Linkages Between Property Prices and Macroeconomic Determinants: Evidence from Germany

FREDERIK SCHRÖDER

Abstract

The global financial and economic crisis has led to significant efforts to better integrate property price channels into macroeconomic models and to improve models. This paper deals with property prices in Germany and their determinants in the period Q1 2000–Q4 2022. Since then, property prices in Germany have risen considerably. The models regularly use indicators that are aligned with the specificities of property, but less macroeconomic determinants. From economic models, theoretical modes of action between macroeconomic determinants and property prices are generally known. Regarding Germany, there are only limited studies on the direct influences of economic determinants. In the context of a regression analysis, this paper examines the relationship between the selected variables that directly drive house prices.

On the one hand the results confirm a positive relationship between property prices and real GDP. On the other hand, a negative correlation was found for real short-term interest rates and inflation. In this study, no significant relationships were found between house prices and unemployment rate and long-term interest rates, despite a culture of long-term fixed interest rates in Germany.

Keywords

Real Estate Markets, Housing Demand, Business Fluctuations

JEL Codes

R31, R21, E32

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Introduction

Since the global financial crisis, the property prices have begun to be investigated (Wetzstein, 2017; Haffner and Hulse, 2021). Previous pre-crisis macroeconomic models have not taken into account satisfactory links between the real economy and asset prices (Duca et al., 2021). The IMF found that house prices are synchronized across countries, and they claimed that this is caused by global interest rate shocks (Hirata et al., 2013; Katagiri, 2018; Andrle and Plašil, 2019). It is therefore reasonable to assume that property prices and interest rates could also be negatively correlated in Germany. Since the beginning of 2020, a contagious disease of a new coronavirus called COVID-19 by the WHO has been spreading around the world. It has led to many deaths and a global recession. Many companies also have significant difficulties in maintaining proper business operations due to supply chain problems. As a result, economic growth has fallen significantly behind the good results of recent years. The unemployment rates of many developed economies have risen noticeably for the first time in years because of the pandemic. The unemployment rate in Germany rose to 6,3% in 2020, as reported by the Federal Statistical Office. Contrary to general expectations, however, property prices in many countries, including Germany, have increased rather than fallen in this catastrophic event.

Opposite to the traditional theoretical prediction of a negative impact of a pandemic on the housing market (Francke and Korevaar, 2021) house prices rose significantly in many countries after the outbreak of COVID, including Germany. The development was also observed when business operations were disrupted, GDP growth rates were negative and unemployment rates were unprecedentedly high (Wang, 2021). During the movements of these macroeconomic determinants, a fall in property prices was generally to be expected. Instead, property prices initially continued to rise. Property prices didn't start declining until after Russia's invasion of Ukraine, which was followed by a shortage of construction supplies and an energy crisis in Germany. Thus, the question arises whether a bubble formation could be present. This paper examines the development of several determinants influencing house prices from long-established models using multivariate regression analysis. The aim is to see which determinants are strongly correlated with property prices.

The paper is structured as follows. In the introduction a literature review of studies on the monetary policy hypotheses was shown. Section 1 outlines the research materials and methods used. The following section reports on the results of the empirical tests. Section 3 discusses the results and implications. The end of the paper accomplishes with a conclusion.

1 Methodology

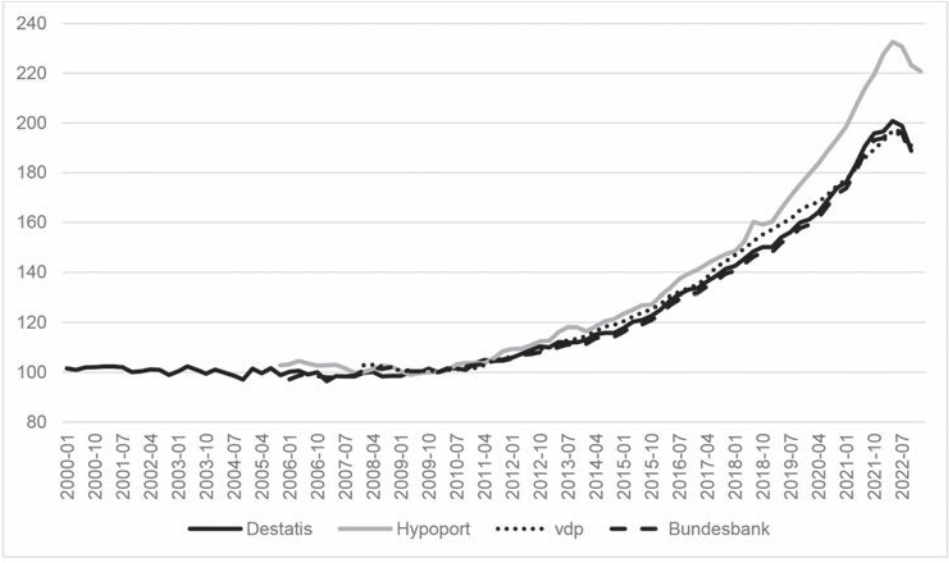
The aim of this paper is to analyze how short-term and long-term real interest rates, unemployment rate, consumer price index (inflation) and real gross domestic product influence the level of property prices in Germany. The goal of the paper is to find determinants that describe property prices in Germany. The study is based on the following two hypotheses: I expect a positive relationship between house prices, inflation

and real gross domestic product. And I assume a negative relationship between house prices, real short- and long-term real interest rates and unemployment.

1.1 Data

House prices are not easy to generate due to the lack of a public register in Germany. In principle, property price indices are compiled by four established institutions: The German Central Bank (Deutsche Bundesbank), the German Federal Statistical Office (Destatis), the Association of German Bond Banks, which represents the interests of the majority of credit institutions issuing bonds in Germany (vdp), and one of the two central brokers of real estate financing (Hypoport AG). These house price indices are generally published quarterly and are indexed as 2010=100 and shown in the following figure.

Figure 1: Indexed prices for residential real estate in Germany



Source: (Deutsche Bundesbank, 2022); (Europace AG, 2022)

Overall, the development of three out of four institutions is quite uniform. The only difference in Figure 1 is the price development of Hypoport AG. From 2017 onwards, there will be a higher increase in property prices, which will intensify again from 2019. Hypoport AG does not claim to record the development of the market as a whole, but only calculates the index on the basis of data from the transactions it supports, which account for around 20% of the transactions in the market as a whole. As a result, the development of the property market is not presented holistically. As an amplifying explanatory approach, the urban-rural divide in the use of financing intermediaries in connection with the stronger increase in property prices in cities could play a role.

As a result, the data from Hypoport AG will not be used further, as there is a suspicion that the data is not representative.

For the study period from the beginning of 2000 to the end of 2022, only the time series with continuous data from the German Federal Statistical Office is available. Since the data of the vdp and the Deutsche Bundesbank differ only marginally, the logarithm of the data series of the German Federal Statistical Office is used for this paper as the property price index and thus also as a dependent variable.

First of all, the real interest rate is considered as an independent variable. However, the determination of the real interest rate is not without problems, since in Germany, in contrast to many other developed economies, property is regularly financed not variably with short-term interest rates, but property is usually financed with long-term fixed interest rates. Against this background, a short-term real interest rate may have only a limited effect on the property market and both a short-term and a long-term real interest rate, as well as a combination in this model, are examined. The following list provides an overview of the variables that capture the basic determinants included in the empirical analysis based on the literature review.

Short-term interest rates (SIR): When setting short-term real interest rates by using short-term nominal interest rates adjusted for inflation, there is a risk of distortion when nominal interest rates approach the lower bound of zero. Therefore, the short-term real interest rate is defined as the shadow rate. This model was originally elaborated by Fischer Black (Black, 1995) in his work "Interest as Options". The shadow interest rate derives from Fischer Black's insight that currencies are an option. If someone has money, they can either spend it today or not spend it and have money tomorrow. So, if less money were repaid on loans than was originally borrowed, investors will choose to exercise this option and not lend their money. Thus, the nominal short-term interest rate is always greater than or equal to zero. In this model, the nominal short-term shadow interest rate is equal to what the nominal short-term interest rate would be if it were allowed to fall below the lower zero bound. But if the short-term shadow interest rate is negative – as during deflation or a severe recession with low inflation – the nominal short-term interest rate will diverge and remain above zero. In Black's model, long-term nominal interest rates can be well above zero, even if nominal short-term interest rates remain close to zero. There is also an ECB shadow rate. The real shadow interest rate is equal to the nominal shadow interest rate minus expected inflation. Due to the option effect, the shadow interest rate is not directly observable on the market. The value of the shadow interest rate depends on assumptions about how interest rates move, so different models may calculate different values for it. The model by Jing Cynthia Wu and Fan Dora Xia was published in "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound" and applied in the context of the work (Wu and Xia, 2016). To eliminate trends, the change in the previous period is considered.

Long-term interest rates (LTIR): The long-term real interest rate is defined as the expected real interest rate in Germany for government securities with a residual maturity of 10 years. In order to eliminate trends, the change in the previous period is taken into account. It is published monthly by the Deutsche Bundesbank. Since the analysis is based

on quarterly figures, the arithmetic mean of the monthly values is formed for the quarter. There is no risk of a distortion at the zero-line analogous to short-term interest rates in the case of long-term interest rates, since the expectations of market participants are queried independently of each other for both the ten-year nominal interest rate and the long-term inflation rate. Thus, the zero line does not form a de facto barrier.

Unemployment rate (UNE): The Federal Employment Agency publishes meaningful time series of the unemployment rate on a monthly basis. Since the analysis is based on quarterly figures, the arithmetic mean of the monthly values is formed for the quarter. Labour market time series are influenced by annually recurring seasonal effects, which make it difficult to assess current trends in the labour market. Seasonal influences can be eliminated by means of statistical methods to enable a better assessment of current developments. In addition to the seasonal adjustment core, the Census X-12 ARIMA method used in the statistics of the Federal Employment Agency for seasonal adjustment contains a module for pre-processing the time series as well as key figures for assessing the results of the seasonal adjustment. The methodological report presents the main features of this seasonal adjustment procedure.

Gross Domestic Product (GDP): As a measure of the economic performance of an economy, the gross domestic product is included. GDP measures the value of domestically produced goods and services and is calculated on a price-adjusted basis (deflation with annually changing prices and chaining of the previous year) and calculated logarithmic returns. The rate of change in price-adjusted gross domestic product is a regular measure of economic growth in national accounts, making it the most important measure of national accounts and one of the indicators of the International Monetary Fund's (IMF) dissemination standard. Data from the Federal Statistical Office (Destatis) are used for the survey on a quarterly basis.

Inflation (CPI): Inflation is defined as the Consumer price index. For Germany, the Harmonised Index of Consumer Prices (HICP) is calculated. The HICP was developed in the European Union (EU) to be able to compare price developments internationally and to combine them into an overall inflation rate for Europe and for the euro area. The index is compiled by the Federal Statistical Office on a monthly basis. Since the analysis is based on quarterly figures, the arithmetic mean of the monthly values is formed for the quarter.

The following table describes the central tendency of the respective variables as well as the distribution of the values of the variables.

Table 1: Descriptive statistics Q2 2000–Q4 2022

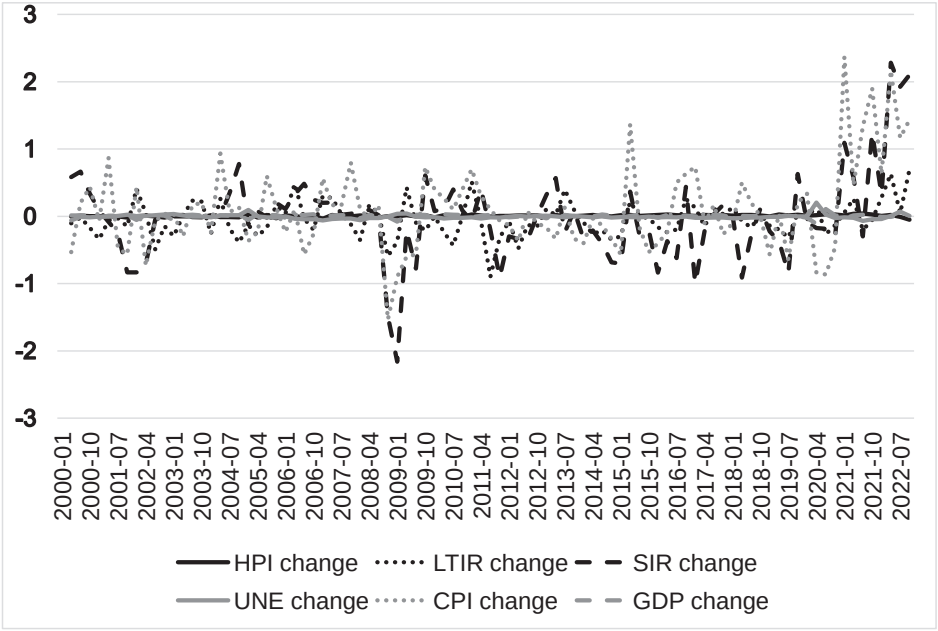
		HPI	LTIR	SIR	UNE	CPI	GDP
N	Valid	91	91	91	91	91	91
	Missing	0	0	0	0	0	0
Mean		.0069	-.0467	-.0064	-.0067	.1015	.0030
Median		.0080	-.0680	.0000	-.0100	.0330	.0100
Std. Deviation		.01628	.26500	.64186	.03364	.64512	.02732
Range		.10	1.59	4.44	.27	3.90	.22
Minimum		-.05	-.90	-2.16	-.07	-1.53	-.11
Maximum		.04	.70	2.28	.20	2.37	.11

Sources: SPSS, own work

1.2 Research Design

First, the data set was compiled. The data has been prepared in such a way that the percentage returns have been converted into logarithmic returns to eliminate possible trends. Only in the case of interest rates, this method is not applicable, since the data contain positive and negative values. Consequently, the absolute change is used to take out a trend.

Figure 2: Time series with trend elimination



Source: Own work

The ordinary least squares method is used. In this process, a function is determined for a set of data points that runs as close as possible to the data points and thus summarizes the data in the best possible way. A straight line, the regression line, is used as a function, especially since a linear relationship between the variables is obvious. The parameters of the function to be estimated are determined in such a way that the sum of the squared residuals becomes minimal. The estimators for α, β and $\sigma^2 = \mathrm{Var}(\epsilon_n)$ using the principle of ordinary least squares will be found. Here, α and β is chosen in such a way that

$$S(\alpha, \beta) = \sum_n (Y_n - \alpha - \beta X_n)^2 = \sum_n \epsilon_n^2$$

becomes minimal, so that the straight line is optimally adapted to the data points (X_n, Y_n).

So the least squares method allows, under certain conditions, to calculate the most probable of all model parameters. To do this, a correct model must have been selected, a sufficient number of measured values must be available and the deviations of the measured values from the model system must form a normal distribution. In practice, the method can be used for various purposes even if these requirements are not met. However, it should be noted that under certain unfavorable conditions, the method of least squares can give completely undesirable results. For example, there should be no outliers in the measured values, as these distort the estimation result. In addition,

multicollinearity between the parameters to be estimated is unfavorable as it causes numerical problems. Incidentally, even regressors that are far away from the others can strongly influence the results of the adjustment calculation.

During the regression, a collinearity diagnostics indicator was used to check whether the independent variables are too strongly correlated. There are no values that indicate multicollinearity problems. Next, the regression coefficient variance decomposition matrix was considered. For each regression coefficient, its variance is distributed over the different eigenvalues. No values were found in the condition index, which assume that there is a collinearity problem.

Furthermore, a Durbin-Watson test was used to check the autocorrelation of the residuals. It is monitored whether the respective previous month's values are suitable for forecasting the current values, i.e. whether the correlation between two consecutive residual variables is non-zero in a regression analysis. When looking at the residuals, the standardized residuals are examined as a function of the forecast value. There are no values of residuals that indicate too high a correlation. This concludes the first phase of the investigation.

Linear regression is performed using the backward elimination method. In this procedure, the independent variables that no longer have a significant influence on the dependent variable are excluded. Thus, all variables are first recorded and a model with all five independent variables is created in this investigation. Subsequently, the independent variables with the highest significance value are successively eliminated, up to a value of < 0.1.

Compared to stock markets, the property market is sluggish. The change in macroeconomic determinants could therefore have a delayed effect. The processing of property transactions in Germany via a notary as well as the time required to approve financing could slow down immediate reactions. Therefore, time lags up to a period of one year are examined in four different steps, each with a further quarter time offset.

2 Results

In the first linear regression model, all independent variables are successively eliminated. Thus, there is no immediate significant effect on property prices in the event of a change in the determinants. In a model with the shadow interest rate and inflation, a significance value of 0.104 is determined, but the unstandardized beta has different signs for independent variables and should therefore not be overinterpreted. When looking at the shadow interest rate alone, the regression coefficient is lower, which could indicate an overfitting of the model. In this model, the significance value is 0.176 and therefore there is no significance.

In the next step, a time lag of one quarter is integrated into the model. Consequently, the number of observations is reduced by one. The next table shows the results.

Table 2: Coefficients from regression model time lag 1 quarter

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	.007	.002		3.678	.000		
	LTIR_chg	.001	.007	.013	.113	.910	.826	1.211
	SIR_chg	-.008	.004	-.301	-2.224	.029	.574	1.741
	UNE_chg	-.061	.058	-.127	-1.062	.291	.740	1.351
	CPI_chg	.002	.004	.084	.602	.549	.541	1.847
	GDP_chg	-.105	.069	-.177	-1.510	.135	.771	1.297
2	(Constant)	.006	.002		3.772	.000		
	SIR_chg	-.008	.004	-.299	-2.254	.027	.594	1.682
	UNE_chg	-.061	.057	-.126	-1.065	.290	.742	1.348
	CPI_chg	.002	.004	.087	.642	.523	.564	1.773
	GDP_chg	-.106	.069	-.178	-1.537	.128	.778	1.285
3	(Constant)	.007	.002		3.945	.000		
	SIR_chg	-.007	.003	-.246	-2.379	.020	.971	1.030
	UNE_chg	-.074	.053	-.153	-1.378	.172	.844	1.185
	GDP_chg	-.116	.067	-.195	-1.742	.085	.823	1.215
4	(Constant)	.007	.002		4.217	.000		
	SIR_chg	-.007	.003	-.246	-2.366	.020	.971	1.030
	GDP_chg	-.080	.062	-.135	-1.301	.197	.971	1.030
5	(Constant)	.007	.002		4.075	.000		
	SIR_chg	-.007	.003	-.268	-2.614	.011	1.000	1.000

a. Dependent Variable: HPI chg. (time lag: 1 quarter)

Source: SPSS, own work

With a time lag of one quarter, a significant result is achieved. The more the shadow interest rate rises, the more the house price index in Germany decreases. Already in the first, saturated model, the value of the shadow interest rate is significant, and the significance increases with the successive elimination of the remaining variables that cause distortion here. The results of the Durbin-Watson test for the model with a time lag of one quarter are presented in table 3.

Table 3: Durbin-Watson from regression model time lag 1 quarter

Model Summary[f]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.337[a]	0,114	0,061	0,01580	
2	.337[b]	0,114	0,072	0,01571	
3	.331[c]	0,109	0,078	0,01566	
4	.300[d]	0,090	0,069	0,01574	
5	.268[e]	0,072	0,062	0,01580	1,783

a. Predictors: (Constant), GDP_chg, CPI_chg, LTIR_chg, UNE_chg, SIR_chg

b. Predictors: (Constant), GDP_chg, CPI_chg, UNE_chg, SIR_chg

c. Predictors: (Constant), GDP_chg, UNE_chg, SIR_chg

d. Predictors: (Constant), GDP_chg, SIR_chg

e. Predictors: (Constant), SIR_chg

f. Dependent Variable: HPI chg. (time lag: 1 quarter)

Source: SPSS, own work

In the next step, a time lag of two quarters is considered. There will be no significant independent variable. When extending the time lag to three quarters, significant results are achieved using a model of two independent variables. The change in GDP has a high significance of 0.011 and there is a positive relationship between real GDP and house price Index. The SIR has a significance value of 0.090 and with a directed hypothesis, a significance would still have to be stated here. However, the effect is not as clear as with the time lag of a quarter. This method with backward elimination is listed in the table below.

Table 4: Coefficients from regression model time lag 3 quarter

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.006	.002		3.143	.002		
	LTIR_chg	-.008	.007	-.117	-1.056	.294	.882	1.134
	SIR_chg	-.006	.004	-.192	-1.538	.128	.697	1.435
	UNE_chg	.059	.062	.119	.950	.345	.689	1.451
	CPI_chg	.003	.004	.117	.887	.378	.620	1.614
	GDP_chg	.188	.071	.315	2.638	.010	.759	1.317
2	(Constant)	.006	.002		3.318	.001		
	LTIR_chg	-.007	.007	-.099	-.907	.367	.914	1.094
	SIR_chg	-.005	.004	-.143	-1.278	.205	.869	1.150
	UNE_chg	.038	.058	.077	.665	.508	.804	1.244
	GDP_chg	.174	.069	.292	2.509	.014	.796	1.256
3	(Constant)	.006	.002		3.263	.002		
	LTIR_chg	-.007	.007	-.100	-.918	.361	.915	1.093
	SIR_chg	-.005	.004	-.152	-1.382	.171	.885	1.130
	GDP_chg	.156	.063	.262	2.455	.016	.946	1.057
4	(Constant)	.006	.002		3.527	.001		
	SIR_chg	-.006	.003	-.181	-1.715	.090	.962	1.039
	GDP_chg	.163	.063	.274	2.597	.011	.962	1.039

a. Dependent Variable: HPI chg. (time lag: 3 quarters)

Source: SPSS, own work

During a further extension of the time lag to four quarters, a significant result is achieved. There is a negative relationship between inflation and house prices. In the model, the remaining independent variables only contributed to distortion and were removed from the model during backward elimination, as shown in the following table.

Table 5: Coefficients from regression model time lag 4 quarter

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.008	.002		4.183	.000		
	LTIR_chg	.008	.008	.119	1.061	.292	.889	1.125
	SIR_chg	-.003	.004	-.090	-.707	.481	.701	1.426
	UNE_chg	.021	.064	.043	.333	.740	.688	1.454
	CPI_chg	-.006	.004	-.225	-1.676	.098	.627	1.595
	GDP_chg	-.024	.073	-.041	-.336	.738	.755	1.325
2	(Constant)	.008	.002		4.199	.000		
	LTIR_chg	.008	.008	.122	1.094	.277	.893	1.119
	SIR_chg	-.003	.004	-.087	-.691	.491	.704	1.420
	CPI_chg	-.007	.003	-.241	-1.954	.054	.730	1.370
	GDP_chg	-.035	.065	-.059	-.545	.587	.943	1.060
3	(Constant)	.008	.002		4.182	.000		
	LTIR_chg	.009	.007	.129	1.166	.247	.904	1.106
	SIR_chg	-.003	.004	-.102	-.838	.405	.741	1.349
	CPI_chg	-.007	.003	-.238	-1.935	.056	.732	1.366
4	(Constant)	.008	.002		4.402	.000		
	LTIR_chg	.008	.007	.116	1.060	.292	.923	1.083
	CPI_chg	-.008	.003	-.284	-2.605	.011	.923	1.083
5	(Constant)	.007	.002		4.278	.000		
	CPI_chg	-.007	.003	-.252	-2.404	.018	1.000	1.000

a. Dependent Variable: HPI chg. (time lag: 4 quarters)

Source: SPSS, own work

As mentioned above, a significant relationship is established with different time lags between property prices and short-term interest rates, GDP and inflation. The models show that the relationship between house prices and short-term interest rates or inflation is negative, with a positive relationship with GDP. No significance was found on long-term interest rates and the unemployment rate.

The adjusted R-squared value is quite low in all three models with significant variables and lies between .053 and .067 (time lag 1 quarter .062; time lag 3 quarters .067; time lag 4 quarters .053). R-squared is a measure of how much of the variation in the dependent variable is explained by the independent variables in the model. It ranges from 0 to 1, with higher values indicating a better fit. Adjusted R-squared is similar like R-squared, but it considers the number of independent variables in the model. It is a more conservative estimate of the model's fit, as it penalizes the addition of variables that do not improve the model's performance. The low R-squared could result from the fact that the data set also has only a small number of predictors and asset prices are generally difficult

to predict from data. The highest R-squared is achieved in the model with a time lag of three quarters. In principle, the result is also plausible, since it is the only model in which two significant variables have remained in the model, even though one of the variables is only one-sidedly significant. The R-squared values are quite low, making it difficult to make an exact forecast of real estate prices. However, the creation of a real estate price model is not the subject of this work, but the comparison of different determinants and their influence on real estate prices. Thus, the low R-squared values do not fundamentally affect the significance of the paper. There is no indication of multicollinearity in the model.

3 Discussion

In the first linear regression, no significant associations were found between the dependent and independent variables. However, this fact is not implausible, since property is neither traded as fungible nor can its trading be observed as transparently as, for example, stocks. Even in the case of informed market participants, the effects of the determinants would take time before an effect could unfold. For this reason, the application of time lags makes sense.

With a time lag of one quarter, a significant result is achieved. The more short-term real interest rates rise, the more the house price index in Germany decreases. In principle, this correlation had been expected, since on the one hand the interest rate is an extremely relevant determinant in property transactions and their financing and on the other hand the real interest rate describes the opportunity for a property investment. This result also confirms the use of the shadow interest rate, which tracks negative real interest rates almost continuously from 2011 to 2022. With a value of 1.783, the Durbin-Watson test is in the range between 1.5 and 2.5 and thus does not indicate the presence of autocorrelation.

A significant correlation between property prices and short-term interest rates can no longer be determined with a time lag of two quarters. However, this fact was also to be expected, since although a time delay is needed before the breakthrough, there are quite fast-reacting markets and a high level of transparency among all market participants. Other asset classes, such as share prices, for example, are also traded on the stock exchange and are therefore much more transparent, but interest rate changes also react almost immediately. Consequently, a delay of two quarters in the effect of the interest rate was not expected.

There is a positive relationship between real GDP and the house price Index with a time lag of three quarters. This delay until the effect on property prices is also plausible, as the impulses from GDP seem quite sluggish. Furthermore, with a delay of three quarters, this approach reveals a further negative relationship to short-term interest rates, but only in the case of a directed hypothesis. This relationship can also be meaningfully derived from macroeconomic models, since when GDP rises and interest rates fall, property prices generally rise.

With a four-quarter time lag, a high significance value between inflation, expressed by the consumer price index, and property prices is diagnosed. However, contrary to expectations, the relationship is negative, regardless of the observation of actual events. For example, inflation has already recorded significant increases in the second half

of 2021, while the central bank has not initially developed any activity. It wasn't until July 2022 that the European Central Bank's interest rates were raised to counter inflation. As a result, asset prices have subsequently fallen. If there had been a direct effect through the inflation channel, a positive relationship would have been expected, although rising inflation would have led to rising property prices. The observation period of this study was characterized by a long-lasting bull market. In this market environment, it is plausible that inflation, as measured by consumer price inflation, has an influence on asset price inflation and is thus positively correlated with property prices. This correlation could thus be further made plausible, as investors anticipate a downturn in an ongoing bull market and invest in asset classes such as property, which are widely regarded as less susceptible to crises. The high stability of the real value of property would also reinforce the significant link with inflation.

Similarly, no significant correlation has been found between house prices and unemployment figures. It could have been expected that as unemployment fell, property prices would rise. One explanation could be that unemployment rate may be a bad predictor, since it only measures whether a person is in work or unemployed. Initially, no statement is made about the nature of the employment relationship. As a result, the quality of the working conditions could have changed and a distortion could have occurred. Similarly, no negative relationship was found between long-term interest rates and property prices. In contrast to various other cited studies in developed economies, a real long-term interest rate was deliberately integrated into the model. However, a positive correlation was not found even with the use of lime lags. The initially assumed culture of long-term fixed interest rates in Germany seems to have only a very limited influence, if at all, on the development of property prices. As part of further investigations, the different explanatory variables with different time lags could be systematically examined. The aim of this study would be to find a model with several significantly correlated variables. It should also be examined whether higher R-squared values can be observed in a model with several highly significant variables.

Given that short-term interest rates can explain property prices with a time lag of a quarter of a year, as can the shadow rate, there is a fundamental explanation for the significant increase in real estate. On this basis, there is no direct evidence of a property price bubble.

4 Conclusions

Using a time series regression model, this study aims to test the hypothesis of the influence of different macroeconomic determinants on the change in property prices. Various studies, including a publication by the IMF, have found cross-border correlations between property prices and interest rates. Since nominal interest rates can lead to distortions at low interest rates, the real interest rate to be used as a basis was determined in two variants, as a long-term interest rate and as a shadow rate. The investigations led to quite different results. Although this correlation is equally plausible and obvious from the macroeconomic models, only the hypothesis of a negative relationship between property prices and short-term interest rates was confirmed. A significant correlation between house prices and long-term interest rates was not found. On the other hand,

the hypothesis of a positive relationship between property prices and real GDP was stated. In this study, no significant relationships were found between house prices and unemployment and the hypothesis cannot be confirmed. Furthermore, a significant correlation between house prices and inflation was found. However, contrary to the hypothesis, there is an underlying negative relationship. A positive effect was expected, so as inflation rises, so do property prices. The effect via the interest rate channel could be an explanation, as interest rates rise, and property prices fall as inflation rises. The results of this study show that the significant increase in property prices in Germany from 2000 to 2022 is related to some meaningful macroeconomic determinants of interest rates, GDP and inflation. Since connections between macroeconomic determinants and property prices with corresponding time lags have been established and there is consequently a fundamental justification for the significant increase in property prices, there is currently no evidence of bubble formation.

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Contact address

Frederik Schröder, Dipl.-Kfm., MBA., LL.M.
Department of Finance, VSFS Prague
Alsterweg 6
31303 Burgdorf, Germany
(frederikschroeder@icloud.com)

Appendix

Collinearity Diagnostics

Collinearity Diagnostics

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions					
				(Constant)	LTIR_chg	SIR_chg	UNE_chg	CPI_chg	GDP_chg
1	1	1.993	1.000	.00	.07	.09	.03	.09	.01
	2	1.549	1.134	.11	.09	.01	.15	.00	.14
	3	.955	1.444	.56	.01	.00	.03	.03	.23
	4	.661	1.737	.05	.06	.16	.48	.02	.28
	5	.560	1.886	.24	.77	.08	.01	.11	.09
	6	.283	2.654	.03	.00	.66	.32	.74	.26
2	1	1.963	1.000	.00	.09	.11	.02	.10	
	2	1.323	1.218	.30	.09	.01	.24	.01	
	3	.798	1.569	.48	.00	.02	.59	.00	
	4	.578	1.843	.17	.81	.22	.03	.04	
	5	.338	2.410	.05	.01	.65	.13	.85	
3	1	1.931	1.000	.00	.10	.12		.11	
	2	1.117	1.315	.65	.09	.00		.04	
	3	.584	1.819	.26	.80	.17		.06	
	4	.368	2.291	.09	.00	.72		.80	
4	1	1.627	1.000	.02		.18		.19	
	2	1.005	1.272	.89		.04		.00	
	3	.368	2.102	.09		.78		.81	
5	1	1.010	1.000	.49		.49			
	2	.990	1.010	.51		.51			
6	1	1.000	1.000	1.00					

a. Dependent Variable: HPI_chg