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Bubble Detective: City-Level Analysis of House Price Cycles

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Bubble Detective: City-Level Analysis of House Price Cycles

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Abstract

This paper investigates house price dynamics at high frequency using city-level observations during the period 1994-2022 in Lithuania. We employ multiple time series-based econometric procedures to examine whether real house prices and house price-to-rent ratios exhibit explosive behavior. According to these recursive right-tailed test results, we reject the null hypothesis of no-bubble and find evidence for long and multiple periods of explosive behavior in the real estate market in all major cities during the sample period. While the size of bubbles varies across cities, especially when we use the house price-to-rent ratio, there is clearly a similar boom-bust pattern. Large house price corrections can in turn have adverse effects on economic performance and financial stability, as experienced during the global financial crisis and other episodes in history.

JEL Classification Numbers:	C12; C22; C33; C53; E31; E62; G12; G21; R21; R31
Keywords:	House prices; bubbles; recursive unit root test; city-level; Lithuania
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Non-Technical Executive Summary

House prices have experienced an uninterrupted boom in recent years, but the extent of the housing boom varies significantly across countries. In Lithuania, following a correction of 43 percent during the global financial crisis, property prices have increased by 140 percent since 2010, thanks to strong income growth and low borrowing costs. However, the global economy and financial markets are now in the midst of sweeping realignments that have a significant bearing on all asset prices, including the most important of all—housing. The sudden and widespread surge in consumer prices after decades of low and stable inflation has forced central banks to tighten monetary policy even against the rising risk of recession, which presents a clear threat to the real estate market.

In this paper, we investigate the question of whether property prices in Lithuania are in a bubble territory by using monthly city-level housing prices and employing the recursive unit root test that is designed for empirical identification of asset price bubbles in real time. Our results indicate that there are long and multiple periods of explosive behavior in real house prices—beyond the level justified by fundamentals—in all major cities during the period 1994–2022. We also observe a similar pattern of exuberance over the sample period when we estimate the model with house price-to-rent ratio, but this measure of the real estate market shows no significant bubble in recent years, except in the case of one city. Furthermore, after remaining stable for an extended period after the global financial crisis, house price growth accelerated significantly during the COVID-19 pandemic. All in all, while the size of bubbles varies across cities, especially when we use the house price-to-rent ratio, there is clearly a similar boom-bust pattern throughout the country.

What can policymakers do at the current juncture? The Bank of Lithuania has already adopted an appropriate set of macroprudential tools, including borrower-based measures and macroprudential capital requirements to prevent the occurrence of housing price bubbles and maintain financial stability after the global financial crisis. These macroprudential measures should help reduce vulnerability in the banking system, increase resilience of borrowers to asset price or income shocks, and thereby minimize downside risks to financial stability. In this context, before the onset of a housing market correction, the authorities should conduct stress tests for banks and other non-bank financial institutions that have high exposures to real estate, and possibly require higher provisioning for mortgage loans for those that are found to be vulnerable based on the stress tests.

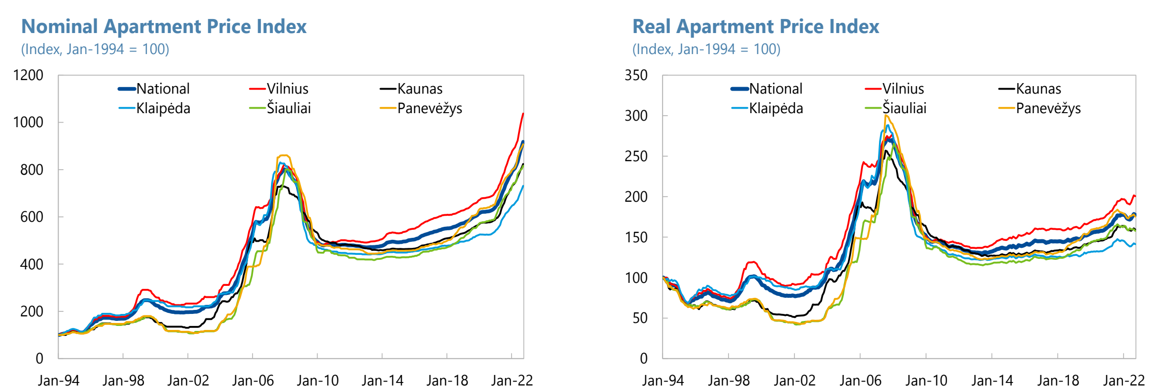
"If the bubbles contain a misconception, as they always do,
then it can't be maintained forever."
—George Soros

I. INTRODUCTION

House prices across the world have experienced an uninterrupted boom in the aftermath of the global financial crisis (GFC). The extent of the housing boom, however, shows significant variation across countries. In the case of Lithuania, for example, following a correction of 43 percent during the crisis, property prices have increased by 140 percent since 2010 (Figure 1). The surge in housing prices gained further momentum during the pandemic, with an average increase of 50 percent between the end of 2019 and September 2022, owing to a plethora of factors including greater demand for space, shortages in housing supply, low borrowing costs and economic support programs. But are we now at the precipice of an approaching burst of another housing bubble? The global economy and financial markets are in the midst of sweeping realignments that have a significant bearing on all asset prices, including the most important of all—housing. The sudden and widespread surge in consumer prices after decades of low and stable inflation has forced central banks to tighten monetary policy even against the rising risk of recession. Consequently, higher interest rates and greater uncertainty are now raising the cost of capital and putting downward pressure on housing markets everywhere.

The reversal of exceptionally easy financing conditions is a clear threat to house prices, but housing—as the most important type of asset—also plays an important role in the economy with potential spillovers to macro-financial stability (Mian, Rao, and Sufi, 2013; Kohlscheen, Mehrotra, and Mihaljek, 2020). This is why it is critical to better understand housing market risks. In this context, a "bubble" is defined as an exuberant rate of change in housing prices beyond the level justified by market fundamentals (Shiller, 2000; Case and Shiller, 2004). To the best of our knowledge, this is the first paper to investigate the question of whether property prices in Lithuania are in a bubble territory by using monthly city-level and employing the recursive unit root test proposed by Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2015), which is

Figure 1. City-Level Housing Prices in Lithuania



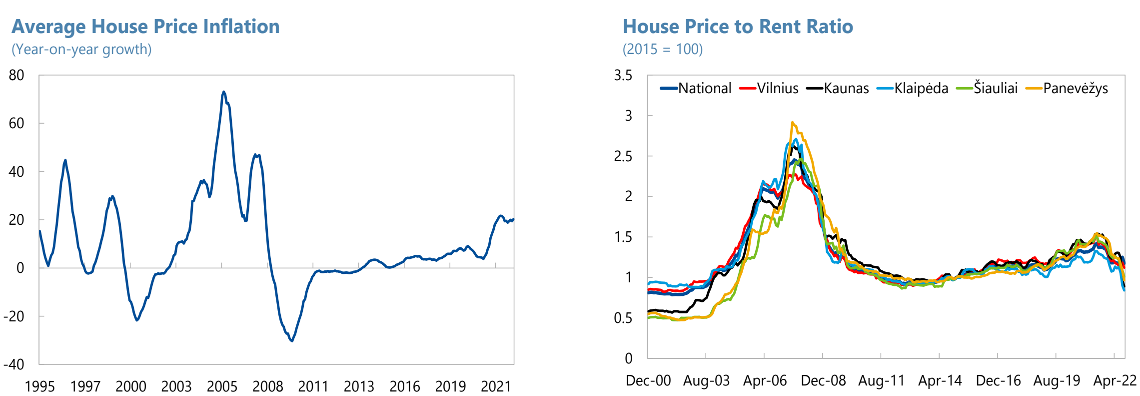
Source: Ober-Haus.

designed for empirical identification of asset price bubbles in real time. According to the recursive right-tailed test results, we reject the null hypothesis of no-bubble and find evidence for long and multiple periods of explosive behavior in the real estate market in all major cities as well as at the national level during the period 1994–2022. In recent years, however, house price growth accelerated significantly only during the COVID-19 pandemic, after remaining stable for an extended period after the GFC, owing to ultra-low interest rates and double-digit income growth. All in all, while the size of bubbles varies across cities, especially when we use the house price-to-rent ratio, there is clearly a similar boom-bust pattern throughout the country.

The house price cycle in Lithuania is already showing signs of correction, which could deepen with higher interest rates and lower income growth. The latest data indicates that house price growth in Lithuania already slowed to a year-on-year rate of 0.4 percent in real terms as of September 2022, from an average of 3.6 percent in the previous eight months and 9.3 percent in 2021. Furthermore, there is considerable heterogeneity in housing price growth across cities in Lithuania. While the real house price index continued to increase at an annual rate of 3.1 percent in Vilnius, house prices in the rest of Lithuania have started declining in real terms, with the sharpest fall of 4 percent in Šiauliai. The correction in house prices is even more pronounced and widespread when we focus on the house price-to-rent ratio (Figure 2). In a recent paper, we show that monetary policy shocks and slower income growth could push real housing prices lower in a panel of emerging European markets, including Lithuania. Large house price corrections can in turn have adverse effects on economic performance and financial stability, as experienced during the GFC and other episodes in history.

What can policymakers do at the current juncture? After the GFC, the Bank of Lithuania has adopted macroprudential tools, including borrower-based measures and macroprudential capital requirements. to prevent the occurrence of housing price bubbles and maintain financial stability. The instruments that are currently in place are loan-to-value (LTV) and debt service-to-income (DSTI) ratios, maximum loan maturity, interest rate stress and sensitivity tests, countercyclical capital buffer, (CCyB), other systemically important institutions (O-SII) buffer, and capital

Figure 2. Measures of the Housing Market in Lithuania



Source: Ober-Haus; Statistics Lithuania; authors' calculations.

conservation buffer (CCB). These macroprudential measures should help reduce vulnerability in the banking system, increase resilience of borrowers to asset price or income shocks, and thereby minimize downside risks to financial stability. Before the onset of a housing market correction, the authorities should conduct stress tests for banks and other non-bank financial institutions that have high exposures to real estate, and possibly require higher provisioning for mortgage loans for those that are found to be vulnerable based on the stress tests.

The remainder of this paper is structured as follows. Section II provides an overview of literature. Section III describes the data used in the empirical analysis. Section IV explains the econometric methodology and the main findings. Finally, Section V summarizes and provides concluding remarks.

II. Literature Review

There is a large body of literature on bubbles, but assessing whether housing prices are beyond the equilibrium value remains a contentious issue. The theoretical origins of explosive behavior in asset prices as a deviation from the level consistent with the rational expectations hypothesis can be found in the pioneering papers by Flood and Garber (1980), Tirole (1982), and Blanchard and Watson (1982). Applying cointegration tests, Arshanapalli and Nelson (2008) find that housing prices and fundamental factors in the U.S. share a common stochastic trend and exhibit explosive behavior prior to the GFC. Burnside, Eichenbaum, and Rebelo (2011) show that boom-and-bust cycles are a salient feature of the housing market, driven by economic fundamentals and speculative market expectations. Using a panel of 49 states in the U.S. during the period 1975–2003, Holly, Pesaran, and Yamagata (2010) discover a cointegrating relationship between house prices and real incomes and identify a limited role for real interest rates. While divergences from the equilibrium value appears to be temporary in most states, there is evidence of persistence in deviations in some states Taking advantage of a broader sample of 20 advanced economies, Geng (2018) finds that while macro-financial factors account for a significant share of variation in housing prices, overvaluation in the housing market—a significant deviation from the sustainable level based on macroeconomic factors over the long run—can be persistent across all countries.

With regards to bubble detection, one strand of the literature suggests using time-series estimation techniques to test for the existence of bubbles in the data. Based on the asset pricing theory, it is argued that a bubble can be observed in the dynamics and stochastic properties of asset prices. In other words, if a bubble emerges, asset prices should reflect its explosiveness property, which in turn allows the formulation of statistical tests for detecting bubbles in the time-series data (Gürkaynak, 2008; Homm and Breitung, 2012). In one of the first attempts to test for stock market bubbles, Diba and Grossman (1988) use reduced form stationarity tests and rule out bubbles if stock prices are no more explosive than market fundamentals. Evans (1991), however, questions the validity of such stationarity-based tests in the presence of a periodically collapsing bubble (i.e., when a bubble spontaneously occurs and bursts), which is the case with stock prices. More recently, however, new bubble detection techniques are developed by Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2015), based on recursive and rolling augmented Dickey-Fuller (ADF) unit root tests that detect explosive behavior in the data and date-stamp the occurrence of bubbles. These tests use a right-tail variation of the ADF unit root test in which the null hypothesis is of a unit root and the alternative is of an explosive process. These recursive and rolling tests have a greater power in detecting bubbles, compared to standard tests, as shown in a number of papers focusing on housing markets the U.S. (Phillips and Yu, 2011), Hong Kong (Yiu, Yu, and Jin, 2013), Israel (Caspi, 2015), New Zealand (Greenway-McGrevy and Phillips, 2015), the U.K. (Petris, Dotsis, and Alexakis, 2019), Australia (Esteve and Prats, 2021).

Cross-country studies show strong linkages between macroeconomic and financial factors and the housing market. Over the long run, housing prices are found to be determined by a combination of demand-side factors (such as income and wealth, financial conditions, and demographic developments) and supply-side factors (such as the availability and state of housing units). A wide range of empirical studies has confirmed this relationship across different countries and over time. For example, analyzing housing prices in 6 advanced economies, Sutton (2002) finds that favorable macroeconomic conditions—captured by changes in income, interest rates and stock prices—have a significant effect on the evolution of housing prices, but the magnitude of change in housing prices tends to move beyond what is warranted by the underlying fundamentals. However, the estimated elasticity of house prices with respect to economic, financial and demographic factors show significant variation depending on the sample of countries, the time period, and the empirical methodology used in the analysis (Terones and Otrok; Tsatsaronis and Zhu, 2004; Girouard and others, 2006; Égert and Mihaljek, 2007; Adams and Füss, 2010; Agnello and Schuknecht, 2011; Cerutti, Dagher, and Dell'Ariccia, 2015).

There is also growing evidence from emerging market economies corroborating the impact of economic and financial factors on housing prices. Focusing on countries in Central and Eastern Europe (CEE), Égert and Mihaljek (2007) find that housing prices are determined by income per capita, real interest rates, credit availability, and demographic factors. Furthermore, the paper compares the impact of macro-financial factors on housing prices in the CEE region and advanced economies and obtains significant differences in the magnitude of various factors. Such findings are also highlighted by Ucal and Gökkent (2009) and Jianhua and Huidan (2013), who show that macroeconomic shocks play a large role in determining house prices in Turkey and China, respectively. Similarly, analyzing the boom-bust cycles in the former Soviet Union countries, Stepanyan, Poghosyan, and Bibolov (2010) show that house price developments are shaped by the dynamics of economic fundamentals, such as income growth, remittance flows, and external financing. More recently, Cevik and Naik (2022) implement a panel quantile regression approach to obtain a granular analysis of real estate markets in Europe and find that income growth and interest rates income growth matter more for higher housing prices than those at the lower quantiles of the property market.

III. Data Overview

The empirical analysis is based on a dataset of monthly observations of city-level housing prices in Lithuania during the period 1994–2022. Since identifying bubbles in asset prices require sufficiently long-term data, we use the Ober-Haus apartment price index, which is available for 5 cities (Kaunas, Klaipėda, Panevėžys, Šiauliai and Vilnius) and the national average on a monthly basis from January 1994 to September 2022.[2] We draw the city-specific consumer price index (CPI) and its housing component from Statistics Lithuania to calculate the house price-to-rent ratio at the city level.[3]

Between 1994 and the onset of the GFC in 2008, housing prices in Lithuania increased by 702 percent in nominal terms and 170 percent in real terms adjusted for inflation. There was considerable variation across cities, with real house prices increasing by 177 percent in Vilnius compared to 159 percent in Šiauliai and 147 percent in Kaunas over the same period. The GFC, however, resulted in a significant correction in the real estate market, with housing prices declining by 41 percent in nominal terms and 52 percent in real terms. The downside adjustment also exhibits heterogeneity across cities in Lithuania, but not as pronounced as the upside. Real house prices fell more in smaller cities by an average of 56.5 percent in Klaipėda, Panevėžys, Šiauliai compared to an average of 49.5 percent in Vilnius and Kaunas. We observe a similar pattern with the house price-to-rent ratio, which is commonly used to gauge deviations from the sustainable level. After the GFC, house prices increased by an average of 95 percent in nominal terms and 36 percent in real terms adjusted for inflation, with considerable variation across cities. More recently, during the COVID-19 pandemic, the residential real estate market gained further momentum, despite a sharp contraction in economic activity in the initial phase. Supported by low interest rates and government compensation schemes, house prices in Lithuania increased by 50 percent in nominal terms and 15 percent in real terms adjusted for inflation between the end of 2019 and September 2022.

IV. ECONOMETRIC STRATEGY AND RESULTS

A bubble in the housing market occurs when "home buyers who are willing to pay inflated prices for houses today because they expect unrealistically high housing appreciation in the future" (Himmelberg, Mayer, and Sinai, 2005). In other words, house prices move into the bubble territory when the rate of increase is no longer related to market fundamentals, mainly rental returns and discount rates. This perspective allows us to apply the standard present-value model that links real house prices to cash flow associated with owning a house:

$$P_t = E_t\left[\frac{R_{t+1} + P_{t+1}}{1 + D}\right]$$

where P_t is a measure of house prices in a given city at time *t*; E_t is the mathematical expectation conditional on information at time t; R_t is rent income; and *D* denotes a constant discount rate. The law of iterated expectations yields the following formula:

[2] The Ober-Haus price index is based on statistics collected from public institutions and private entities, covering five large cities in Lithuania. Detailed information on the methodology and the latest data are available at https://www.ober-haus.lt/en/rinkos_apzvalgos/lithuanian-price-index/.

[3] The housing component in the city-level CPI series includes rents and utilities. We also use the national CPI data for the rental index and obtain similar results.

$$P_t = E_t\left[\frac{R_{t+1}}{1+D} + \frac{R_{t+2}}{(1+D)^2} + \cdots + \frac{R_{t+k}}{(1+D)^k} + \frac{P_{t+k}}{(1+D)^k}\right]$$

Imposing the no-bubbles condition yields the level of housing prices that reflects fundamentals:

$$P_t^F = \sum_{j=1}^{\infty} \frac{1}{(1+D)^j} E_t\left[R_{t+j}\right]$$

Following Campbell and Shiller (1987) and Wang (2000), we defined the difference between house prices and cash flows as $S_t \equiv P_t - \frac{1}{D}R_t$. If rental return is $I(1)$ and there is no bubble in housing prices, then P_t is also $I(1)$ (i.e., ΔP_t is stationary) and S_t is stationary, which means that housing prices and rents are cointegrated. In Figure 3, we present the house price-to-rent ratio at the city and national level in Lithuania over the period from January 1994 to September 2022.

Evans (1991) argue that standard right-tailed unit root tests have limited power to detect explosive behavior with periodic collapses, due to the fact that periodically collapsing bubbles behave like an $I(1)$ process or even a stationary linear autoregressive process when the probability of a bubble collapse is not negligible. To overcome this problem, Phillips, Wu, and Yu (2011) and Phillips, Shi, and Yu (2015) propose a recursive unit root test to detect asset price bubbles in real time:

$$P_t = \beta_0 + \beta_1 P_{t-1} + \sum_{j=1}^{K} \lambda_j \Delta y_{t-j} + \varepsilon_t$$

where β_0, β_1, and λ_j are model coefficients , K is the maximum number of lags, and ε_t is the error term. The key parameter of interest is β_1, which is equal to 0 under the null and greater than 0 under alternative. In other words, if we reject the null hypothesis, there is a phase of explosive behavior in the data. The model is estimated by the Ordinary Least Squares (OLS) and the t-statistics associated with the estimated β_1 is referred to as the ADF statistic.

According to Phillips, Wu, and Yu (2011), a sup ADF (SADF) statistic can be used to test for the presence of explosive behavior in asset prices. This approach relies on repeated estimation of the ADF model on a forward expanding sample sequence, and the test is obtained as the sup value of the corresponding ADF statistic sequence. In this case, the window size (fraction) r_w expands from r_0 to 1, where r_0 is the smallest sample window width fraction (which initializes computation of the test statistic) and 1 is the largest window fraction (the total sample size) in the recursion. The starting point r_1 of the sample sequence is fixed at 0, so the endpoint of each sample equals to r_w and changes from r_0 to 1. The ADF statistic for a sample that runs from 0 to, for example, r_2 is denoted by $ADF_0^{r_2}$. The SADF test is then a sup statistic based on the forward recursive regression and is defined as:

$$SADF(r_0) = \sup_{r_2 \epsilon [r_0,1]} ADF_{r_1}^{r_2}$$

Building up on this procedure proposed by Phillips, Wu, and Yu (2011), Phillips, Shi, and Yu (2015) develop a double-recursive algorithm that enable bubble detection and consistent estimation of the origination and termination dates of bubble episodes while allowing for the presence of multipole structural breaks within the sample period. When the sample includes multiple bubble episodes, the Phillips-Wu-Yu (2011) test may fail to show the existence of bubbles, especially in analyzing long time series or rapidly changing data. Therefore, Phillips, Shi, and Yu (2015) propose the backward sup ADF (BSADF) statistic, which is defined as the sup value of the ADF statistics sequence over the interval $[0,\ r_2 - r_0]$. That is,

$$BASDF_{r_2}(r_0) = \sup_{r_1 \epsilon [r_2 - r_0]} ADF_{r_1}^{r_2}$$

in which the endpoint of each subsample is fixed at $T_2 = [r_2 T]$ where $r_2 \epsilon\ [r_0, 1]$, and the start point of each subsample, $T_1 = [r_1 T]$ varies from 1 to $T_2 - T_0 + 1(r_1 \epsilon [0, r_2 - r_0]$. The corresponding ADF statistics sequence is $\{ADF_{r_1}^{r_2}\} r_1 \epsilon [0, r_2 - r_0]$. A generalized version of the SADF test, based on the sup value of the BSADF, is then expressed as the following:

$$GSADF(r_0) = \sup_{r_2 \epsilon [r_0, 1]} BSADF_{r_2}(r_0)$$

which can be used to test the null of a unit root against the alternative recurrent bubbles. It is important to note that the fact that the two sequential versions of the ADF test as the sup values in the sequences of the subsamples implies that all these test are right-tailed, i.e., the rejection is obtained for large positive values.

The starting date $[T\hat{r}_e]$ of an episode of asset price bubble is defined as the first observation with the BSADF statistic excessed the corresponding critical value,

$$\hat{r}_e = \inf_{r_2 \epsilon [r_0, 1]} \{r_2 : BSADF_{r_2}(r_0) < scv_{r_2}^{\alpha_T}\}$$

where $scv_{r_2}^{\alpha_T}$ is the $100(1 - \alpha_T)$ percent critical value of the SADF statistic based on $[Tr_2]$ observations and the significance level of α_T, which may depend on the sample size T. The termination date $[T\hat{r}_f]$ of an episode of asset price bubble is calculated as the first observation after $[T\hat{r}_e] + \delta \log(T)$ with the SADF statistic falls below the corresponding critical value,

$$\hat{r}_f = \inf_{r_2 \epsilon [\hat{r}_e + \delta \log(T), 1]} \{r_2 : BSADF_{r_2}(r_0) < scv_{r_2}^{\alpha_T}\}$$

where $\delta \log(T)$ is the minimal duration of an asset price bubble. To lessen the potential effect of unconditional heterogeneity and to account for the multiplicity issue in recursive testing, we implement the wild bootstrap as proposed by Phillips and Shi (2020).

We use a rich high-frequency dataset of city-level housing prices covering 5 cities and the national average in Lithuania over the period from January 1994 to September 2022. The length of the time dimension with 345 months makes it particularly suitable for the econometric approach adopted in this study to detect house price bubbles. The number of lags in the test regression is determined according to Schwert (1989), which sets $maxlag = int(4(\frac{T}{100})^{0.25})$. The inference of the right-tail ADF, SADF and GSADF statistics requires critical values computed using Monte Carlo simulations.

In Table 1, we present the results of ADF, SADF and GSADF tests on real house prices, evaluating the null hypothesis of a unit root against the alternative recurrent bubbles at the national and city level. Our preferred methodology is the GSADF test, which utilizes a recursive flexible window approach that is more robust in identifying multiple bubbles in time series. The test statistics are significantly greater than the 1 percent critical value. As a result, we reject the null hypothesis of no-bubble and thereby find evidence of explosive behavior in real housing prices across five cities as well as at the national level in Lithuania during the period from January 1994

Table 1. Bubble Detection Test for City-Level Real House Prices

			Confidence Interval		
Region	**Test**	**Test Statistic**	***90***	***95***	***99***
	ADF	-1.44	-0.42	-0.11	0.68
Kaunas	SADF	2.90	1.14	1.41	2.04
	GSADF	3.69	1.92	2.13	2.60
	ADF	-2.32	-0.42	-0.11	0.68
Klaipėda	SADF	3.36	1.14	1.41	2.04
	GSADF	3.67	1.92	2.13	2.60
	ADF	-1.92	-0.42	-0.11	0.68
Panevėžys	SADF	2.62	1.14	1.41	2.04
	GSADF	3.52	1.92	2.13	2.60
	ADF	-1.76	-0.42	-0.11	0.68
Šiauliai	SADF	3.19	1.14	1.41	2.04
	GSADF	3.83	1.92	2.13	2.60
	ADF	-2.04	-0.42	-0.11	0.68
Vilnius	SADF	1.84	1.14	1.41	2.04
	GSADF	3.96	1.92	2.13	2.60
	ADF	-2.00	-0.42	-0.11	0.68
National	SADF	2.36	1.14	1.41	2.04
	GSADF	3.62	1.92	2.13	2.60

Source: Authors' calculations.

to September 2022. As shown in Table 2, we obtain similar results for the house price-to-rent ratio, but this alternative measure of the real estate market shows greater variation in the extent of explosive behavior across cities, partly because of more limited time dimension of the data.

We also plot the chronology of explosive behavior in house prices across five cities and at the national level in Lithuania—in real terms in Figure 3 and for the house price-to-rent ratio in Figure 4. Focusing on real house prices, we can identify two distinct periods of strong exuberance

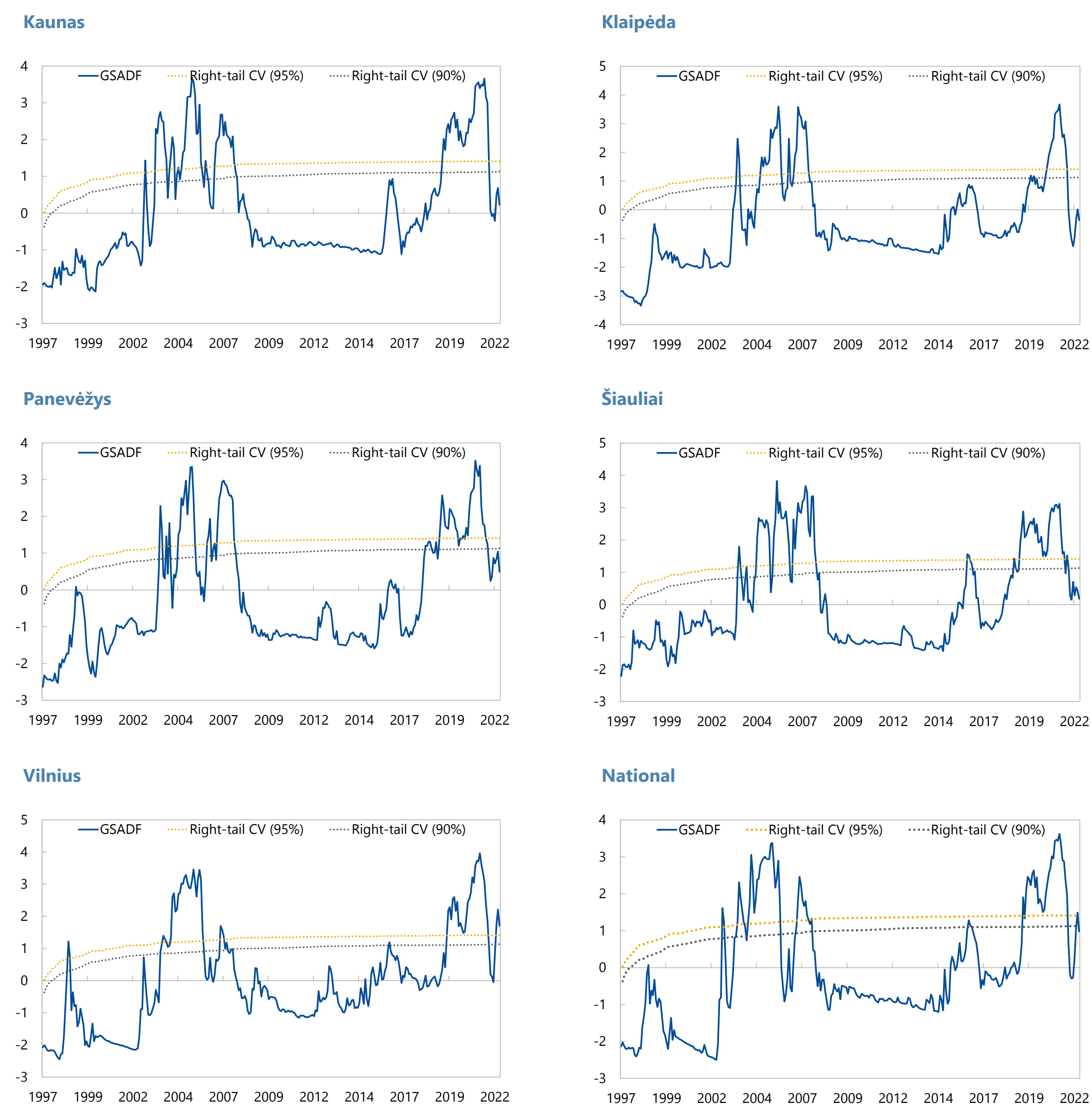
Table 2. Bubble Detection Test for City-Level House Price-to-Rent Ratios

			Confidence Interval		
Region	**Test**	**Test Statistic**	***90***	***95***	***99***
Kaunas	ADF	-1.90	-0.45	-0.14	0.60
	SADF	2.93	1.12	1.40	1.95
	GSADF	2.93	1.88	2.11	2.56
Klaipėda	ADF	-1.73	-0.45	-0.14	0.60
	SADF	2.59	1.12	1.40	1.95
	GSADF	2.59	1.88	2.11	2.56
Panevėžys	ADF	-2.13	-0.45	-0.14	0.60
	SADF	2.76	1.12	1.40	1.95
	GSADF	3.75	1.88	2.11	2.56
Šiauliai	ADF	-2.07	-0.45	-0.14	0.60
	SADF	4.04	1.12	1.40	1.95
	GSADF	4.04	1.88	2.11	2.56
Vilnius	ADF	-2.24	-0.45	-0.14	0.60
	SADF	3.95	1.12	1.40	1.95
	GSADF	3.95	1.88	2.11	2.56
National	ADF	-2.15	-0.45	-0.14	0.60
	SADF	3.36	1.12	1.40	1.95
	GSADF	3.36	1.88	2.11	2.56

Source: Authors' calculations.

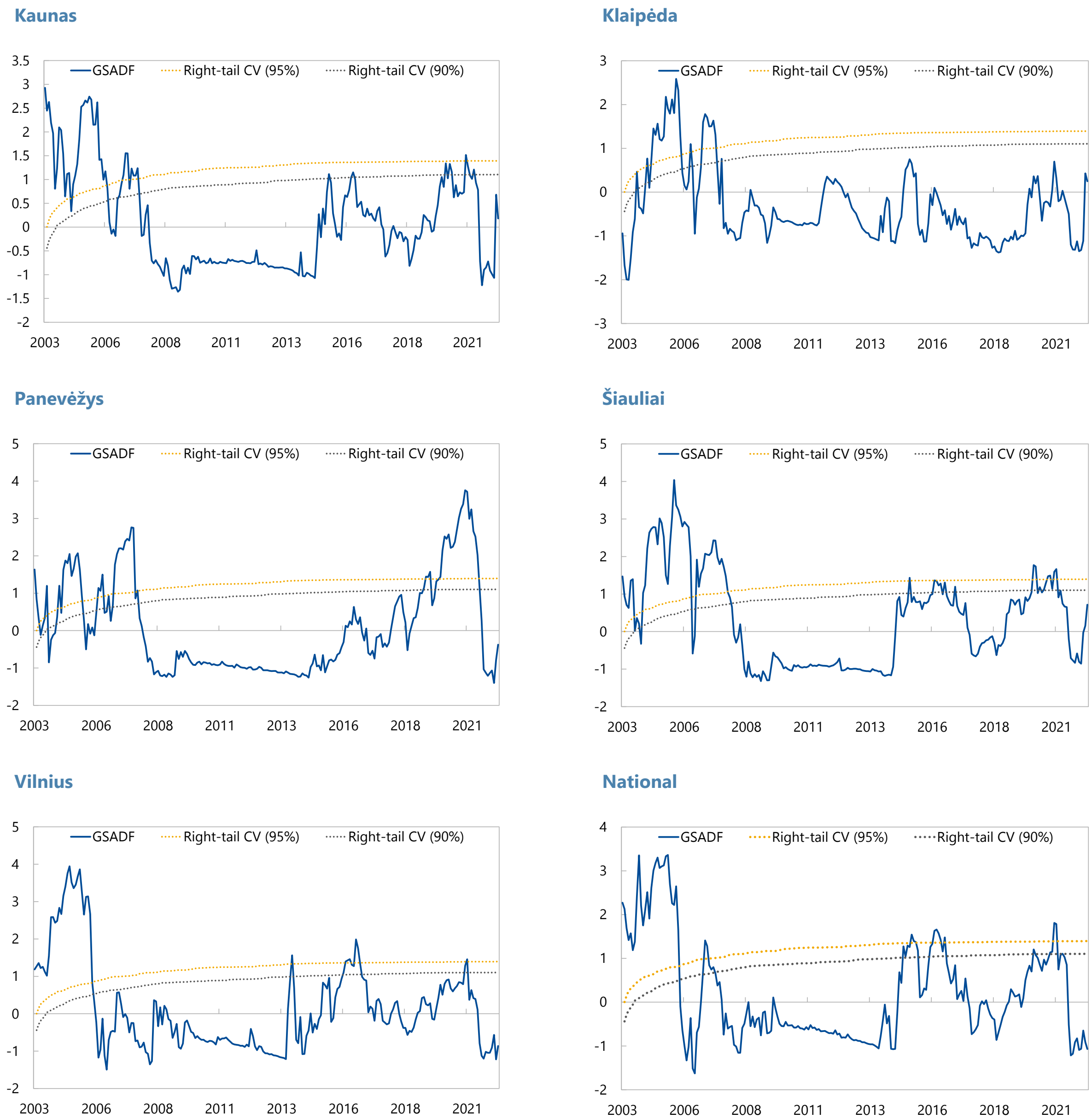
at the city and national level: (1) from 2002 until the GFC; and (2) from 2019 until mid-2022. During these periods, the estimated GSADF statistics exceed the corresponding 95 percent critical values. It is clear that the size of bubbles varies across cities, but there is a similar boom-bust pattern with considerable oscillations even during the periods of explosive behavior in housing prices. This is also the case when we focus on the house price-to-rent ratio. However, the pattern of exuberance is different compared to real house prices partly because data availability constraining the house price-to-rent ratio to the period of 2003-2022. We observe explosive behavior in the house price-to-rent ratio prior to the GFC across Lithuania, but this

Figure 3. Explosive Behavior of Real House Prices: GSADF Test



Source: Authors' calculations.

Figure 4. Explosive Behavior of House Price-to-Rent Ratios: GSADF Test



Source: Authors' calculations.

measure of the real estate market shows no significant bubble in recent years, except in the case of Panevėžys. As presented in Figure 4, while the estimated GSADF statistics exceed the corresponding 95 percent critical values at the national level and in all cities excluding Klaipėda, the extent of explosive behavior gets only close to the pre-GFC level in Panevėžys.

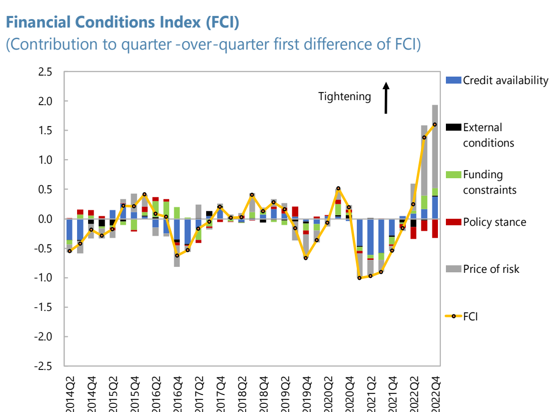
V. Conclusion

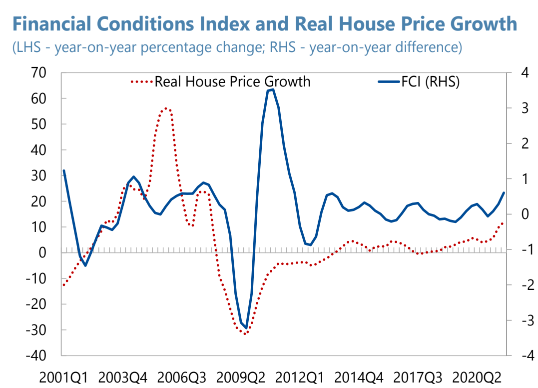
House prices have experienced an uninterrupted boom around the world after the GFC, but the extent of the boom shows significant cross-country variation. In the case of Lithuania, for example, property prices have increased as much as 140 percent since 2010, following a correction of 43 percent during the GFC. With suddenly tightening financial conditions and slower income growth, it is a macro-critical question whether we are now at the precipice of an approaching burst of another housing bubble.

In this paper, we employ multiple time series-based econometric procedures to examine whether real house prices and house price-to-rent ratios at the city and national level in Lithuania exhibit explosive behavior during the period from January 1994 to September 2022. According to these recursive right-tailed test results, we reject the null hypothesis of no-bubble and find evidence for long and multiple periods of explosive behavior in the real estate market in all major cities as well as at the national level. In recent years, however, house price growth accelerated significantly only during the COVID-19 pandemic, after remaining stable for an extended period after the GFC, owing to ultra-low interest rates and double-digit income growth. All in all, while the size of bubbles varies across cities, especially when we use the house price-to-rent ratio, there is clearly a similar boom-bust pattern throughout the country

The house price cycle in Lithuania is already showing signs of correction, with real house price growth slowing to a year-on-year rate of 0.4 percent as of September 2022, from an average of 3.6 percent in the previous eight months and 9.3 percent in 2021. The price adjustment in the real estate market could deepen as a result of lower income growth and higher interest rates. Macro-financial conditions are an important determinants of house price movements, and the continuing recalibration of monetary policy in the eurozone and elsewhere is resulting in a significant tightening of financial conditions in Lithuania. As shown in Figure 5, there is a significant relationship between the financial conditions index (FCI) and real house price growth.

Figure 5. Financial Conditions and Housing Prices in Lithuania





Source: IMF; Ober-Haus; and authors' calculations.

The FCI calculated by Sengaviano and others (*forthcoming*) has been on an upward trajectory since the last quarter of 2020 and gained further momentum in 2022 with repricing of risk and shrinking credit availability.

What can policymakers do at the current juncture? After the GFC, the Bank of Lithuania has appropriately adopted macroprudential tools, including borrower-based measures and macroprudential capital requirements. to prevent the occurrence of housing price bubbles and maintain financial stability. These macroprudential measures should help reduce vulnerability in the banking system, increase resilience of borrowers to asset price or income shocks, and thereby minimize downside risks to financial stability. In this context, before the onset of a housing market correction, the authorities should conduct stress tests for banks and other non-bank financial institutions that have high exposures to real estate, and possibly require higher provisioning for mortgage loans for those that are found to be vulnerable based on the stress tests.

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