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THE IMPACT OF SELECTED MACROECONOMIC VARIABLES ON HOUSE PRICES IN CROATIA

UDC / UDK: 332.72:330.131.7(497.5)
JEL classification / JEL klasifikacija: C52, E22, R30
DOI: xx
Preliminary communication / Prethodno priopćenje
Received / Primljeno: March 3, 2023 / 3. ožujka 2023.
Accepted / Prihvaćeno: October 9, 2023 / 9. listopada 2023.

Abstract

Recognizing the macroeconomic determinants that have a statistically significant influence on the formation of house prices is in the interest of the general public due to its informative effect on various interest groups involved in housing construction. Thus, real estate buyers, investors, as well as local government and self-government units should be interested in this information because monitoring of standard macroeconomic variables can provide conclusions about the possible development of residential property prices. Previously conducted research can be classified into four distinctive categories depending on what they take as determining variables: microelements specific to individual micro location, the impact of the COVID-19 pandemic, standard macroeconomic variables, or tourism development. The aim of this study is to analyze the influence of selected macroeconomic variables on residential property prices in Croatia. This study employs Autometrics, i.e. an automatic computer implementation of general-to-specific VAR (vector autoregressive) modelling framework and quarterly data on real GDP, domestic credit, consumer prices, interest rate, tourist arrivals and house prices in the period from March 2005 to September 2022. Performed Granger causality tests and impulse response functions analysis indicate that an increase in real GDP, domestic credit and tourist arrivals increases house prices in Croatia while an increase in consumer prices and interest rate reduces them.

Keywords: Autometrics, Croatia, general-to-specific modelling, house prices, VAR model

1. INTRODUCTION

In the literature that deals with the study of real estate, there is a significant number of articles that investigate the prices of different types of real estate, and determine the factors that have an influence on the formation of such prices. In this paper, the focus will be on residential real estate. This interest is fully justified from many aspects. Namely, from the position of an individual interested in buying residential real estate, it will be of great interest to know the factors that determine the current, but also the future price of the purchased real estate, taking into account the effort to make such real estate affordable and lose as little as possible over time on its value.

Investors who build residential properties also benefit from knowing the factors that influence the formation of the final sale price. Assuming more or less constant construction costs, the correct positioning of the property to be built can significantly affect the investor's profit.

The social aspect of building residential real estate should not be forgotten either. The very construction of residential real estate is necessarily accompanied by infrastructure projects for the construction of roads, electricity, water supply, gas, and sewage networks, as well as the construction of accompanying infrastructural, but also commercial, facilities that affect the quality of life of a particular region. Therefore, knowing the factors that will attract the construction of residential real estate in an area is also important for local government and self-government units in order to adequately manage the urbanization of the target area.

As previously stated, in this paper the focus of the research will be on residential real estate (housing), while the goal of the research will be to determine statistically significant factors that influence the formation of their price. In accordance with this, and with the review of previous research mentioned in the next chapter, it is possible to set up a starting research hypothesis. Considering usual macroeconomic variables, the expectation is that an increase in real GDP, domestic credit and tourist arrivals increases house prices in Croatia while an increase in consumer prices and the interest rate reduce them.

In this sense, the paper is divided into five parts. This introductory part is followed by a literature review, which is important for determining the approach of the research itself, as there are different research approaches in the literature. The next chapter defines and shows the input data for the model, which is presented in the following chapter where the results of the conducted research are presented. The paper ends with final comments, general conclusions, as well as stating the shortcomings of the conducted research.

2. LITERATURE REVIEW

When trying to determine the elements that have an impact on house prices, it is possible to classify several lines of such research in the existing literature. One of such research approaches studies the influence of the so-called

microelements on the formation of house prices. Examples of such research can be seen in the work of Jiang and Qiu (2021), who, using the example of 31 provinces and cities in China for the year 2019, determine that the house prices are mostly influenced by land prices and disposable income of the population. A similar study was conducted in 2014 in China with a wider range of variables whose impact was measured in relation to house prices (Wang et al., 2017). In that research, variables derived from house demand, house supply, and the house market were taken. Regardless of the extended spectrum of tested variables, the result remained the same, i.e. the price of land has the greatest influence on house prices in China. Research on microelements that have an impact on house prices was also carried out in 2013 for the area of Dortmund, Germany (Wittowsky et al., 2020). In this extensive research, a whole series of variables related to dwelling type, neighboring dwellings, accessibility and location were analyzed. The results were in accordance with the theoretical basis of the research and showed that the location has the most significant influence on the house price fluctuations.

The next research approach in the detection of house prices determinants is the one that investigates the impact of the COVID-19 pandemic. Although it occurred in a relatively short period of time, the COVID-19 pandemic caused significant disruption to numerous sectors of the economy of all countries around the world. The general conclusion that can be drawn from all the research is that the COVID-19 pandemic, among other things, caused a drop in house prices. As example of such research, it is possible to cite the one by Del Giudice et al. (2020), who found, based on the example of the Campania region in Italy, that the house prices dropped by 4,16% in the short-run and 6,49% in the mid-run (late 2020 – early 2021). Wang (2021) came to similar, but not so unequivocal, results by studying the impact of COVID-19 on house prices in different parts of the USA. Namely, noticing the different movement of house prices in different parts of the country, Wang concluded that the decline in house prices occurred in those areas that relied more on service industries (tourism, service and aviation), which require face-to-face interactions.

A broad group of research, and thus the third line of research in the study of determinants of house prices, is occupied by research that looks at house prices from a macro aspect. These are studies that have macroeconomic variables as their starting point, the movement of which they try to link with the movement of house prices in the area of their research. One such study is that of Jud and Winkler (2002), who conducted their study on a sample of 130 metropolitan areas across the United States for the period 1984-1998. The results of the research established a strong positive connection of house prices with variables such as growth of population, income, construction costs and interest rates. A similar result was reached by Sutton (2002) analyzing the real estate markets in the United States, United Kingdom, Canada, Ireland, Netherland and Australia for the period from 1995 to 2002. His results confirmed the statistically significant positive influence of national income, interest rates and stock prices on house prices in analyzed countries. Radonjić et al. (2019) using the model averaging technique for data from Montenegro for the period from 2011 to 2017, identify the following macroeconomic

variables that have a significant impact on house prices: GDP, the mortgage interest rate, availability of mortgages, the unemployment rate and the average net salary.

The fluctuation of house prices was also analyzed in terms of monetary policy measures as a separate transmission channel, i.e. through the implementation of certain economic policy measures. As an example of this, a study conducted in Turkey for the period from 2002 to 2016 can be singled out (Yildirim & İvrendi, 2017). Analyzing a total of 11 macroeconomic variables related to the Turkish house market, they determined a statistically significant positive relationship between money supply shocks, mortgage rates, real economic activity (industrial production and output) and housing permit shocks on house price fluctuations. Moreover, they found that the house market plays an important role in transferring monetary policy to the real economy in Turkey. Similar monetary transmission variables were found to be significant in China as well (Zhang, Hua & Zhao, 2012). Analyzing the period from 1999 to 2010, they determined a significant connection of mortgage rates, producer prices, broad money supply and real effective exchange rate on house prices. On the other hand, common variables such as income, GDP, value-added industrial output and international trade did not prove to be significant in explaining the fluctuation of house prices in China.

As a special research based on its results, the one conducted in Lithuania for the period from 2001 to 2014 can be singled out (Cohen & Karpavičiūtė, 2017). The authors determined that the statistically significant determinants of house prices are GDP, unemployment and the means of macroprudential policy on house prices. With the exception of emigration as a specific variable, inflation and interest rates, which were found to be significant in all other aforementioned research papers, proved to be statistically insignificant variables as well.

The last line of research papers that determine the impact on house prices are those papers that investigate the impact of tourism. In this group, the research results are not as unambiguous as in previous research. Namely, the general conclusion that could be expressed is that tourism activity positively affects home prices. A good overview of papers on the impact of tourism on house prices can be found in Čeh Časni & Filić (2022). One of their conclusions is that due to the lack of data on prices at the regional and local level, the literature on the relationship between tourism and housing prices is rather limited and that further research is needed in this area. By analyzing a large number of papers, they come to the conclusion that there are three groups of papers regarding the results of the impact of tourism activity on house prices. The first group includes a large number of authors that found a positive relationship between tourism activity and housing prices. The second group includes just a small number of authors that found a negative relationship or the absence of a relationship whereby the third group includes authors that found indirect impacts of tourism activity on housing prices. This was also the result of research conducted in 103 Italian cities over the period of 1996-2007 (Biagi, Brandano & Lambiri, 2015) and in Turkey for the period of 2010-2020 (Yildirim & Karul, 2022). However, the results in Italy also showed that this influence is not the same in all analyzed cities. The reason for this may lie in the negative effects of tourism on house affordability. Detailed research of this

phenomenon on the example of the Republic of Croatia was carried out for the period of 2012 - 2018 with the usage of generalized method of moments (GMM) and showed that strong effects emerging through tourism seasonality, such as employment rate fluctuations, difficulties in the maintenance of economic status, capital underutilization risks, revenue instability, and overpopulation present challenges for local residents to afford real estate (Mikulić et al., 2021). Šimek, Franov and Krce Miočić (2022) came to the conclusion of the same negative impact of tourism on the inability of the local population to buy housing, analyzing a wider period from 2005 to 2021.

In addition to these research studies that investigate the impact of tourism on house prices, other studies can be cited that have been carried out as part of almost all the previously mentioned research approaches using the example of the Republic of Croatia as an example. As an example of research that determines the impact of the COVID-19 pandemic on house prices in Croatia, it is possible to single out Slišković, Solenički and Beg (2021) who, using the hedonistic model for the period from 2010 to 2020, find no evidence that the pandemic has significantly changed the trend of house prices increase which is contrary to the aforementioned research results in other countries. In the same research, the authors also determined the positive impact of subsidizing housing loans on the increase in house prices, which was also the goal of research by other authors. Dumičić, Časni & Šprajaček (2012) investigated the relationship between the housing sector and macroeconomy in Croatia by estimating a structural vector autoregressive (SVAR) model and quarterly data of the real GDP for the Euro zone and Croatia, financial conditions index, the consumer price index and the real hedonic real estate price index in the period from March 1997 to March 2008. The obtained results suggest that the developments in house prices and other domestic variables were mainly caused by external shocks whereby the changes in real estate prices have significant influence on domestic variables in Croatia. Kunovac and Žilić (2020), using an event study approach for the period from 2015 to 2019, show that the housing subsidy made house less affordable, especially for the non-recipients. A similar result is reached by Tica (2020) using regression analysis for the period from 2003 to 2019, where it investigates the impact of housing loan subsidies and low interest rates on foreign currency savings in Croatia on house prices and determines that there is a statistically significant relationship. Furthermore, he determined the existence of a difference in the determinants that explain house prices in Zagreb compared to the Adriatic and the rest of Croatia as three statistical regions in the Republic of Croatia. On the Adriatic and the rest of Croatia, house prices are best described by the non-performing loans (NPL) variable, while the GDP variable is equally useful for all regions. Another important conclusion is that although there are a large number of papers that modeled the determinants of residential real estate prices, when it comes to Croatia, due to the problem of data availability, most of the studies are panel analysis and non-time series analysis.

Lovrinčević and Vizek (2008) tried to reach a conclusion about the impact of accession of new member states to the EU on house prices by using the Error correction model (ECM) and cointegration analysis on data for the Republic of Croatia for the period from 2000 to 2006. They did not establish an unequivocal conclusion that would be valid for all new member states, but for the Croatia they

determined statistically significant long-term (income, inflation, interest rates) and short-term determinants of house prices (loans to households, marriage dynamics, inflation).

It is interesting to mention the research conducted for the period from 2002 to 2018 (Slišković, 2019) where, using the dynamic stock-flow model, an attempt was made to investigate the determinants that affect house prices in Croatia during the financial and economic crisis (2008 – 2015). Although the research results show that GDP and employment are statistically significant variables, their influence is so small that the authors conclude that it can be considered that macroeconomic variables have no influence on construction activity at all. In addition to this unexpected result, many atypical results were found that are not in accordance with economic theory and logic, and represent the specificity of the Croatian housing market.

Finally, it is worth mentioning the research conducted for the period from 2005 to 2018 in 27 EU countries, which established a list of standard determinants with a statistically significant impact on the increase in house prices: economic growth, unemployment and credit to the private sector (Škrabić Perić, Rimac Smiljanić & Kežić, 2022). However, the authors themselves point out that the most important result of their research is that hotel accommodation plays a role as a buffer of the growth in house prices caused by tourism.

This last result also motivated authors of this paper to contribute to the determination of factors with an impact on the house price movements in the Republic of Croatia. In doing so, as input variables we use a combination of macroeconomic variables and variable from the domain of tourism using a new methodology. When choosing macroeconomic variables that will be included in our model, we were guided by the previously presented research and used a standard set of variables that are usually used in this type of research. In addition, we were also guided by the paper of Slišković (2019) which investigated the most commonly used variables of the house price determinants in selected empirical surveys. Her research showed that the most often used variables as determinants of house prices are interest rate, income (such as national income, income per capita, household disposable income and industrial production as approximation of GDP), loans, inflation, demographic factors, etc. However, due to the limitations of the methodology used in this paper and the importance of tourism as an economic sector in Croatia, in our analysis we included tourist arrivals. Beside this, we additionally made an overview of the most relevant papers discussed in the Literature review regarding the house prices in Croatia. This overview includes the authors, the used variables (dependent, independent or endogenous), their frequencies, the estimated periods, and the used methodologies and is presented in Appendix 1. From the overview it is possible to notice the similarity in the used variables, however, the differences are manifested in the used methodologies and the time periods of the analysis. Although variables used in our model are not original and new, the scientific contribution of this research will be achieved by using a new methodology that has not been tested before on this series of data and on the example of Croatia by using a combination of variables that includes tourism and the estimation period with the latest data containing external shocks such as COVID-19 pandemic and the Russian invasion of Ukraine.

3. DATA

The main goal of this paper is to analyze the influence of selected macroeconomic variables on house prices in Croatia. The data on real gross domestic product (*RGDP*), domestic credit (*CRED*), consumer prices (*CPI*), interest rate (*INT*)[1] and house prices (*HPI*)[2] are obtained from the Croatian National Bank (2023, 2023a and 2023b) while the data on tourist arrivals (*ARR*) are obtained from the Croatian Bureau of Statistics (2023) databases. The data are analyzed on a quarterly basis from March 2005 to September 2022[3] and are shown on Figure 1.

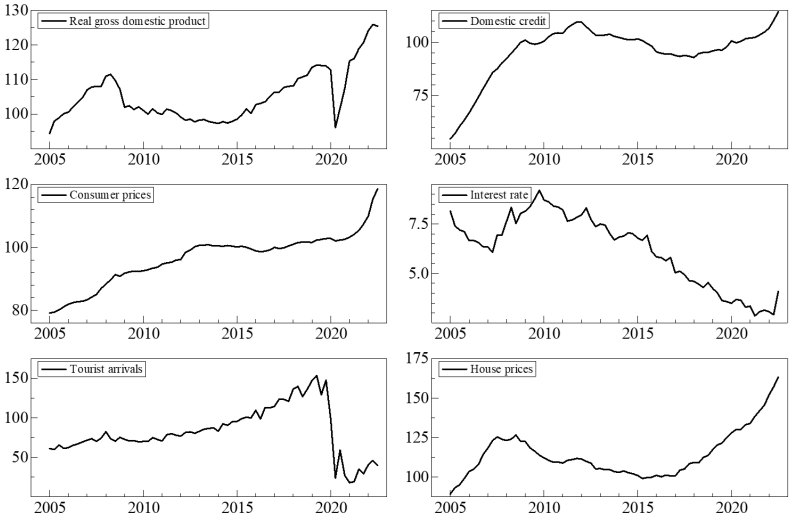


Figure 1 Real gross domestic product, domestic credit, consumer prices, tourist arrivals, house prices (seasonally adjusted indices, 2015 = 100) and interest rate (seasonally adjusted, in %)

Source: Croatian National Bank (2023, 2023a and 2023b) and Croatian Bureau of Statistics (2023).

[1] Since the Croatian National Bank does not announce overall average lending interest rate of Croatian banks, the analysis includes the average lending interest rate on long-term household loans with a currency clause because the majority of granted loans in Croatia (in the period before adapting the euro as a national currency) were long-term household loans with a currency clause.

[2] According to the Croatian National Bank (2023b) the house price index measures trends in the market prices of residential properties purchased by households, irrespective of the property's previous owner or intended use and includes the value of the land. The index comprises all data on transactions in real property (houses and apartments) in Croatia. For more details and methodological issues see Croatian National Bank (2023b).

[3] The dataset starts from March 2005 and includes the most recent data about selected macroeconomic variables. Namely, the data before March 2005 about tourist arrivals are no logner comparable due to the change in the methodology. The new Sojourn Tax Act (Official Gazette, No. 152/08 and No. 59/09) prescribes a different methodology for monitoring tourists, so the data from 2005 to 2009 were revised to make them comparable. The new methodology excludes nautical ports, the business entities sleeping cars and couchette, and the business entities in river and sea water transport (only scheduled lines).

It is visible that consumer prices generally achieve upward trend throughout the observed period. Tourist arrivals achieve strong upward trend until 2019 but after that until 2021 a sharp decline is noticeable due to the start of the COVID-19 pandemic which limited the physical movement of citizens (i.e. tourists) within and between the countries around the world. Real GDP, domestic credit and house prices have similar fluctuations throughout the observed period. However, unlike domestic credit and house prices, real GDP sharply declines in 2020 due to the negative impact of COVID-19 pandemic on Croatian economy. If this decline is excluded, then real GDP, domestic credit and house prices achieve very similar movements initially rising until the start of the global financial crisis in 2008 (the so-called *Great Recession 2007–2009*), after that they are declining until 2015-2016 and then again rising until the end of the observed period. Finally, interest rate initially decreases until the beginning of the global financial crisis, then rises until the 2010 and after that tends to fall until the end of the observed period.

4. METHODOLOGY, EMPIRICAL ANALYSIS AND RESULTS

To analyze the impact of selected macroeconomic variables on house prices in Croatia the general-to-specific VAR (vector autoregressive) modelling framework is applied. This framework consists of Granger causality tests and impulse response functions analysis, but before setting the model it is necessary to examine the degree of integration of variables since models with nonstationary data can lead to misconclusions and estimation problems (Österholm, 2005). Consequently, the extended Dickey-Fuller ADF test (Dickey & Fuller, 1979), Phillips and Perron PP test (Phillips & Perron, 1988), Kwiatkowski, Phillips, Schmidt and Shin KPSS test (Kwiatkowski et al., 1992) and test with structural brake (Saikkonen & Lütkepohl (2002) and Lanne et al. 2002) are applied and shown in Table 1[4.] To eliminate the influence of seasonal factors variables are seasonally adjusted[5]. In addition, all variables except the interest rate are expressed as indices in logarithmic form.

The ADF and PP test results indicate possible stationarity in levels for domestic credit that is rejected by the KPSS test. The ADF and KPSS tests indicate possible stationarity in levels for tourist arrivals that is clearly rejected by the PP test. Furthermore, the ADF test results indicate the possibility that consumer prices and house prices are integrated of order I(*2*) that is rejected by the results of the PP and KPSS tests. Similar results are suggested by the KPSS test for domestic credit. However, it can be noted that the results of the PP and KPSS tests are more unambiguous compared to the results of the ADF test. All these results are not surprising since the analyzed period, as previously stated, includes (negative)

[4] The OxMetrics (Doornik, 2018) and EViews (S&P Global Inc., 2022) econometric packages are used for the multiple time series analysis.
[5] Using the X12-ARIMA method.

effects of the global financial crisis and COVID-19 pandemic which led to visible breaks in the data. Therefore, for those variables where there is doubt about their order of integration, an additional unit root test with structural brake is applied. As expected, the results of the test with structural brake remove the doubts. Hence, unit root tests results and insight into the movement of variables, generally suggest that all variables are integrated of order I(*1*), i.e. they become stationary after differencing.

Table 1

Unit root tests

Variable and test	Level		First difference	
	Constant	Constant and trend	Constant	Constant and trend
ADF test	**Prob.**			
LRGDP	0,7660	0,8241	0,0000	0,0000
LCRED	0,0311	0,1005	0,0877	0,3815
LCPI	0,9826	0,6347	0,7364	0,9587
INT	0,8192	0,8139	0,0000	0,0000
LARR	0,0280	0,1142	0,0001	0,0000
LHPI	0,9216	0,9599	0,2007	0,3632
PP test	**Prob.**			
LRGDP	0,6986	0,7734	0,0000	0,0000
LCRED	0,0000	0,0053	0,1410	0,4821
LCPI	0,8897	0,7576	0,0090	0,0454
INT	0,8064	0,7869	0,0000	0,0000
LARR	0,1791	0,4442	0,0001	0,0000
LHPI	0,8933	0,9617	0,0008	0,0035
KPSS test	**LM-stat.**			
LRGDP	0,545300	0,207232	0,139199	0,098262
LCRED	0,481620	0,203282	0,479563	0,264313
LCPI	1,015035	0,203061	0,171928	0,176477
INT	0,870959	0,228438	0,121183	0,114174
LARR	0,152408	0,155358	0,118615	0,046178
LHPI	0,356570	0,195327	0,266164	0,218227
Test with structural break	**Test stat.**			
LCRED	-2,3402	-1,0231	-2,8969	-2,8358
LCPI	0,7736	-2,1385	-2,6590	-2,2035
LARR	-2,1109	-2,2488	-4,7933	-4,0380
LHPI	0,0037	-1,8488	-2,7640	-2,4521

Notes: "L" indicates logarithm of the variable. For the implementation of ADF, PP test and the test with structural brake Schwarz information criterion has been implemented. KPSS test asymptotic critical values: constant: 1% level (0,739), 5% level (0,463), 10% level (0,347); constant and trend: 1% level (0,216), 5% level (0,146), 10% level (0,119). Test with structural break critical values: constant: 1% level (-3,48), 5% level (-2,88), 10% level (-2,58); constant and trend: 1% level (-3,55), 5% level (-3,03), 10% level (-2,76).

Source: own calculations.

As summarized in Benazić (2023), Doornik and Hendry (2018) induced that Hoover and Perez (1999) revisited the work of Lovell (1983) in order to revive automatic computer-based econometric modelling techniques and to prove their benefits. Hendry and Krolzig (1999) extended the modelling algorithm of Hoover and

Perez (1999) and created a user-friendly computer program called PcGets. Lately, based on Hendry and Krolzig (1999) and Hoover and Perez (1999), Doornik (2008) and Doornik (2009) created an automated procedure named Autometrics as the third generation of the general-to-specific modelling framework (Doornik & Hendry 2018).

In Autometrics, the selection of coefficients (i.e. variables, regressors) is achieved in three stages (Doornik & Hendry (2018), Doornik and Hendry (2018a), Panday (2011) and Cunha and Pereira (2015)). In the first stage, the general unrestricted model (GUM) is set up considering empirical findings and theory. The GUM should be comprehensive and it must pass all diagnostic tests. In this stage, the significance level that will be used for the reduction of coefficients (i.e. variables, regressors) is determined. The significance level specifies the extent to which a deterioration in information relative to the GUM is accepted. The insignificant coefficients (i.e. variables, regressors) are further removed from the GUM in the second stage. This is done to reduce complexity while diagnostic validity tests of reductions provide consistency of the terminal (final) model. The second stage ends when there are no more coefficients (i.e. variables, regressors) to remove according to the significance level. In the third stage, based on a tie-breaker, one or more terminal models are selected.

Classical estimation of the VAR model begins with the determination of the number of lags in the model by using the information criteria which makes a big difference compared to the general-to-specific VAR modeling. Therefore, the classical way of modeling in the estimated model also leaves individual insignificant coefficients in the selected lags simultaneously removing possible individual significant coefficients in the omitted lags. The fact that the general-to-specific VAR modeling primarily focuses on the individual significant coefficients gives it an advantage over the classic VAR modeling. However, automatic model selection algorithms have positive and negative characteristics compared to classical modelling methods. They are simple, fast and add robustness to the selection (Doornik (2008), Cunha and Pereira (2015) and Doornik and Hendry (2018)) but on the other side there is a possibility of data-mining bias, borderline significant variables can be omitted while insignificant may be included etc.

As a consequence, the following initial unrestricted stationary VAR model is estimated:

$$\Delta y_t = A_1 \Delta y_{t-1} + \cdots + A_p \Delta y_{t-p} + \cdots + C D_t + u_t, \quad (1)$$

where $\Delta yt = (\Delta y_{1t},\ldots,\Delta y_{Kt})$ is a vector of K endogenous stationary variables, D_t is a vector of deterministic variables including constant and specified dummy variables, u_t is K-dimensional vector of residuals, while A and C are matrices of parameters of the model.

The vector of endogenous variables includes four lags of each variable in the model. Namely, the real GDP, domestic credit, consumer prices, interest rate, tourist arrivals and house prices, while the vector of deterministic variables includes constant and a number of dummy variables for the breaks in the data caused by the spillover effect of the global financial crisis on the Croatian economy

and COVID-19 pandemic. The decision of using four lags of each variable is based on a one-year-window. Respectively, all the needed information to predict the next quarter values are contained in a one-year period.

The Autometrics settings for the model estimation in OxMetrics econometric package are set as follows (Doornik & Hendry, 2018):

- Target size (the significance level that is used for reduction): 0,05.
- Pre-search lag reduction: Active.
- Outlier and break detection: Impulse indicator saturation (IIS).
- Backtesting against: GUM 0.
- Tie-breaker: SC (Schwarz Criterion).
- Diagnostic tests p-value: 0,05 (5% significance level).
- GIVE: do reduced form first: Active.
- Estimation method: Ordinary Least Squares.
- Diagnostic test arguments: Default.

The diagnostic tests of the terminal model are presented in Table 2. The diagnostic tests include single variable and vector serial correlation test, ARCH (autoregressive conditional heteroscedasticity) test, normality test, Heteroscedasticity test and RESET test.

Table 2

VAR diagnostic tests (single and vector)

Serial correlation	DLRGDP: AR 1-4 test: F(4,39) = 0,49937 [0,7363] DLCRED: AR 1-4 test: F(4,39) = 0,23375 [0,9177] DLCPI: AR 1-4 test: F(4,39) = 1,9597 [0,1199] DINT: AR 1-4 test: F(4,39) = 0,64383 [0,6345] DLARR: AR 1-4 test: F(4,39) = 2,4681 [0,0606] DLHPI: AR 1-4 test: F(4,39) = 0,83822 [0,5093] Vector AR 1-4 test: F(144,89) = 0,93504 [0,6433]
ARCH	DLRGDP: ARCH 1-4 test: F(4,58) = 0,75513 [0,5587] DLCRED: ARCH 1-4 test: F(4,58) = 0,64735 [0,6310] DLCPI: ARCH 1-4 test: F(4,58) = 0,92294 [0,4569] DINT: ARCH 1-4 test: F(4,58) = 1,3316 [0,2691] DLARR: ARCH 1-4 test: F(4,58) = 0,39926 [0,8084] DLHPI: ARCH 1-4 test: F(4,58) = 1,1577 [0,3389]
Normality	DLRGDP: Normality test: Chi^2(2) = 0,41559 [0,8124] DLCRED: Normality test: Chi^2(2) = 0,54618 [0,7610] DLCPI: Normality test: Chi^2(2) = 0,68980 [0,7083] DINT: Normality test: Chi^2(2) = 5,7463 [0,0565] DLARR: Normality test: Chi^2(2) = 3,6850 [0,1584] DLHPI: Normality test: Chi^2(2) = 4,4030 [0,1106] Vector Normality test: Chi^2(12) = 17,024 [0,1487]
Hetero	DLRGDP: Hetero test: F(14,36) = 0,50112 [0,9170] DLCRED: Hetero test: F(14,36) = 1,3561 [0,2247] DLCPI: Hetero test: F(14,36) = 0,54184 [0,8906] DINT: Hetero test: F(14,36) = 1,2676 [0,2739] DLARR: Hetero test: F(14,36) = 0,33472 [0,9842] DLHPI: Hetero test: F(14,36) = 0,60041 [0,8466] Vector ZHetero test: F(84,179) = 0,87779 [0,7477]
RESET	Vector RESET23 test: F(72,147) = 1,0738 [0,3542]

Notes: "D" indicates first difference, while "L" indicates logarithm of the variable.

Source: own calculations.

It is clearly visible that all diagnostic tests indicate that the terminal model is adequately estimated, i.e. the terminal model residuals are not serially correlated, there are no ARCH effects in the residuals, the residuals are normally distributed, the residuals are unconditionally homoscedastic and the original model functional form is not mis-specified as indicated by the RESET test.

Table 3 shows F-tests of the terminal model on the significance on all regressors (except unrestricted), retained regressors, tests on the significance of each variable, tests on the significance of each lag and all lags up to 3.

Table 3

F-tests on the significance on all regressors (except unrestricted), retained regressors, of each variable, of each lag and all lags up to 3

Test on all regressors except unrestricted	F(132,228) = 10,9203 [0,0000]
Tests on retained regressors, F(6,38) =	DLRGDP_1: 5,66642 [0,000], DLCRED_1: 12,7852 [0,000], DLCPI_2: 4,33969 [0,002], DLCPI_3: 2,72695 [0,027], DINT_1: 3,80302 [0,005], DLARR_1: 7,46952 [0,000], DLREP_2: 5,42862 [0,000], I:2008(4): 4,54512 [0,001], I:2009(1): 5,13437 [0,001], I:2010(2): 2,69191 [0,028], I:2011(2): 2,38364 [0,047], I:2012(2): 3,03393 [0,016], I:2019(3): 3,13151 [0,014], I:2020(1): 13,4133 [0,000], I:2020(2): 128,249 [0,000], I:2020(3): 2,07602 [0,079], I:2020(4): 10,6507 [0,000], I:2021(1): 30,2303 [0,000], I:2021(3): 25,3334 [0,000], I:2022(1): 6,01158 [0,000], I:2022(2): 12,5902 [0,000], I:2022(3): 2,66372 [0,030], Constant U: 3,08974 [0,015]
Tests on the significance of each variable	DLRGDP: F(6,38) = 5,6664 [0,0003], DLCRED: F(6,38) = 12,785 [0,0000], DLCPI: F(12,76) = 3,7349 [0,0002], DINT: F(6,38) = 3,8030 [0,0046], DLARR: F(6,38) = 7,4695 [0,0000], DLHPI: F(6,38) = 5,4286 [0,0004], Constant: F(6,38) = 3,0897 [0,0146], I:2008(4): F(6,38) = 4,5451 [0,0014], I:2009(1): F(6,38) = 5,1344 [0,0006], I:2010(2); F(6,38) = 2,6919 [0,0282], I:2011(2): F(6,38) = 2,3836 [0,0472], I:2012(2): F(6,38) = 3,0339 [0,0160], I:2019(3): F(6,38) = 3,1315 [0,0136], I:2020(1): F(6,38) = 13,413 [0,0000], I:2020(2): F(6,38) = 128,25 [0,0000], I:2020(3): F(6,38) = 2,0760 [0,0790], I:2020(4): F(6,38) = 10,651 [0,0000], I:2021(1): F(6,38) = 30,230 [0,0000], I:2021(3): F(6,38) = 25,333 [0,0000], I:2022(1): F(6,38) = 6,0116 [0,0002], I:2022(2): F(6,38) = 12,590 [0,0000], I:2022(3): F(6,38) = 2,6637 [0,0295]
Tests on the significance of each lag	Lag 3: F(6,38) = 2.7269 [0.0266], Lag 2: F(12,76) = 4,5376 [0,0000], Lag 1: F(24,133) = 6,5307 [0,0000]
Tests on the significance of all lags up to 3	Lag 3 – 3; F(6,38) = 2,7269 [0,0266], Lag 2 – 3: F(18,107) = 3,7709 [0,0000], Lag 1 – 3: F(42,181) = 6,5242 [0,0000]

Notes: "D" indicates first difference, while "L" indicates logarithm of the variable.

Source: own calculations.

From the above results it is obvious that all retained regressors (except unrestricted) together in the terminal model are highly significant. Individual retained regressors, as well as each variable in the terminal model are also significant. Finally, the test results show that each lag in the terminal model, including all lags together up to 3, is also highly significant.

The terminal model is further tested by plotting the roots of companion matrix in order to check its stability condition. The model is stable (stationary) if all roots have modulus less than one and lie inside the unit circle. Otherwise, the model is not stable, the system might be explosive and some results may be invalid.

Appendix 2 shows that the companion matrix has no roots outside the unit circle meaning that the terminal model satisfies the stability condition.

The parameter constancy is checked by graphical examination using recursive graphics. Appendix 3, 4, 5 and 6 show the plots of 1-step residuals, 1-step Chow tests, break-point Chow tests and forecast Chow tests for each equation and the entire system. It is clearly visible that 1-step residuals lie within 95% confidence intervals and that 1-step Chow tests, break-point Chow tests and forecast Chow tests values are significantly below 1% p-value. Therefore, it can be concluded that the terminal model satisfies parameter constancy at the level of each equation and the entire system.

In order to analyze the causality between variables in the model, Granger causality/block exogeneity Wald tests are applied. The purpose of these tests is to see whether a set of endogenous variables in the model can be treated exogenous in relation to each of the remaining variables in the model. Test results are presented in Table 4.

Table 4

VAR Granger causality/block exogeneity Wald tests (exclusion restrictions)

Dependent variable: DLRGDP			**Dependent variable: DLCRED**		
Excluded	**Subset Chi^2(2)**	**Prob.**	**Excluded**	**Subset Chi^2(2)**	**Prob.**
DLCRED	0,46794	0,4939	DLRGDP	0,21747	0,6410
DLCPI	2,6670	0,2636	DLCPI	5,8194	0,0545
DINT	1,0257	0,3112	DINT	3,3269	0,0682
DLARR	3,1287	0,0769	DLARR	0,090770	0,7632
DLHPI	3,0769	0,0794	DLHPI	7,9795	0,0047
Dependent variable: DLCPI			**Dependent variable: DINT**		
DLRGDP	0,024372	0,8759	DLRGDP	2,0211	0,1551
DLCRED	0,20661	0,6494	DLCRED	2,0109	0,1562
DINT	9,9828	0,0016	DLCPI	1,2153	0,5446
DLARR	0,39920	0,5275	DLARR	1,3909	0,2383
DLHPI	6,3144	0,0120	DLHPI	0,22359	0,6363
Dependent variable: DLARR			**Dependent variable: DLHPI**		
DLRGDP	6,4001	0,0114	DLRGDP	17,763	0,0000
DLCRED	0,046139	0,8299	DLCRED	3,7954	0,0514
DLCPI	3,9773	0,1369	DLCPI	6,4077	0,0406
DINT	1,9249	0,1653	DINT	4,0468	0,0443
DLHPI	3,7944	0,0514	DLARR	0,023634	0,8778

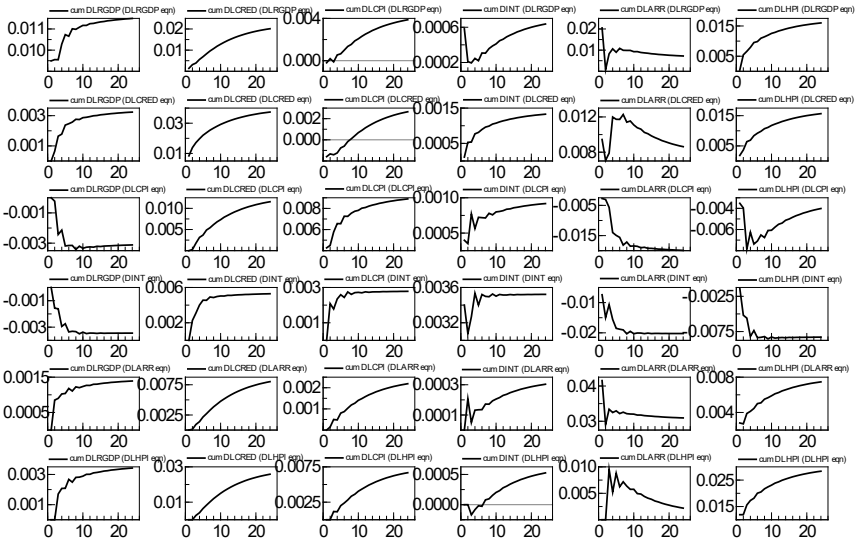
Notes: "D" indicates first difference, while "L" indicates logarithm of the variable.

Source: own calculations.

The results indicate that real GDP, domestic credit, consumer prices and interest rate cause house prices. Tourist arrivals and house prices cause real GDP while consumer prices, interest rate and house prices cause domestic credit. Interest rate and house prices cause consumer prices while none of the variables cause

interest rate.[6] Finally, real GDP and house prices cause tourist arrivals. Hence, the most causal relationships can be observed in the area of house prices.

The analysis proceeds with the orthogonalized accumulated impulse response functions. The purpose of this analysis is to investigate the dynamic interactions among the variables in the model. The orthogonalized impulse responses are based on an innovation of size one-standard deviation in the transformed model, i.e. a model where the matrix of errors is orthogonalized using a Cholesky decomposition. However, Cholesky decomposition is sensitive to the order of variables in the model and therefore, in order to analyze influence of variables order change, impulse response functions are generated with reverse order of variables in the model. Obtained results, not shown here for the preservation of space, are very similar. Figure 2 shows the results of orthogonal accumulated impulse response functions. Considering that the primary goal of this paper is to analyze the influence of selected macroeconomic variables on house prices in Croatia, the focus will be only on these impulse response function effects.



Notes: "D" indicates first difference, while "L" indicates logarithm of the variable. Cholesky ordering.

Figure 2 VAR orthogonal accumulated impulse responses

Source: own calculations.

It is visible that an increase in real GDP, domestic credit and tourist arrivals cumulatively increase house prices in Croatia. Namely, the increase in real

[6] The exogeneity of the average lending interest rate on long-term household loans with a currency clause causes, i.e. the fact that this interest rate significantly affects the Croatian economy, but not *vice versa*, was analyzed and also shown in the paper Benazić and Učkar (2021).

GDP is an indicator of real economic growth and indicates increase in citizens' welfare thus making real properties more accessible, which is reflected in the increase in demand for real properties and the rise in house prices. The increase of domestic credit also makes real properties more affordable, which is again reflected in the increase in demand for real properties and the rise in house prices. The increase in tourist arrivals increases citizens' welfare making real properties more accessible, which is reflected in the increase in demand for real properties and the rise in house prices. Additionally, arrivals to the destination can also affect the interest in owning real properties by tourists (foreigners), which ultimately creates pressure on house prices, taking into account that foreigners can be real property owners in Croatia. An increase in consumer prices initially cumulatively decreases house prices but after three quarters from the initial shock the effect diminishes. An increase in consumer prices reduces the purchasing power and welfare of those interested in real property ownership which is reflected in the decrease in demand for real properties and the drop in house prices. Finally, an increase in interest rate permanently and cumulatively decreases house prices in Croatia. An increase in the interest rate increases the burden of loan repayment and increases the cost of credit, which leads to a drop in demand for real properties and house prices.

It is noticeable that the results of previously conducted Granger causality tests are aligned with the impulse response functions. Hence, according to the Granger causality tests and impulse response functions analysis results, it can be concluded that an increase in real GDP, domestic credit and tourist arrivals increase the house prices in Croatia, while an increase in consumer prices and interest rate reduces them.

This also confirms the research hypothesis set out in the introductory part of this paper. The obtained results are mostly in line with the results of other research presented in the Literature review, especially the research oriented towards macroeconomic variables as determinants of house prices. By comparison with the previously referenced research presented in the Literature review, it is noticeable that there is a dominant agreement about the interest rate as a determinant that affects house prices in almost all of the mentioned research. As for the other variables used, they all proved to be significant in some studies, with even the same direction of influence on the movement of house prices. However, there is no single case that used all variables used in this study, nor that the variables were always significant in all studies.

5. CONCLUSIONS

There is significant interest in the academic and professional community to research determinants with a significant impact on the movement of house prices. This is evident from the fact that there are different research directions approaching this problem, each from its own side. This paper presents specific research that begins in determining the factors of house prices by determining the influence of microelements characteristic for a specific microlocation, the impact

of the COVID-19 pandemic, macroeconomic elements, and ultimately the influence of tourism on the movement of house prices.

The main goal of this study was to analyze the impact of selected macroeconomic variables on house prices in Croatia using the Autometrics, i.e. an automatic computer implementation of general-to-specific VAR (vector autoregressive) modelling framework relaying on the Granger causality tests and impulse response functions analysis. Performed Granger causality tests suggest that real GDP, domestic credit, consumer prices and interest rate influence house prices while the causality of tourist arrivals on house prices has not been confirmed. The results of the impulse response functions analysis indicate that an increase in real GDP, domestic credit and tourist arrivals increases house prices while an increase in consumer prices and interest rate reduces them.

In the end, the analysis has some shortcomings. For example, only selected macroeconomic variables were used to examine the behavior of house prices. In addition, the research does not include exogenous variables that can also affect house prices. Also, the impact of tourism is represented by only one variable, while the application of another variable from the domain of tourism could give different results. An interesting question for future research is the causal relationship of the reduced number of tourist arrivals due to the increased overnight rates resulting from the effort to maintain the same rate of return form investors in tourism in the conditions of the increase in house prices that occurred due to the previously increased number of tourist arrivals.

Despite the shortcomings, the scientific contribution of the paper is reflected in the fact that the obtained results are in accordance with the results of previously conducted research, but these results were obtained using a new and different methodology, a slightly different combination of variables that include tourism and different estimation period with the latest data containing external shocks such as COVID-19 pandemic and the Russian invasion of Ukraine. This also confirms the scientific robustness of research results.

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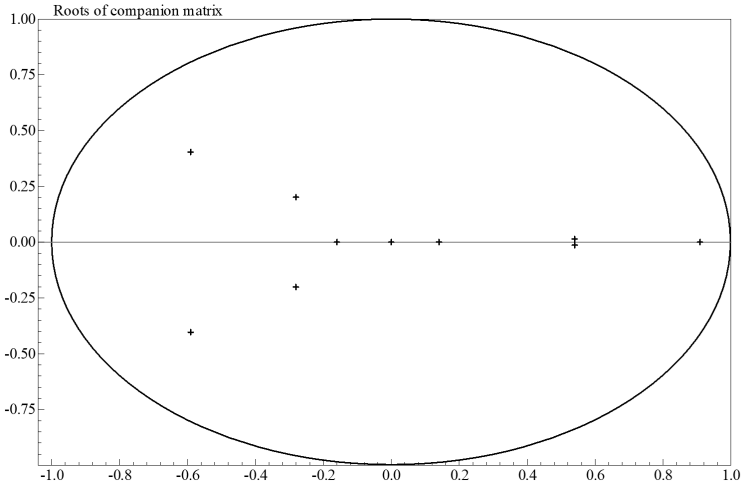
APPENDIX

Appendix 1 A brief overview of the most relevant (selected) papers regarding the house prices in Croatia

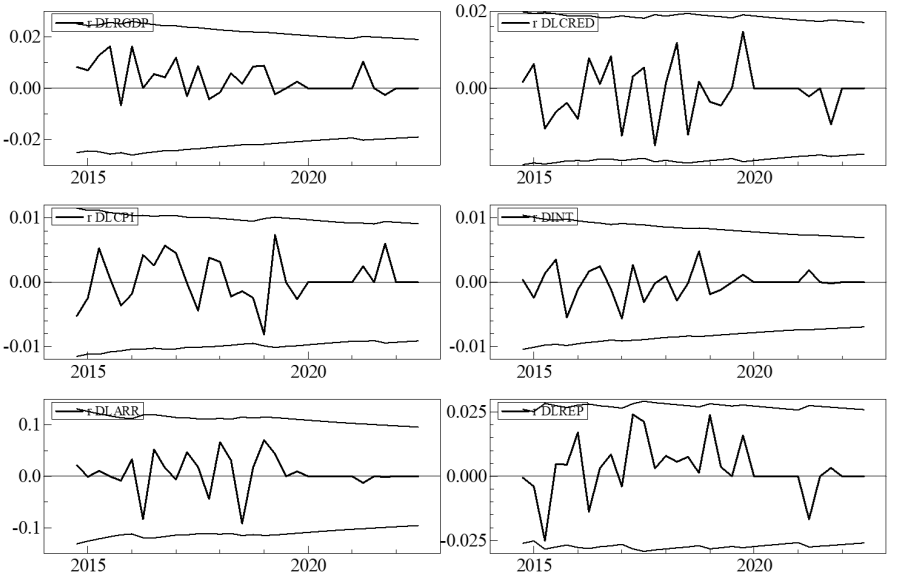
	Variables	Frequency	Period	Methodology
Lovrinčević & Vizek (2008)	*Endogenous*: average real price per square meter of a newly built apartment/house, real interest rate on long-term loans with currency clause to households, the volume of construction works index, consumer price index, real net average wages per employee	Quarterly	1995 Q1 - 2006 Q2	ECM - cointegration
Dumičić, Čeh Časni & Šprajaček (2012)	*Endogenous*: real GDP for the Euro zone and Croatia, financial conditions index, the consumer price index, the real hedonic real estate price index	Quarterly		SVAR
Slišković (2019)	*Dependent*: house price index, price of m^2 of newly built and sold dwellings; *Independent*: Housing stock per household, rent as component of CPI, gross domestic product, average net wages, total bank housing loans, interest rate on long-term kuna loans to households indexed to foreign currency, user cost of housing, user cost of capital, useful area (in m^2) of the dwellings for which the building permits were issued, the number of employed persons, short-term interest rates on kuna loans to non-financial corporations not indexed to foreign currency, cost of building land as a component of PNEW, value of building material, complete units and structures and propulsion material used, housing stock on the market (in m^2)	Quarterly	2002 Q1 - 2018 Q4	Dynamic stock-flow model
Kunovac & Žilić (2020)	*Dependent*: price per square meter of a residential unit; *Independent*: per capita tourist overnight indicators for foreign buyer and seller, municipality fixed effect, Dummy	Annually	2015 - 2019	Hedonic regression
Tica (2020)	*Dependent*: residential real estate index prices (Croatia, Zagreb, Jadran, other); *Independent*: residential real estate index price (new and old apartments), GDP, construction works index, approvals for construction, interest rate on long-term housing loans in euro, housing loans balance in kuna and euro, foreign currency deposits, interest rate on foreign currency deposits, total loans from category B and C	Quarterly	1997 Q1 (max.) - 2019 Q3	Regression models
Mikulić, Vizek, Stojčić, Payne, Čeh Časni & Barbić (2021)	*Dependent*: housing affordability index; *Independent*: migrant share, property income, unemployment rate, distance, density, transrel, development index, coast, island, metro, tourist accommodation, tourist concentration, tourism seasonality, vulnerability to tourism	Annually	2012 - 2018	Panel GMM
Slišković, Solenički & Beg (2021)	*Dependent*: requested price of the apartment in euros per square meter, realized price of the apartment in euros per square meter; *Independent*: area, number of rooms; *Independent-dummies*: new construction, Zagreb, Adriatic, other, year of sale, pandemic shock, housing loan subsidies, earthquake shock	Observations	2010 - 2020	Hedonic model
Šimek, Franov & Krce Miočić (2022)	*Dependent*: real house price index; *Independent*: demand for housing per capita, total nights spent at tourist accommodation establishments, building permits (m^2 of useful floor area index), real GDP, interest rate of credit institutions on kuna housing loans to households with a currency clause, number of employees	Quarterly	2005 Q1 - 2021 Q2	Ordinary least squares (OLS)

Appendix 2 Roots of companion matrix



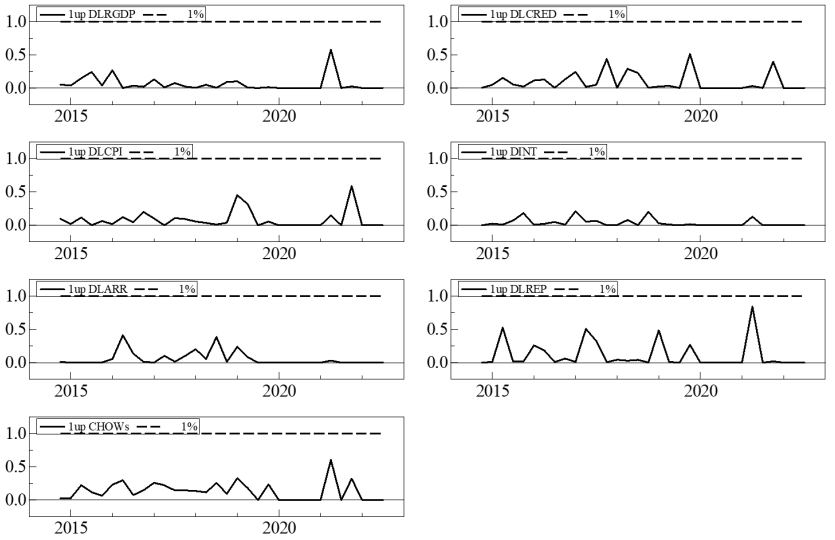
Source: own calculations.

Appendix 3 1-step residuals for each equation



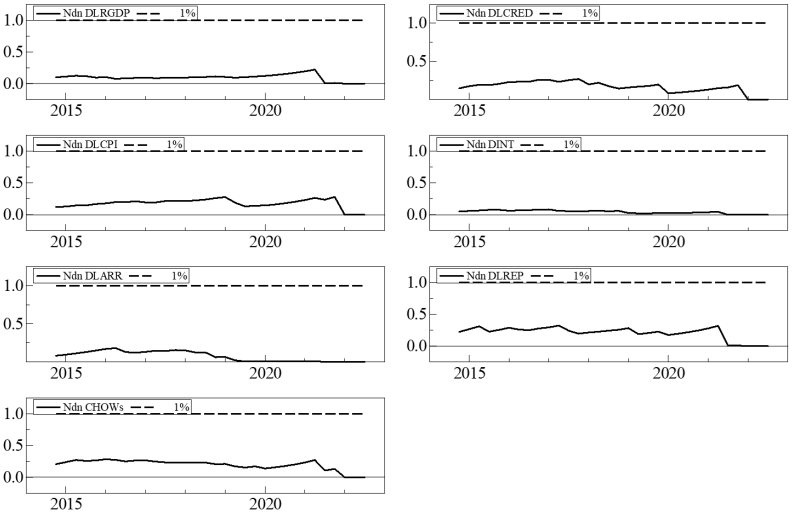
Source: own calculations.

Appendix 4 1-step Chow tests for each equation and the entire system



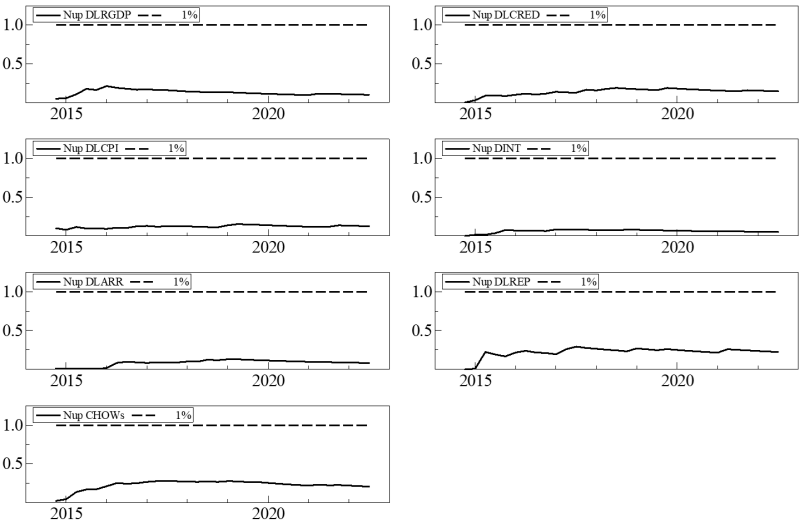
Source: own calculations.

Appendix 5 Break-point Chow tests for each equation and the entire system



Source: own calculations.

Appendix 6 Forecast Chow tests for each equation and the entire system



Source: own calculations.

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UTJECAJ ODABRANIH MAKROEKONOMSKIH VARIJABLI NA CIJENE STAMBENIH OBJEKATA U HRVATSKOJ

Sažetak

Utvrđivanje makroekonomskih determinanti koje imaju statistički značajan utjecaj na formiranje cijena stambenih objekata u interesu je široke javnosti zbog svojeg informacijskog učinka koji ima na različite interesne grupacije uključene u stambenu izgradnju. Stoga bi kupci nekretnina, investitori, kao i jedinice lokalne uprave i samouprave trebali biti zainteresirani za navedene informacije jer praćenje kretanja standardnih makroekonomskih varijabli može pružiti zaključke o mogućem kretanju cijena stambenih objekata. Prethodno provedena istraživanja mogu se svrstati u četiri različite kategorije ovisno o tome što uzimaju kao determinirajuće varijable: mikroelemente specifične za pojedinu mikrolokaciju, utjecaj pandemije COVID-19, standardne makroekonomske varijable ili turistički razvoj. Cilj je ovog istraživanja analizirati utjecaj odabranih makroekonomskih varijabli na cijene stambenih objekata u Hrvatskoj. Ovo istraživanje koristi se računalnim algoritmom „Autometrics", tj. automatskom računalnom implementacijom „od općeg prema specifičnom" VAR (vektorske autoregresije) okviru za modeliranje kvartalnih podataka realnog BDP-a, plasmana, potrošačkih cijena, kamatne stope, turističkih dolazaka i cijena stambenih objekata za razdoblje od ožujka 2005. do rujna 2022. Provedeni Grangerovi testovi uzročnosti i analiza funkcija impulsnih odziva ukazuju da povećanje realnog BDP-a, plasmana i turističkih dolazaka povećava cijene stambenih objekata, dok ih povećanje potrošačkih cijena i kamatne stope smanjuju.

Ključne riječi: „Autometrics", Hrvatska, modeliranje „od općeg prema specifičnom", cijene stambenih objekata, VAR model.

JEL klasifikacija: C52, E22, R30.