs and inflation is due to the adverse effects of inflation on real economic activity.

Hoesli et al. (2008) explored the inflation hedging characteristics of US and UK investments. The authors used an error correction approach to analyze the relationship between commercial real estate returns and economic, fiscal and monetary factors, and inflation. The research period is also not explicitly mentioned for all data, but the paper does say they used long-term total returns and inflation data over the period 1963-1993 for part of the analysis. The authors employed an error correction model to analyze the long-run and short-run relationships between these variables. Key findings of the cited study included: a positive link with anticipated inflation: asset returns, in the long run, show a positive correlation with anticipated inflation; no link with inflation shocks: asset returns do not exhibit a systematic relationship with unexpected inflation shocks. The adjustment processes to changes in inflation are gradual and not instantaneous; and finally: real estate returns, especially in the private market, demonstrate unique characteristics compared to stocks and bonds in their response to inflation. Summarizing: the results indicated that, in the long run, asset returns are positively linked to anticipated inflation but not to inflation shocks.

Staying on western market, Moigne and La (2008) aimed to re-examine the inflation-hedging ability of Canadian direct real estate from 1973–2007. They used correlations and time-series regressions on data from IPD/ICREM/Russell. The findings indicated that, while real estate generally acts as an inflation hedge, this effect is significantly influenced by the high inflation period between 1973–1984. After 1985, in a lower inflation environment, this hedging ability diminishes, with the exception of certain provinces and property types.

Back in Asia, Kuan-Min et al. (2008) aimed to examine the inflation hedging effectiveness of real estate in Taiwan. To do so, the authors used Taiwanese monthly housing returns and inflation data. They used inflation as the threshold variable to create a nonlinear vector correction model that divides the inflation rates into high and low regimes. The study found that when inflation rates are higher than 0.83%, housing returns can hedge against inflation. However, when inflation rates are lower than 0.83%, housing returns do not hedge against inflation. These studies are of interest for this article, although the authors in Taiwan obtained quite the opposite results.

Zhou and Clements (2010) examined the inflation hedging ability of real estate in China. The authors use data from 2000 to 2008, including the annual average actual inflation rate, real estate price changes, and Chinese stock statistics. They employed several statistical methods, including Augmented Dickey-Fuller and Ng-Perron unit root tests, Granger causality tests, and correlation analysis. Their findings suggest that Chinese residential property could hedge against unexpected inflation.

In the United States, Case and Wachter (2011),

eISSN: 2300-5289 | Received 2024-07-13 | Revised 2024-12-19 | Accepted 2025-01-07

analyzed the inflation sensitivity of real estate investments in comparison to other inflation-sensitive assets. Equity REITs were chosen to represent real estate investments. The researchers showed that equity REITs produce higher returns during periods of low inflation than they do during periods of high inflation. What is noteworthy, however, is that regardless of the level of inflation, investments in equity REITs were able to protect capital from the negative impact of inflation. The research is interesting in that the authors obtained results that coincide with the research presented in this article.

In Asia Lee et al. (2011), the authors examined the inflation-hedging capabilities of real estate stock prices in three distinct emerging East Asian markets, i.e.: Malaysia, the Philippines, and Taiwan. The data set used spans from 1990 to 2009 for Malaysia, 1996 to 2009 for the Philippines, and 1981 to 2009 for Taiwan. It includes monthly data on real estate sector return indices, total market return indices, industrial production, M2 money supply, and consumer price indices. Methodologically, the study employed the Augmented Dickey-Fuller and Kwiatkowski-Phillips-Schmidt-Shin tests to check for unit roots in the time series. The study then used the Dynamic OLS method to estimate the cointegrational relationship between real estate stock prices and inflation. The results of the study showed that real estate stock prices in Malaysia and Taiwan served as a hedge against expected inflation, but not against unexpected inflation. Conversely, in the Philippines, real estate stock prices did not demonstrated a hedging effect against either expected or unexpected inflation.

A year later in Europe Obereiner and Kurzrock, (2012) aimed to investigate the inflation-hedging properties of indirect real estate investments in Germany. The authors used monthly data of open-end real estate funds and real estate stocks. They employed the Fama and French and the Stevenson and Shiller approaches to analyze the relationship between the returns of these investments and inflation. The findings suggest that there is no evidence for short-term inflation-hedging abilities of open-end real estate funds and real estate stocks in Germany.

Going back to Asia, Lee (2013) aimed to investigate the inflation-hedging effectiveness of different property types in the Hong Kong market. The author used annual and semi-annual data, and employed the Fama and Schwert (1977) model to analyze the relationship between inflation and real estate returns. Asian data was used and the Engle and Granger and Johansen cointegration approaches employed to investigate the long-term inflation-hedging effectiveness of real estate; this led to conflicting results using a regression and a cointegration model. Lee concluded that only residential properties in Hong Kong provided an effective hedge against expected, unexpected, and actual inflation during the studied period (1980-2008).

Also in Asia, Yeap and Lean (2017) aimed to establish whether housing in Malaysia is a good hedge against inflation, particularly considering different types of inflation and house prices. The aim of the research was to examine if housing in Malaysia can protect investments against inflation, especially looking at how different types of houses perform against different types of inflation (consumer price inflation and energy inflation). The authors used data on house prices in Malaysia, aggregated into four major types of houses. They also used data on both consumer inflation and energy inflation. The researchers used a method called Nonlinear Autoregressive Distributed Lags to analyze the relationship between house prices and inflation in both the short and long term. This approach helped them to understand how house prices react to both increases and decreases in inflation. The authors found that, in the long run, house prices generally react symmetrically to both consumer and energy inflation. However, only terraced houses seem to be a good hedge against consumer inflation in the long run. In the short term, the relationship is more complex, with house prices reacting asymmetrically to both types of inflation. Overall, the study suggested that housing in Malaysia may not be a reliable hedge against inflation in the short term.

While in USA, Christou et al. (2018) aimed to determine whether house prices in the US can be used to hedge against inflation. The authors used a quantile cointegration approach to analyze the relationship between house prices and inflation. The researchers concluded that house prices act as an inflation hedge when inflation is relatively high, and house prices are relatively low.

Coming back to Malaysia, Lee and Isa (2019) aimed to examine the inflation hedging properties of different asset classes. They used time-series data spanning from 1980 to 2016 with data on nominal stock returns, gold prices, real estate returns, Treasury bond yields, and Treasury bill rates. The authors employed the Autoregressive Distributed Lag bounds

testing approach to investigate cointegration between asset returns and inflation. The study found that all asset classes, except Treasury bill rates, exhibit cointegration with inflation, indicating their potential as inflation hedges. However, the strength of this hedging ability varied across different asset classes and time periods.

In 2020, Taderera and Akinsomi used a different approach to property data, focusing not on their prices but on the income they generate. The study aimed to investigate whether commercial real estate in South Africa is a good hedge against inflation. The authors used an ARIMA model to analyze the relationship between CPI and commercial real estate performance. They have found that office income returns and retail total returns have a positive relationship with inflation.

Since 2021, there has been some research carried out on the Polish real estate market. The increased interest of Polish researchers was induced by rising inflation. The first article, not yet including inflation in the analysis but examining house price cycles, was published by Trojanek (2021). He aimed to analyze housing price cycles in Poland between 2000 and 2020, focusing on 18 provincial capital cities. The author used a unique dataset of asking house price dynamics, comprising 4,509,144 apartment offers. Geometric average prices for 1 m^2 of usable floor area were calculated, and price indices were determined. The results indicate that apartment prices in these cities increased by 120% in real terms and 253% in nominal terms during this period.

A year later, Melnychenko et al. (2022) examined the impact of inflation on the real estate market in Poland. The authors used quarterly quotes of the average price per square meter of housing in the eight largest cities in Poland in the 2009-2021 period. They used a panel model to determine price changes as a function of changes in inflation, the central bank's base rate, dwellings built, and new mortgage loans. They also used the Holt-Winter model of exponential smoothing with a damped trend to model and predict the price dynamics. The forecasting results showed a small relative error (up to 4%) in comparison with the actual data. The study also identified a moment of price trend change in 2017. The authors concluded that the results provide valuable insight into the relationship of real estate market indicators, allowing consumers to predict available options and make decisions.

Later this year, Wolski (2022) aimed to determine if investments in the Polish capital market could protect capital from depreciation caused by inflation. The author used data from the first quarter of 2009 to the fourth quarter of 2021. The data set included: the bond market, stock market, gold prices in PLN, residential real estate and inflation rates. The analysis, using the multiple regression equation in the Engle - Granger test, showed that the analyzed indices were not related to the level of inflation, leading to a rejection of the research hypothesis. Therefore, the study concluded that investments in the Polish capital market during the studied period did not protect capital from depreciation due to inflation.

The same authors a year later (Wolski, 2023) a year later was to find the relationship between residential real estate prices and inflation in the Polish economic conditions, to see if real estate could be used as a hedge against inflation. The data set used were the real estate hedonic indices calculated by NBP (National Bank of Poland) and the actual and forecasted inflation rates published by the GUS (Statistics Poland) and the NBP. The period from the first quarter of 2009 to the fourth quarter of 2021 was examined. The methodology used was cointegration analysis with the Engle - Granger test. The analysis found no relationship between real estate prices and inflation, leading to a negative verification of the research hypothesis.

Dittmann (2024) carried out studies with the aim to assess the potential of residential property in Poland as an inflation hedge investment. The author used hedonic price indices provided by the NBP for the six largest cities in Poland for the period from the third quarter of 2006 to the fourth quarter of 2022. The methodology involved using innovative measures of the level of inflation hedging. The study found that investments in residential property in Poland, especially those that included rental income, offered a high level of inflation hedging.

There are studies that examine prices within the Polish market; however, they primarily focus on the relationship between property prices and specific economic variables, market equilibrium, or the influence of certain factors on property prices, rather than analyzing the connection between prices and inflation (e.g. Żelazowski, 2011; Bełej & Kulesza, 2015; Batóg, 2016; Dittmann, 2016; Kubus, 2016; Foryś & Tarczyńska-Łuniewska, 2017; Brzezicka et al., 2018; Wolski, 2020; Trojanek, 2021; Tomala, 2022; Bełej, 2023; Cellmer et al., 2024).

After quite a wide literature review, it can be

concluded that there is no consensus on whether real estate is a reliable hedge against inflation in the global market. This makes the conclusions consistent with the review studies of Dabara et al. (2016).

2. Material and methods

The Polish housing market should be considered quite specific. This does not necessarily mean that it is very different from, for example, the Czech market, but the fact that Poland still has a national currency (like Czechia), while economic ties with the Eurozone are very strong, makes the euro by far the most important currency of our economy after the Polish zloty. This also has consequences for the investment process in currencies, where the euro has, for years, been an element of capital hedging against the depreciation of the zloty. Currencies are more liquid, on the other hand , the exchange rate is subject to significant fluctuations. Other reasons to consider the EUR as the most important currency are that foreign corporations investing in the Polish housing real estate market are, to a large extent, settled in EUR, or individuals working abroad take exchange rate fluctuations into account when investing in housing real estate on the domestic market. Studies carried out in Romania, a country, like Poland, belonging to the European Union, but also ones carried out in Africa, show the significant role of the exchange rate in the formation of property prices (Petrisor-Mateut, 2021; Umoru & Tedunjaiye, 2023). There are plenty of other studies showing the importance of the exchange rate for prices in the housing market (e.g. Bahmani-Oskooee & Wu, 2018, Sümer & Özorhon, 2020; Ngo, 2017; Zhou, 2021).

The commercial real estate sector finances its development with both domestic and foreign capital, with credit financing of investments being of significant importance in this sector. The value of loans granted by the domestic banking sector to companies for real estate, including residential, office, and other properties, amounted to PLN 62 billion at the end of 2022, an increase of PLN 2 billion compared to 2021. Loans granted for commercial real estate by foreign banks should be added to this figure. There is no official data on such loans, but NBP experts estimate their value at around PLN 94 billion (Łaszka, 2023, p.18). It should be emphasized that banks not only provide loans for the purchase or construction of commercial real estate (including the construction of flats by developers), but also provide loans secured by mortgages on these properties, including investment and working capital loans. At the end of 2022, the value of loans to businesses secured by real estate amounted to PLN 139 billion (compared to PLN 132 billion in 2021), of which 43% of loans were denominated in the euro (Łaszek, 2023, p.18). Due to such a high weight of the euro, the authors decided to introduce the PLN/EUR exchange rate into the model as one of the explanatory variables. It should be noted that the Engle - Granger test (Engle & Granger, 1987), a method coinciding with Wolski (2022, 2023), was used for the cointegration analysis, but the inclusion of the exchange rate in the analysis led to opposite results.

Capital depreciation resulting from inflation in Poland has accelerated strongly in recent years and has been much stronger than in the euro area (Figure1). As a result of the depreciation of the zloty, inflation in Poland per euro was significantly lower than in the euro area itself. For investors estimating the value of capital in the Polish zloty and investors settling in the euro, this is a significant difference that affects the investment attractiveness of the Polish real estate market. The higher profitability of such estimated investments is associated with currency risk, which had a strongly positive effect in the analyzed period.

2.1. Data

As an indicator of the level of housing real estate prices, the study used the hedonic index of flat prices published since Q3 2006 by the National Bank of Poland for the 7 largest Polish cities. The prices corrected with the hedonic index take into account qualitative differences of premises and the changing structure of the sample in subsequent periods (Widłak, 2010; Foryś, 2016; Trojanek, 2018). Such an approach enables a consistent analysis of the property market even over many years. The index itself only indicates changing trends without specifying particular values. This feature makes it impossible to determine the attractiveness of a specific property from an investor's point of view, but does not affect the results of the survey. The analysis omits income related to housing rental properties. As industry reports indicate, it can be assumed that the purchase of flats for rent is a rare practice. Hence, rental income from flats was omitted from the analysis (Feliksiak, 2022; Gontarczyk, 2023).

In the early periods of the available data, property prices in Poland grew very dynamically, i.e. by almost 60%. This was due to an increase in the availability of mortgages, in particular those denominated in Swiss francs (CHF), and very optimistic expectations for

eISSN: 2300-5289

Poland's further development. Towards the end of 2007, prices started to decline and one can even speak of a slight slump in the housing real estate market caused by the global financial crisis of 2008. After these slumps, the decline in property prices continued until mid-2013. Since then, investment interest in housing real estate has increased considerably and a continuous rise in prices has been recorded for the 10 subsequent years.

The average quarterly euro exchange rate published by the National Bank of Poland and the Harmonized Index of Consumer Prices published by Eurostat were used as variables characterizing the profitability of investments in the property market (Figures 1 and 4). The use of the HICP index allows for a better comparison of price changes in different markets in the European Union, which better reflects investment preferences and the value of changing capital.

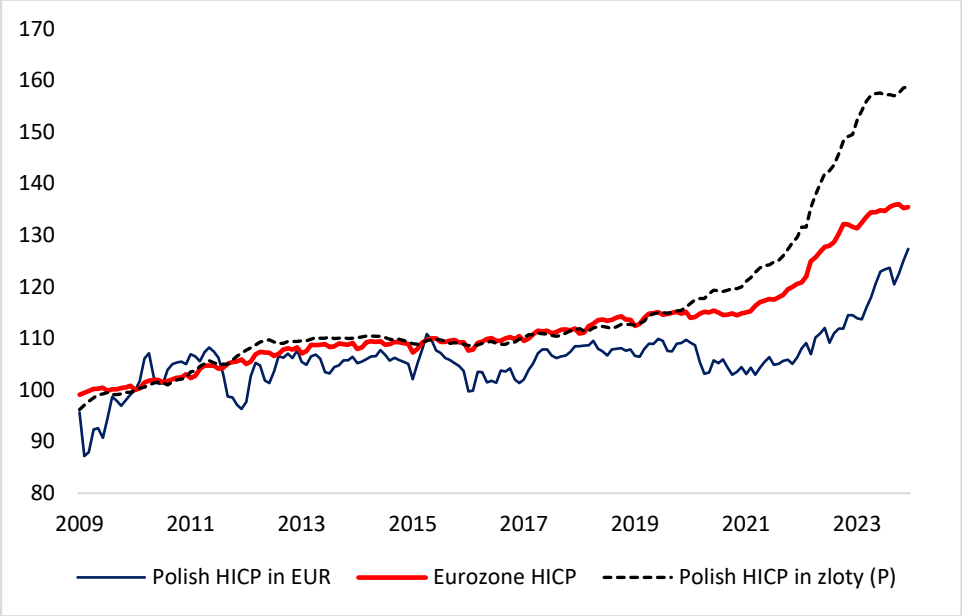

Fig. 1. Harmonized index of consumer prices (HICP) in Poland expressed in PLN (P) and scaled by the average PLN/EUR exchange rate and in the Eurozone (Q1 2010 = 100). *Source*: own study.

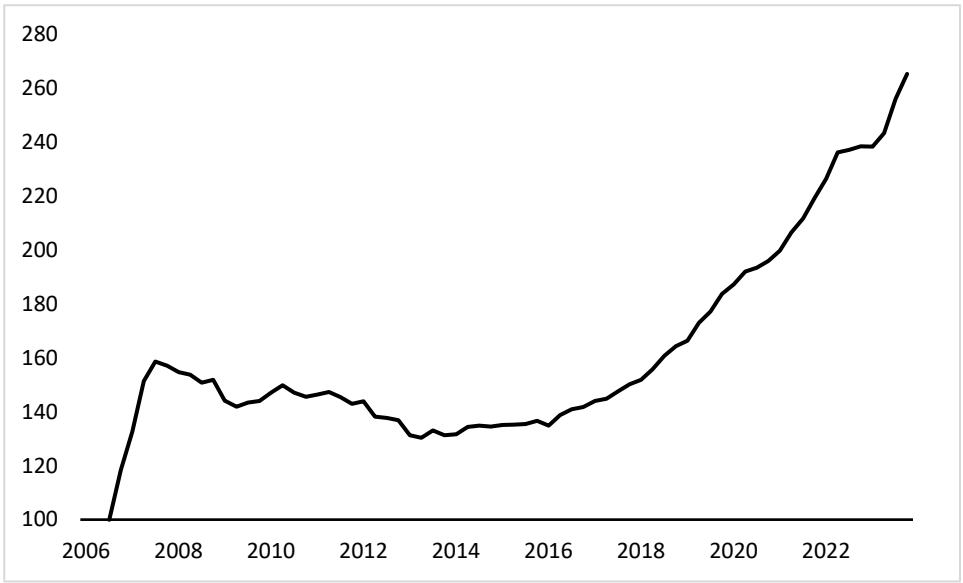

Fig. 2. Harmonized hedonic index of the existing housing real estate market in Poland (2006 q3 = 100) (H). *Source*: own study.

eISSN: 2300-5289 | Received 2024-07-13 | Revised 2024-12-19 | Accepted 2025-01-07

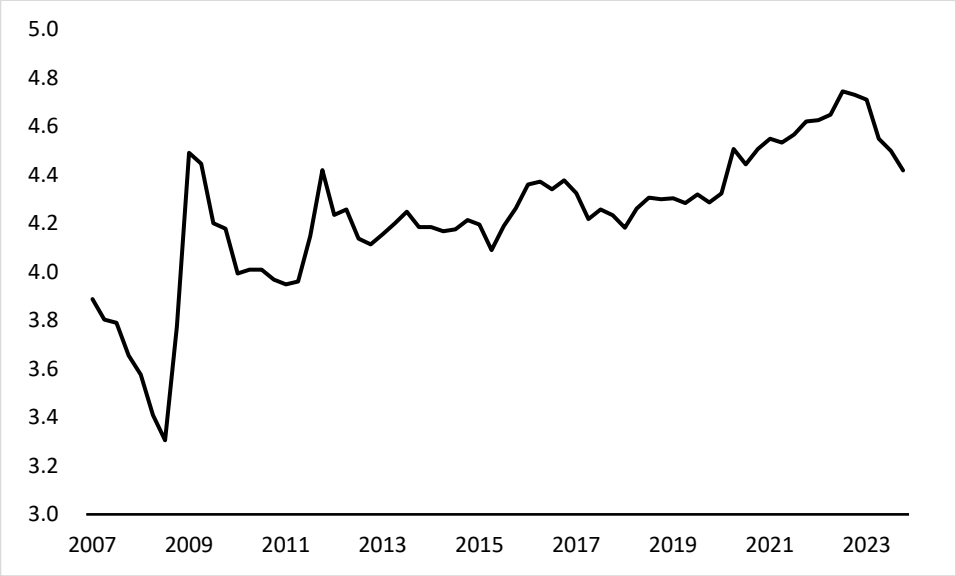

Fig. 3. Exchange rate PLN/EUR (EUR). *Source*: own study.

The global economic crisis of 2008 influenced strong euro exchange rate fluctuations against the Polish zloty. During this period, the Polish economy was perceived as growing, which resulted in a strong outflow of foreign capital and a rapid depreciation of the zloty, reaching 50% at times. Later periods also saw large fluctuations, caused mainly by external factors, such as the PIIGS crisis in 2010 - 2011.

The study used annual inflation, as measured by the HICP index, as the threshold variable (Figure 4). The use of annual inflation instead of quarterly inflation is mainly due to the fact that investors are oriented towards such a defined indicator. Additionally, it is characterized by lower volatility, which is more in line with softer reactions and less frequent changes in investment regimes.

Data from the housing real estate market up to 2009 shows large fluctuations and low reliability, which led to limiting the research sample to the years 2009 – 2023 (Hill & Trojanek, 2022; Głuszak et al., 2018; Konowalczuk, 2014).

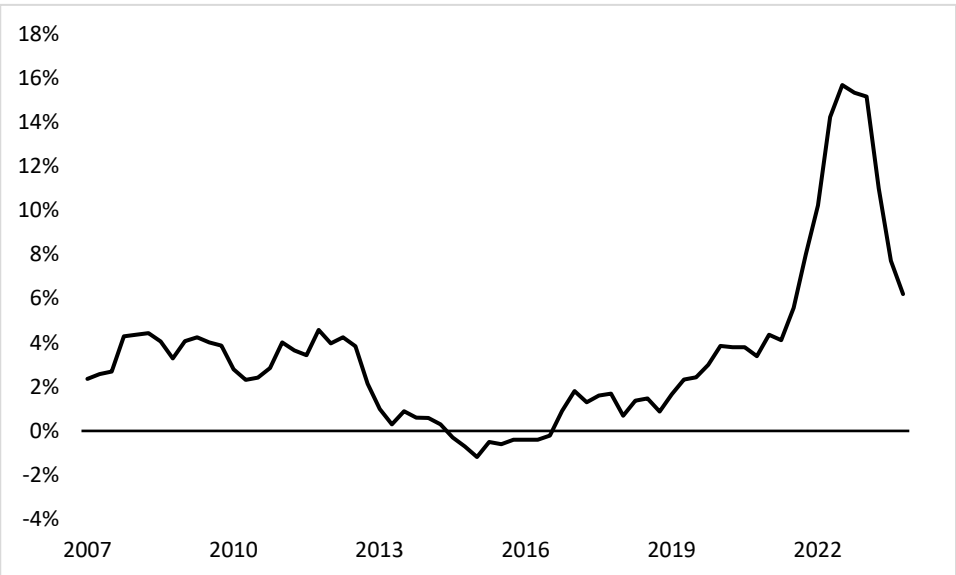

Fig. 4. Annual inflation as expressed by the Harmonized Index of Consumer Prices (HICP) in Poland (PY%). *Source*: own study.

Table 1

Descriptive statistics and test

	H	P	EUR	PY%
Mean	162.29	101.98	4.21	3.49
Median	147.25	100.40	4.23	2.61
Maximum	265.39	145.30	4.74	15.70
Minimum	100.00	80.30	3.31	-1.19
Std. Dev.	36.58	15.35	0.29	4.01
Skewness	1.24	1.23	-0.69	1.70
Kurtosis	3.59	4.48	3.73	5.53
Jarque-Bera	19.09	25.20	7.29	44.77
Sum	11360	7445	303	209
Sum Sq. Dev.	92334	16957	6	950
ADF	3.129	0.976	-1.772	-0.303
PP	0.473	0.869	-3.923	-1.977
KPSS	0.747***	0.747***	0.732***	0.400*

*** - test rejected at 1% significance level

* - test rejected at 10% significance level

Source: own study.

2.2. Econometric model

All variables in the model are non-stationary of first degree I(1), which was statistically verified by ADF and KPSS tests (Table 1). The non-stationarity of the time series used implies the use of cointegration analysis methods. The general form of ECM (Error Correction Model) models is:

$$\Delta y_{1t} = \alpha \hat{\varepsilon}_{t-1} + \sum_{i=0}^{I} \gamma_{1i} \Delta y_{1t-i} + \sum_{k=2}^{K} \sum_{i=0}^{I} \gamma_{1i} \Delta y_{kt-i} + \mu_t \quad (1)$$

where $\hat{\varepsilon}_t$ denotes the residuals from the first step of the regression of the long-run relationship:

$$y_{1t} = \beta_0 + \beta_2 y_{2t} + \beta_2 y_{3t} + \cdots + \beta_K y_{Kt} + \varepsilon_t \quad (2)$$

where:

α – Error Correction Term (ECT) parameter measuring the speed of adjustment of the explained variable to the equilibrium path of the long-run relationship,

β_k– parameters of long-term relationship dynamics $(k = 0.2 \ldots K)$,

β_k – parameters of short-term relationship dynamics,

$i = 0,1, \ldots, I$ – lag length,

The parameters of relation (2) are estimated using the ordinary least squares method. The condition for the existence of relation (1) is the integration of variables in the first degree $y_{kt} \sim I(1)$ and their cointegration $\varepsilon_t \sim I(0)$. On the other hand, in the absence of stationarity of the residuals in the cointegrating equation, the phenomenon of spurious regression occurs.

For the purpose of the study describing the relationship between property prices, consumer goods prices and the PLN/EUR exchange rate without distinguishing high and low inflation regimes, model (1) can be presented in the form:

$$\Delta h_t = \alpha(\beta_0 + \beta_1 p_{t-1} + \beta_2 eur_{t-1}) + \sum_{i=0}^{I} \gamma_{1i} \Delta p_{t-i} + \sum_{i=0}^{I} \gamma_{2i} \Delta eur_{t-i} + \mu_t \quad (3)$$

where:

H_t - property price index for the 7 largest Polish cities (NBP),

P_t - harmonized individual consumption deflator HICP,

EUR_t - quarterly average PLN/EUR exchange rate (NBP),

small letters denote natural logarithms of variables.

The standard form of the ECM model assumes that the influence of variables is symmetric. However, if this assumption is not met, inference based on model (3) may lead to wrong conclusions (Leszkiewicz-Kędzior, 2014). Taking the two regimes into account leads to an extension of model (3) to the form of the Threshold

eISSN: 2300-5289 | Received 2024-07-13 | Revised 2024-12-19 | Accepted 2025-01-07

Error Correction Model (TECM):

$$\Delta h_t = \left(\alpha^+ (\beta_0^+ + \beta_1^+ p_{t-1} + \beta_2^+ eur_{t-1}) + \sum_{i=0}^{I} \gamma_{1i}^+ \Delta p_{t-i} + \sum_{i=0}^{I} \gamma_{2i}^+ \Delta eur_{t-i} \right) \tau^+ + \left(\alpha^- (\beta_0^- + \beta_1^- p_{t-1} + + \beta_2^- eur_{t-1}) + \sum_{i=0}^{I} \gamma_{1i}^- \Delta p_{t-i} + \sum_{i=0}^{I} \gamma_{2i}^- \Delta eur_{t-i} \right) \tau^- + \mu_t \quad (4)$$

where superscript "+" and "-" denote the parameters in each regime.

In model 3, the sample is divided into two subsamples corresponding to different regimes according to the formula:

$$\tau^+ = \begin{cases} 1, & Z_t > \tau \\ 0, & Z_t \leq \tau \end{cases} \qquad \tau^- = \begin{cases} 0, & Z_t > \tau \\ 1, & Z_t \leq \tau \end{cases} \quad (5)$$

Z_t denotes the threshold variable, which, due to the non-stationarity of time series, is usually taken as an exogenous variable or the error correction component. In the analyzed model, the threshold variable Z_t is annual inflation determined according to the formula:

$$Z_t = \left(\frac{P_t}{P_{t-4}} - 1 \right) * 100\% \quad (6)$$

The division into sub-samples depends on the assumed value of the limiting parameter τ, corresponding to the amount of annual inflation at which the regime change occurs. The determination of high or low inflation is ambiguous and the problem of estimating the boundary parameter τ has a key impact on the model parameter estimates and the final conclusions. Due to the strong non-linearity of the TECM model, sequential methods are used to estimate its parameters. In the first step, the model parameters (4) are estimated for each $\tau \in \mathrm{T}$, for T which is generally a set of ascendingly ordered values of the threshold variable after the 15% smallest and largest elements of it have been cut off. Then, a selection criterion is determined for each regression, which can be the variance of the residuals or one of the information criteria. A consensus estimate of the threshold is the argument minimizing the variance or the selected information criterion (cf Hansen 2000).

3. Results

The study analyzed a model in the form of (4) including the effect of the PLN/EUR exchange rate (Model 1) and a version with a restriction excluding the exchange rate, in which the HICP price index was used as the only explanatory variable (Model 2).

A very important element of the analyses was the estimation of the value of the threshold parameter τ. For this purpose, a sequential estimation was used, in which the Akaike information criterion (AIC) was used as a measure of fit. Over the period studied, annual inflation in Poland as measured by the HICP ranged from slight deflation to increases of over a dozen per cent. After cutting off the 15% lowest and highest values from the sample, the values of the threshold parameter τ ranging from 0.30% to 4.59% were analyzed. As a result of applying sequential estimation, the estimated threshold parameter for both models was $\tau = 2.3\%$ (Figure 5). This is only 0.2 p.p. lower than the inflation target of the National Bank of Poland, which is 2.5%. As a result of splitting the sample with respect to the threshold parameter associated with the high and low inflation regime, two sub-samples of 34 and 26 observations respectively were obtained.

The study used the two-stage Engel-Granger method, which allows for estimating the parameters of long- and short-terms relationships (Engele & Granger 1987). Of particular note are the statistically significant long-terms relationships (ECT) in both regimes. Differences in investor response are particularly evident in the case of the low-inflation regime, where long-run parameters are markedly higher in ranges below the estimated threshold τ (Figure 6).

The high significance of the effect of the variables, as well as the stationarity of the residuals, confirms the cointegration of the variables used in the models, which are generated by non-stationary stochastic processes integrated in first degree I(1). This confirms the correct construction of the model and further inference. Property prices converge to the long-term relationship described by the high and low inflation regimes relatively quickly, as indicated by the high values of the ECT parameter estimates, which are -0.32 and -0.25 for Model 1 and -0.26 and -0.14 for Model 2, respectively (Table 2). The convergence to the equilibrium path in both regimes is relatively fast. Adjustment to the long-run relationship occurs much faster in high-inflation regimes, as well as in Model 1, which takes into account the impact of the exchange rate.

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Fig. 5. Akaike information criterion in relation to the threshold parameter τ for model with (Model 1) and without exchange rate (Model2). *Source*: own study.

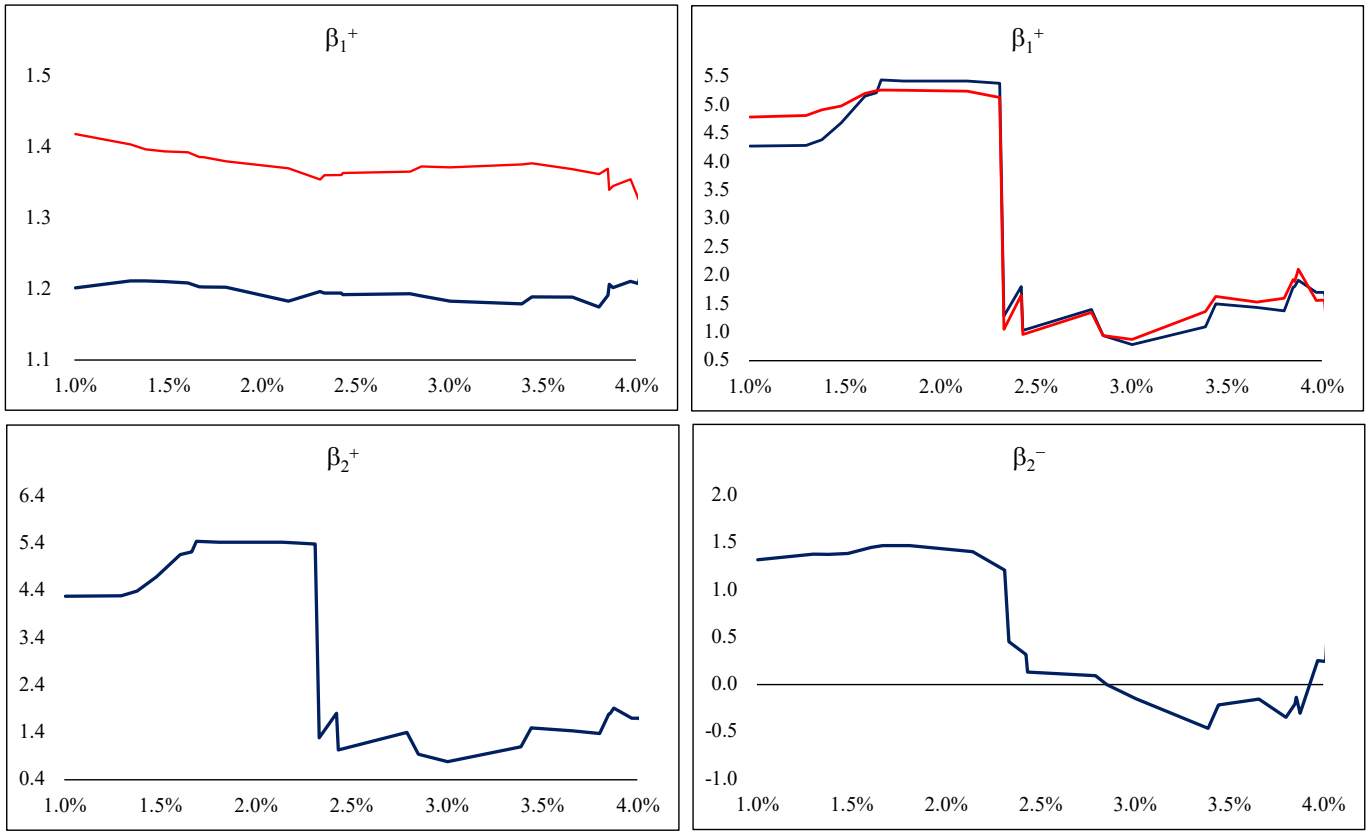

Fig. 6. Estimates of the parameters of the long-term relationship depending on the threshold parameter τ for model with (Model 1) and without exchange rate (Model2). *Source*: own study.

A key element of the models are the distinction between two regimes in which investor behavior is different. For comparison, Table 2 contains the estimation results of analogous models that do not distinguish between separate regimes (Non-Thresholds Model 3 and Model 4). Despite the stationarity of the residuals of the first step of the Engele-Granger procedure for Model 3 and Model 4,

eISSN: 2300-5289 | Received 2024-07-13 | Revised 2024-12-19 | Accepted 2025-01-07

the ECT parameter estimates are statistically insignificant This means that there is no adjustment for long-run relationships, in such models, the variables are not cointegrated, and the relationships are spurious.

Table 2

Estimation results of the analyzed models

			Threshold Models				Non-Threshold Models	
			Model 1 1		Model 1 2		Model 1 3	Model 1 4
	variable	symbol	τ^+	τ^-	τ^+	τ^-		
ECT		α	-0.32 (-3.69) 0.00	-0.25 (-2.74) 0.01	-0.26 (-3.18) 0.00	-0.14 (-1.68) 0.10	0.00 (0.04) 0.97	-0.02 (0,00) 0.57
Long-term relationship	const	β_0	-1.28 (-4.61) 0.00	-20.5 (-4.88) 0.00	-1.16 (-3.94) 0.00	-19.9 (-4.42) 0.00	-2.25 (-5.04) 0.00	-2.09 (-4.54) 0.00
	p_{t-1}	β_1	1.20 (13.79) 0.00	5.14 (5.61) 0.00	1.35 (21.64) 0.00	5.39 (5.52) 0.00	1.29 (9.15) 0.00	1.54 (15.59) 0.00
	eur_{t-1}	β_2	0.59 (2.45) 0.02	1.21 (2.14) 0.04			0.92 (2.46) 0.02	
Short-term relationship	Δp_t	γ_{10}	0.70 (3.06) 0.00	-	0.73 (2.93) 0.01	-	0.60 (3.05) 0.00	0.42 (1.8) 0.08
	Δp_{t-1}	γ_{11}	0.46 (2.14) 0.04	-	0.41 (1.83) 0.07	-	-	0.42 (1.72) 0.09
	Δeur_t	γ_{20}	-	-			-0.24 (-2.29) 0.03	
	Δeur_{t-1}	γ_{21}	-	-			-	

"-" variable removed from model due to not being statistically significant
The values of the t-student statistic are given in parentheses, with corresponding probabilities given below.
Source: own study.

Parameter estimates for Model 1 and Model 2 are similar, but the authors believe that Model 1 is a better representation of investor behavior, with currency market fluctuations being an important element of decision-making. According to (4), Model 1 can be written as:

$$\Delta\hat{h}_t = (-0.32(-1.28 + 1.20p_{t-1} + 0.59eur_{t-1}) + 0.70\Delta p_t + 0.46\Delta p_{t-1})\tau^+ + (-0.25(-20.5 + 5.14p_{t-1} + 1.21eur_{t-1}))\tau^- \quad (7)$$

Based on the estimates of the long-run elasticities, it can be concluded that investors' reactions and price changes in the property market are markedly different when annual inflation is below and above 2.3%. In periods of higher inflation, the long-run elasticity with respect to the HICP is 1.20. This suggests that housing real estate investments fully compensate for fluctuations in consumer goods prices, and that the average yield in these periods is around 20% above price increases. However, high yields relative to consumer prices may be dragged down by exchange rate fluctuations and the cumulative effect may not be as favorable to investors. The increased uncertainty associated with inflation causes greater fluctuations in the exchange rate of the zloty against the euro and reduces the profitability of housing real estate investments. A long-run elasticity of 0.59 is interpreted as a 10% increase in the exchange rate will increase property prices by almost 6% in the long run. The effect of an increase in the exchange rate is beneficial for investors calculating their investments in euros, while domestic investors will see the value of their capital decrease against foreign currencies. Of course, the opposite interpretation is true in the case of the strengthening of the zloty and a drop in the exchange rate. When this happens, domestic investors can count

eISSN: 2300-5289

on the benefits of the appreciation of the domestic currency being compensated in the long term by small falls in property prices, which can be perceived as a positive effect of exchange rate risk.

Long-term effects are much stronger in periods of low inflation, as statistically verified and confirmed by the Wald test. Below the threshold, a strong easing of monetary policy can be expected, with a consequent decline in bank deposit yields and a concomitant reduction in mortgage rates. These are strong signals stimulating a decomposition of investment portfolios and a shift of capital from low-interest liquid assets to the much less liquid property market. The long-run increase in housing real estate values during periods of low inflation is more than five times stronger than the increase in consumer goods prices as evidenced by the long-run elasticity of 5.14. However, such a high elasticity is associated with small fluctuations in the HICP, which seems to make economic sense. For example, if the prices of consumer goods increased by 1% per annum then a long-run effect of an increase in house prices of more than 5% should be expected. The effects associated with exchange rate fluctuations are also stronger. The long-run elasticity of 1.21 shows that the effects of exchange rate fluctuations and the associated exchange rate risk are overcompensated.

Direct effects related to short-term parameters are much weaker, which is due to the specifics of the property market, which is relatively less sensitive to dynamic changes and the current market situation. Property prices react with a time lag to the general economic situation (Kucharska-Stasiak, 2009; Hoesli & MacGregor, 2000), of which consumer price inflation is one of the most important indicators. In the high inflation regime, the elasticity of 0.70 and 0.46 with respect to the HICP growth in the current and lagged period shows that a quarterly increase in inflation of 1% influences a general increase in market stress and a rise in property prices of 0.70% in the current period, and an additional 0.46% in the following period. An analogous reaction is to be expected if a quarterly fall in inflation and a fall in property prices is recorded. The impact of currency market fluctuations is statistically insignificant which further confirms the short-term "rigidity" of property prices. In the low-inflation regime, both short-term price fluctuations and the exchange rate were found to be even weaker, and their impact was statistically insignificant.

4. Discussion

In the literature, it is difficult to find articles that introduce a low and high inflation regime in a study. However, studies showing the hedging properties of real estate over long periods are quite popular. Research on real estate as an inflation hedge is plentiful (Dabara et al., 2016). Sometimes the conclusions are contradictory, but it should be remembered that the result of the study depends strongly on the analyzed market, the period, the data used, or the specifics of the model studied (Martin, 2010). However, the relationship between real estate investment and inflation is complex, and its dynamics can vary depending on the prevailing macroeconomic conditions. As a rule, studies focus on long-term observations with an examination of whether inflationary shocks, associated with periodic increases in the price level, are translated into increases in real estate prices. Thus, researchers tend to analyze to what extent real estate protects capital when inflation is stable and when inflation is periodically elevated (see among others: Bond & Seiler, 1998; Hoesli et al., 2008; Lee, & Isa 2019). To date, there have been no studies in Poland that introduce a low and high inflation regime into the model, but in the world literature the authors have found two studies, the results of which, however, contradict each other. In Taiwan, Kuan-Min et al. (2008) concluded that housing returns can protect against inflation when the inflation rate exceeds 0.83%. Conversely, housing returns fail to offer protection against inflation when the rate falls below 0.83%. On the contrary, in United States, Case & Wachter (2011), demonstrated that equity REITs generate superior returns during low inflation periods compared to high inflation periods. Notably, irrespective of the inflation rate, equity REIT investments effectively preserved capital against the adverse effects of inflation. This research is particularly compelling as its findings align with the results presented in this article. In Poland, the work of Wolski (2022, 2023) is the closest to the current study. However, although co-integration analysis using the Engle-Granger test was appied in the study, , completely different results were obtained. It can be concluded from the research that housing real estate is not an effective hedge against inflation. Yet, looking at the details one can see the differences in the construction of the model. In the present study, the authors used the exchange rate PLN/EUR as an explanatory variable, which had a very strong influence on the obtained results. In addition, in Wolski's mentioned work, low and high inflation regimes were not used. The authors of the present

eISSN: 2300-5289 | Received 2024-07-13 | Revised 2024-12-19 | Accepted 2025-01-07

study divided the periods described in the model into a low inflation period and a high inflation period. Dividing the data according to this criterion significantly improved the model's parameters and allowed for better analysis of the data. It turned out that this is very important, especially in the low inflation regime. In view of these changes made in the construction of the model, it turned out that, in contrast to Wolski, housing real estate was shown to be a good inflation hedge, especially in a low inflation regime. These are interesting results that bring new quality to the study of property prices and inflation levels in the Polish market. Looking at the possibility of further research, it seems a good idea to expand the model to include, for example, mortgage data. This direction was taken by the authors as further work on inflation hedge properties of housing real estate.

5. Conclusions

It was possible for the authors to verify and quantify the cointegrating relationship which confirmed the veracity of the existing relationships and the correctness of the conclusions drawn. The cointegration of non-stationary variables was verified by statistical tests confirming the significance of the adjustments to the long-run relationship and the stationarity of the residuals.

The long-run elasticities of house prices with respect to the personal consumption deflator are significantly different in periods of high and low inflation. In both regimes, the elasticity remains above one, indicating full long-run capital protection of PLN invested in real estate against the effects of domestic inflation.

Real estate investments do not hedge capital against exchange rate risk. The long-term elasticity with respect to the exchange rate is much lower than unity in periods of high inflation and higher than unity in periods of low inflation. At the same time, it should be borne in mind that exchange rate risk can have a negative as well as a positive effect on the value of an investment depending on whether it is associated with an appreciation or depreciation of the domestic currency. Short-term fluctuations in the prices of consumer goods and the exchange rate only affect property prices in a high-inflation regime, but their impact is very weak due to the specifics of the property market and the short-term "rigidity" with respect to the current economic situation.

Summarizing the results of the broadcasts and relating them to the main hypothesis and as well as the auxiliary hypotheses, it should be noted that all hypotheses were positively verified. Investments in housing real estate in Poland can be successfully used as a hedge against inflation. The exchange rate of PLN/EUR, as it was shown, affects housing real estate prices. In periods of low inflation, housing real estate investments are a much better hedge of capital than in periods of high inflation. The variables used in the study are non-stationary and integrated at first degree I(1), and the use of threshold cointegration analysis enabled the identification of high and low inflation regimes and the analysis of long- and short-term dependencies.

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