ECB policy consistency – loss of independence and the real estate bubble?

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Abstract

During the period 2015-2018 European Central Bank (ECB) has implemented a large-scale asset purchases program in order to revive inflation expectations and achieve sustainable annual HICP dynamics close to 2%. Furthermore, bank communicated that policy should remain accommodative for a long time in the foreseeable future. Based on an extended Taylor rule with Wu-Xia shadow rates and variable Holston-Laubach-Williams natural rates we analyzed discretionary deviation in policy of ECB, US Federal Reserve (Fed) and Bank of England. We identified a widening dovish bias in ECB Governing Council policy during the years 2015-2019. Such policy resulted in increase of real estate prices and the risk of market bubble measured by the UBS index. The likely consequence of this problem is a decrease in public trust in central banks and increase of support for populist movements.

Keywords: forward guidance, large scale asset purchases, quantitative easing, time consistency, real estate bubbles

JEL classification codes: E52, E58

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1. Introduction

The aim of this paper is to measure an adverse impact of European Central Bank (ECB) policies on the real estate market in the major European capitals. We proposed a method of calculating the discretionary bias based on the residuals of modified Taylor rule, developed with Wu-Xia shadow rates and Holston-Laubach-Williams natural rate. We also excluded potential distortions related to unconscious mistakes of monetary authorities e.g. due to errors in inflation forecast and imperfect information about output gap. Therefore, we achieved the series, which reflects conscious discretionary policy stance. The calculations were done for US Federal Reserve, ECB and Bank of England for the period 2004-2019. We found that Governing Council of ECB eased their policy considerably stronger comparing to other central banks after the introduction of public sector purchases program in 2015.

Secondly, we used VAR analysis to measure whether ECB dovish bias inflated real estate bubbles in major European cities. Our analysis was based on indices prepared by UBS investment bank for Frankfurt, Munich, Paris, Milan and Amsterdam in the years 2004-2018. We found that discretionary bias of monetary policy played a major role in increasing imbalances in majority of mentioned cities (expect Milano and Amsterdam).

Finally, we presented conclusions of our research in the context of debate about central bankers' independence. Adverse impact of the ECB policy on housing affordability could lead to deterioration of confidence in the central bank. In case of Europe we see a problem of transparency in the public debate. There was practically no discussion whether strong discretionary bias of the European Central Bank monetary authorities is a sing of going beyond their mandate based on Google Trend web search. In comparison with ECB, the Fed is much more often accused of loss credibility (US bank is criticized due to the Twitter comments of Donald Trump). Highlighted problems are fueling support for populism in Europe.

This paper is structured as follows. Section 2 describes academic literature regarding distributional effects of accommodative monetary policy and adverse impact on the real estate market. Section 3 presents brief revision of ECB unconventional monetary policies. Section 4 introduces measurement of monetary policy discretion, concepts of Wu-Xia shadow rates and natural rates. Section 5 provides information about UBS real estate bubble indices and presents methodology of our research. Section 6 discusses models' output. Finally, section 7 concludes the paper with the discussion about institutional consequences of adverse impact of the LSAP policies.

2. Literature review

Typically, time-inconsistency bias in monetary policy has been described as a temptation of increasing present activity at the cost of future inflation (Surico 2008). However, in the previous years the increase of consumer prices in the developed economies was lower than the central banks' inflation targets, also economic activity remained moderate. The greater attention is dedicated to a problem of secular stagnation (Summers 2014, Baldwin & Teulings 2014) – the idea assumes that hysteresis occurred in the global economy, which lowered natural rate of interest and inflation. In such environment the accommodative policies including large scale asset purchases (LSAP) and negative real rates reinforced by the forward guidance may actually did not generate desired outcome, as inflation is much less responsive comparing to the past. Some authors started to highlight inefficiencies of such policies – asset purchases did not alter long-run inflation expectations (Eusepi et al 2018).

Given the lack of inflationary pressures the adverse effects of monetary policies are likely to be omitted. The new phenomenon highlighted by the authors is a social problem of increasing inequality, due to the change of financial assets valuations and real estate prices. Impact of unconventional LSAP and forward guidance policies is heterogeneous across the households, divided by the income groups. The research on distributional effects of monetary policy does not have single conclusion. Saiki & Frost (2014) analyzed case of Japan and showed that LSAP policies resulted in increase of inequality measured by a simple Gini coefficient. More complex study by Coibion et al. (2017) provided similar conclusion in the US. Authors showed that response of consumption and expenditures by high net-worth households on contractionary monetary shocks is larger than that of low net-worth households in the data.

The contradictory outcomes are visible in case of research from Eurozone area (Selezneva et al 2015, Hohberger et al 2019). Especially DSGE models suggest that wealth increase related to financial assets is mitigated by labor income increase. However, picture is much more complicated. Other authors point out there exist a heterogeneity between the countries of Eurozone block depending on household saving structure and redistributable fiscal policies (Guerello, 2018). The Italian case is described even as reverse Robin Hood policy (Casiraghi et al 2018) – transfers from households being in lowest income quartile to the highest one.

Our analysis is focused on the interconnected problem of housing affordability. There is a relatively strong consensus that low-rates policy of US Federal reserve resulted in the housing market bubble (e.g. Dokko 2011, McDonald & Stokes 2013). The recent situation of Europe is different. While problem of excessive household's leverage seems to be contained e.g. by the macro prudential policies, the new dilemma is related to wealth effects and housing affordability.

In the recent years housing prices in European Capital and other major cities increased excessively comparing to labor incomes and inflation. The possibility of migration is scarcer comparing to e.g. US, given the availability of land in Europe is much lower. Therefore in 2018 we observed civil unrest in France – Yellow Jacket movements protested against the increasing inequality between major cities and other areas. We argue these protests has strong background in the unconventional policies of the European Central Bank. Further expansion of monetary policy should likely intensify riot in the less developed areas.

3. ECB experiences with unconventional monetary policy.

This section briefly summarizes unconventional policy instruments introduced by the ECB after the global financial crisis of 2008-2009. Such activities have twofold character. First of all, central bank introduced new liquidity-providing open market operations – called LTRO or TLTRO. Secondly EBC started conducting large scale asset purchases.

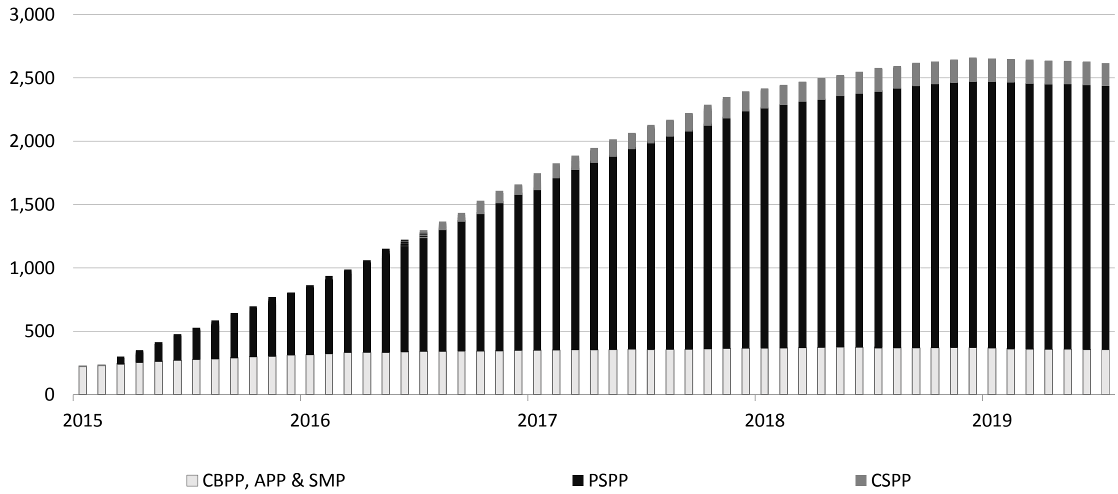
The unconventional refinancing operations started in December of 2011. Firstly, ECB announced refinancing operations with three-year maturity, called LTRO. Later than central bank extended duration of operations up to four years to stimulate credit activity. A first series of extended program, called TLTROs was announced on 5 June 2014. The second series (TLTRO II) started from 10 March 2016. The maturity of operations from the second package and slowdown of European economies, forced ECB to start third package from September 2019.

The history of asset purchases started with three phases of Covered Bond Purchases (CBPP). The first tranche started in 2009, ECB purchased approximately €60bn of assets. Second phase (CBPP2) was conducted in the late 2011 and resulted in increase of central bank's monetary portfolio by additional €16bn. Finally, ECB's Governing Council announced final tranche of purchases in 2014. At the moment of writing ECB maintains €260bn of asset related to CBPP3 program and additional €20bn of asset backed securities.

Probably the most pronounced decision of ECB Governing Board was to introduce sovereign bond purchases in March of 2015. The public sector purchases programme (PSPP) lasted for nearly three years and resulted in acquisition of €2.08try asset. Simultaneously from 18 July

2016, Governing Council has launched new programme of corporate sector purchase (CSPP). In December 2018 Governing Board decided to stop purchases and maintain monetary portfolio at a stable level. Central bank is reinvesting maturing assets. Evolution of monetary portfolio from the EBC is presented at the figure 1.

Figure 1 – Monetary portfolio of the ECB (€bn).



Source: ECB

During the ECB Sintra Conference in 2019 President M.Draghi announced consideration of launching another phase of purchases in second half of the year. Therefore, degree of policy accommodation is likely to increase further in the coming future. Meanwhile European Systemic Risk Board (ESRB 2019) warns that residential prices are likely overvalued or even strongly overvalued in the major Eurozone countries expect Italy (Germany, France, Benelux, Austria, Spain and Portugal). In March 2015, prior introduction of PSPP program, report presented no systemic imbalances.

4. Monetary rule, shadow and natural rates in European Economies

This section explains policy rule, used to determine discretionary bias of monetary authorities. We apply modified Taylor rule with two additional concepts used in the estimation – the Wu & Xia shadow rate (2016) and Holston-Laubach-Williams natural rate (2017, further HLW).

The generalized policy rule proposed by John Taylor (1993) is given by the following formula:

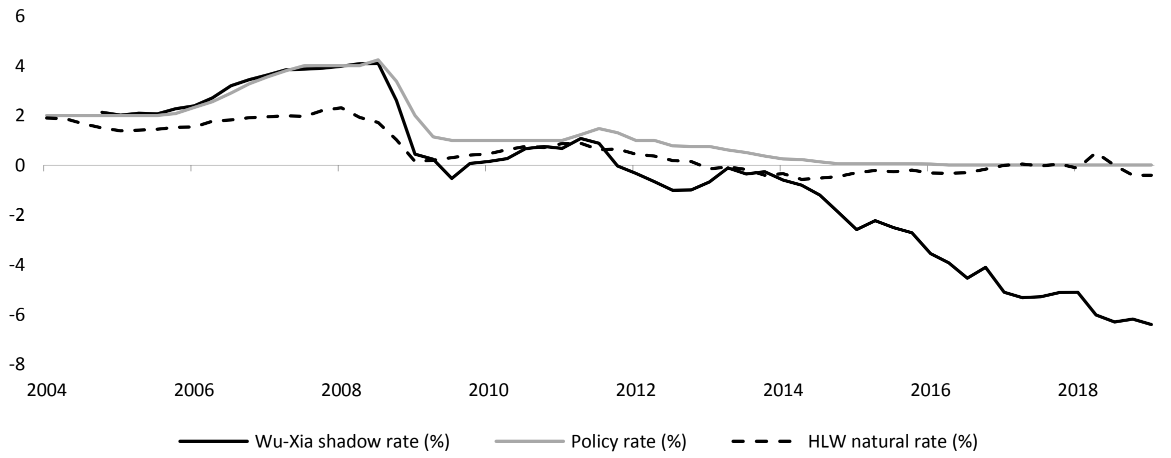
$$i_t = i_t^* + \beta_1 * (\pi_t - \overline{\pi_t}) + \beta_2 * (y_t - \bar{y}_t) + e_t \quad (1)$$

where i_t is the central bank policy rate, i_t^* is the long-run equilibrium natural rate perceived by monetary authorities, $\pi_t - \overline{\pi_t}$ denotes difference between the current inflation annual dynamics and the central bank inflation target, $y_t - \bar{y}_t$ is the difference between the log of the current GDP level and its potential and unobservable level, finally β_1 and β_2 are estimated parameters.

We aim to incorporate the effect of the zero-lower bound in these policy considerations. Therefore, we will use Wu-Xia shadow rate ($WXSR_t$) instead of classical policy rate. Wu & Xia assumes that key central bank short-term interest rate remains at maximum of shadow rate s_t and realized effective lower bound $\underline{r}_t$. The shadow rate s_t is described as an affine function of some state variables X_t following a first order vector autoregressive process. Authors proposed a method of derivation based on Factor augmented vector autoregression with 97 macroeconomic variables in order to compute level of policy accommodation.

The estimates of the shadow rates provided by the authors can be treated as an indication to what level rates will be lowered, if there were no limitations regarding easing. We are using the series provided by Wu & Xia as an explanatory variable of policy rule, without any modifications to the series. The discrepancy between key rate of ECB and Wu-Xia shadow rate for the Eurozone is presented at the figure 2.

Figure 2 – Eurozone policy rate, Wu-Xia shadow rate and HLW natural rate.



Source: ECB, Wu-Xia (2016), Holston et al (2017).

Our policy rule will assume time-varying level of the natural rate i_t^*. The natural rate can be described as a level of interest rate, which allows to maintain inflation at the central bank's target with the zero output gap. According to HLW the natural rate $HLWNR_t^*$ can be described by a following equation:

$$HLWNR_t^* = \frac{1}{\sigma} * g_c + \theta \quad (2a)$$

where σ denotes the intertemporal elasticity of substitution in consumption, g_c is the growth rate of per capita consumption, and θ is the rate of time preference. HLW substituted consumption growth rate with potential output trend growth rate (g_t), also included international shocks (z_t)

$$HLWNR_t^* = g_t + z_t \tag{2b}$$

Again, we are using the data directly provided by the authors without any amendments. By doing that, we assume few simplifications. The unobservable level of rates perceived as natural by monetary authorities may be different due to the discrepancies regarding potential growth rate e.g. difference between the estimates for euro area made by HLW and International Monetary Fund was equal nearly by 0.5pp. To partially mitigate this phenomenon, we decided to add estimated constant to the estimated equations.

The final shape of Taylor-rule formula is given by the equation 3.

$$WXSR_t = HLWNR_t^* + \beta_0 + \beta_1 * (\pi_t - \overline{\pi_t}) + \beta_2 * (y_t - \bar{y}_t) + e_t \tag{3}$$

where $WXSR_t$ stands for Wu-Xia shadow rate, $HLWNR_t^*$ is a natural rate estimated with mentioned model, $(\pi_t - \overline{\pi_t})$ describes deviation from inflation target and $(y_t - \bar{y}_t)$ output gap. β_1 and β_2 are estimated parameters based on ordinary least squares method, e_t is an equation residual. We are using cubic interpolated output gap data from the IMF, as there exists full history of data revisions. This is another small simplification; We do not expect it could derail the research conclusions - the dynamics of change in output gap tends to be similar in both cases with minor discrepancies. Contrary, the greater uncertainty is related to the future re-estimations of the trajectory – revisions can bring strong changes especially in the turning points of the business cycle. The estimation is done using the simple OLS approach with Newey-West correction for the standard errors.

The next step of our analysis is to decompose further residual obtained in equation (3). We attempt to explain it by forecast error of central banks macroeconomic projections regarding GDP growth, inflation and for open economies assumptions about foreign interest rates or exchange rates (if applicable). Secondly, we describe discretionary impact as an unobservable latent variable following a random walk process.

$$\begin{cases} e_t = \alpha_0 + \alpha_1 * Fcast_t + a_2 * disc_t + u_t \\ disc_t = disc_{t-1} + v_t \end{cases} \tag{4}$$

where $Fcast_t$ is a vector of forecast errors from macroeconomic projections, $disc_t$ is a latent variable, α_x are estimated parameters, $u_t$and v_t random disruptions. The estimation is done with a Kalman filter. The smoothed series should provide better indications of discretionary bias, not distorted by a random errors related to e.g. macroeconomic forecast errors.

5. Methodology & UBS real estate bubble index construction.

This chapter presents methodology of our research on real estate market. Our aim is to verify, whether pursuing the LSAP & forward guidance increased bubble risk. We use residuals of Taylor rule described in the previous section, to characterize dynamics of UBS real estate bubble indices.

Mentioned indicators tend to describe relative valuation of residential prices in the major European, American and Asian capitals and major cities. Our analysis is focused on the Amsterdam, Frankfurt, London, Paris and Milan.

The headline index is described as a weighted average of five standardized components. First two: price-to-income and price-to-rent ratios describes housing affordability. Numerators in both cases are derived using transactional prices of 60m2 flat located near the city center. Denominators i.e. values of earnings and rents are survey based. Another two indicators: mortgage-to-GDP ratio and construction-to-GDP ratio measures cyclical shifts in the economics activity related to real estate sector. Finally, the last component compares relative prices in the city to the ones achieved in the countryside. The weighting system is derived based on the factor analysis and differs between the locations.

Index spans over nearly 30 years of activity – from 1990 to 2018. Data is reported quarterly. According to the authors, values below -1.5 denote that real estate markets is depressed, from -1.5 to -0.5 – undervalued. Fair valuation spans over -0.5 to 0.5 range. Finally, values ranging from 0.5 to 1.5 suggest overvaluation. Higher level of index denotes bubble risk.

We propose following VARX equation:

$$\begin{bmatrix} \Delta disc_t \\ \Delta bbl_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} \\ \alpha_{2,1} & \alpha_{2,2} \end{bmatrix} * \begin{bmatrix} \Delta disc_{t-1} \\ \Delta bbl_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{1,3} \\ \alpha_{2,3} \end{bmatrix} * (y_{t+h} - \bar{y}_{t+h}) + \begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix} \qquad (5)$$

Where Δbbl_t denotes change of lagged UBS index value, $\Delta disc_t$ change of discretionary bias and $(y_{t+h} - \bar{y}_{t+h})$ output gap. $\begin{bmatrix} c_1 \\ c_2 \end{bmatrix}$, $\begin{bmatrix} \alpha_{1,1} & \alpha_{1,2} \\ \alpha_{2,1} & \alpha_{2,2} \end{bmatrix}$ and $\begin{bmatrix} \alpha_{1,3} \\ \alpha_{2,3} \end{bmatrix}$ are estimated parameters, $\begin{bmatrix} e_{1,t} \\ e_{2,t} \end{bmatrix}$

equations' residuals. The model will be expanded with additional autoregressive components if needed.

We expect to observe a negative relationship between discretionary bias in monetary policy and the bubble risk measured by UBS index.

6. Estimation Results

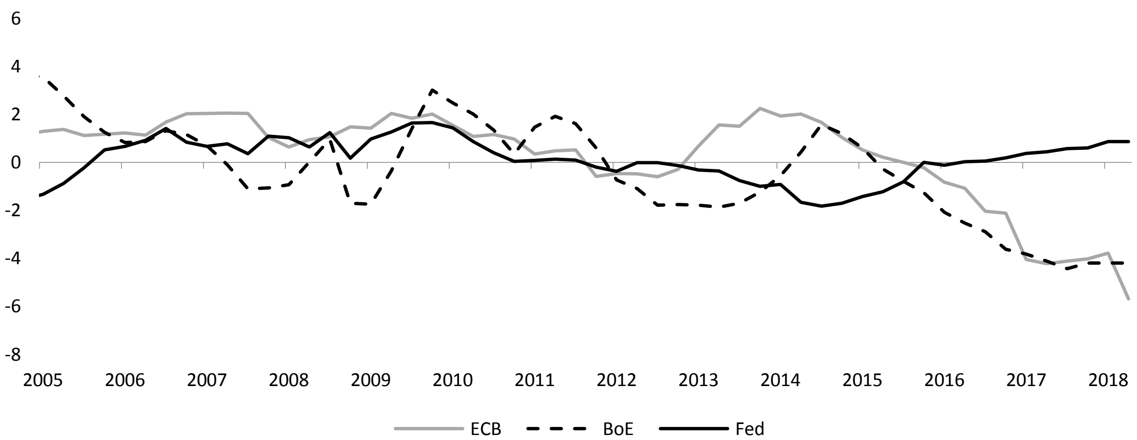
The first step of our analysis is to compute the Taylor rule parameters in line with the methodology presented in the section 4. The estimates are presented in the Table 1.

The estimation suggest that both the ECB and the Fed believes that natural rate is close to the HLW model level. There is a stronger discrepancy in case of the bank of England. The evidence is consistent with the market long-term inflation expectations. 5Y5Y swap measuring CPI is persistently hovering around 3% (the upper bound of the inflation target).

Amongst the 3 central banks ECB tends to be strongest focused on the inflation, while Bank of England reacts strongly on changes in the output gap. Our Taylor rule confirms the Fed is pursuing a dual mandate. Mentioned policy rule has the weakest explanatory power in case of the ECB – equation explains only 48% of variance. The statistically higher residuals tend to occur after introduction of the LSAP program in 2015.

Our analysis suggested that more accommodative policy of ECB was intentional. The Kalman filter estimations showed that forecast errors or output gap revisions did not have systematic impact on the monetary authorities' behavior. All parameters turned out to be statistically insignificant. Therefore, the procedures concluded with simple trend smoothing. The estimated series are presented in the figure 3.

Figure 3 – Conscious discretionary bias derived for the Taylor rule residuals



Source: Authors estimation.

There is a clear downward trend in the ECB and BoE data from March 201, when ECB governing board inaugurated public sector purchase program. Since then values of both series became lower by respectively 600bp and 400bp.

We imputed the estimated series in the VARX models. The analysis of impact of more accommodative approach in monetary policy on real estate bubble risk shows heterogeneous response. There was a visible coincidence in case of Frankfurt and Munich. Some negative but more benign tendencies have been also seen in case of Paris and neutral in Milan – but parameters describing impact of change in ECB turned out statistically insignificant at the significance level (e.g. 5%). On the other hand, the response from and Amsterdam were positive – the research literature explains it is single country amongst selected where lowest 20% benefit the most from residential prices increase and its distribution differs significantly from other peers (Adam & Tzamourani 2016).

The detailed parameters of estimated models are presented in the table 3. The charts with cumulative impulse response functions of selected models are presented in the table 4. According to the models 100bp permanent decrease of ECB bias results in 7pp increase of UBS index for Frankfurt, 9pp for Munich and 6pp for Paris. The reaction for Milan is equal to 0.

The monetary policy contributed to the increasing risk for a real estate market, but has not played a decisive role. The variance decomposition shows only 15% of forecast errors could be explained by a monetary policy shock in Munich, 10% in Frankfurt, 5% in Paris. There was no evidence on impact in Italy.

An imperfection of two models (for Frankfurt and Munich) are low test statistics related to autocorrelation of residuals. Detailed test statistics are presented in the tables 4 and 5. On the other hand selected model presented most desirable levels of information criterion. There were also no significant changes in the impulse response in case of adding another lags.

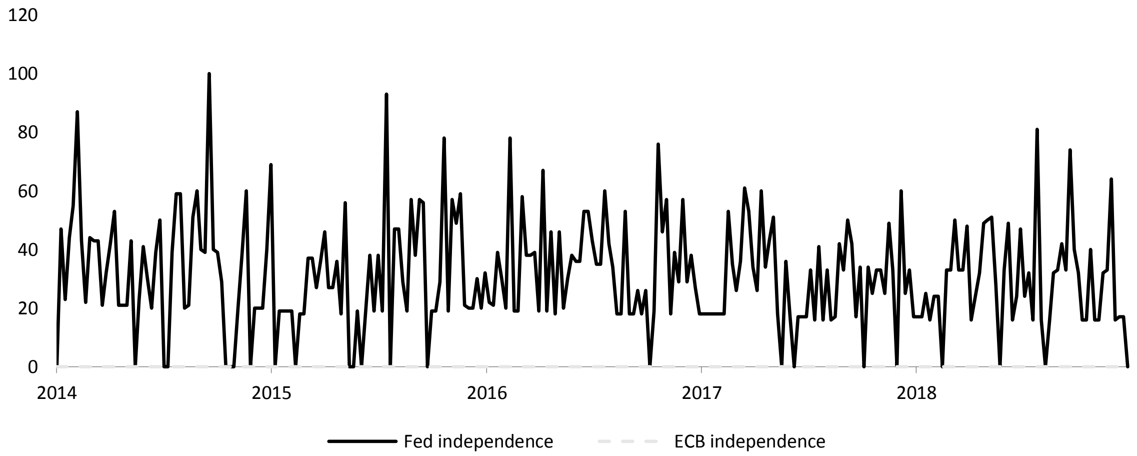
7. Policy conclusions

Our research confirmed that monetary policy contributed to the problem of increased real estate bubble risk / lower housing affordability. However European central bankers played only a supplementary role - it not true they were a major culprit.

The adverse social effects of accommodative polices has institutional implications. Former governor of Royal Bank of India Raghmuran G. Rajan (Rajan 2019) highlights the risk of loss of central banks' independence, when their policies will be perceived as supporting country elites only. In such case politicians will find it easier to pursue excessive accommodative policies. Governor Rajan recommends greater transparency and clarification of the central bank goals.

As our research showed negative symptoms, damaging credibility are visible in the European Union i.e. Governing Council presently maintains excessively accommodative policies, the deterioration of housing affordability could be perceived as policy which supports elites against average household. Unfortunately, the Rajan's recommendations are not followed - there is no transparency in the decisions-making mechanism e.g. similar macroeconomic forecast were used to introduce and taper PSPP program, ECB president communicated propensity to ease policy just two weeks after introduction of forward guidance stating there will be no change to interest rates. There is practically no discussion whether strong discretionary bias of the European Central Bank monetary authorities is a sign of going beyond their mandate or silent breaching independence of central bank. The number of Google searches asking about ECB independence is far lower comparing to the Fed, despite the former is maintaining discretionary dovish bias, the latter hawkish (Figure 4). Furthermore, the comments of dovish candidates, suggesting a case for greater stimulus for the economy, are passively or even positively welcomed in the major media outlets (e.g. Politico 2019).

Figure 4 – Web search for central bank independence



Source: Google Trend.

This study does not answer the question what are the reasons of such preferences – we are rather focused on consequences of its maintenance. Continuation of asset purchases program in the current form is likely to further stimulate growth of asset prices either on real estate, equity or sovereign & corporate bond markets. Elevated social & economic anxiety builds up social support for revolutionary parties (Inglehart & Norris 2016). Therefore, the further continuation of accommodation may result in greater risk of extreme events, i.e. Brexit, non or weakly tractable by standard econometric models.

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Table 1: Modified Taylor rule parameters

	ECB	Fed	BoE
Constant – deviation of natural rate from HLW	-0.65 (0.58)	-0.04 (0.26)	-2.69 (0.51)***
Deviation from inflation target	0.72 (0.34) **	0.39 (0.19)**	0.49 (0.25)*
Output Gap	0.22 (0.29)	0.60 (0.12)***	1.62 (0.18)***
R^2	0.48	0.83	0.75

Source: Authors estimation.

Table 2: VAR estimation – impact of discretionary bias on real estate markets.

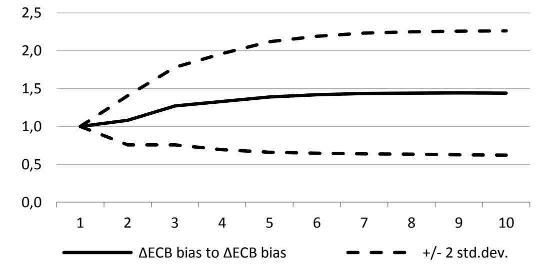
City:	Frankfurt		Munich		Amsterdam	
	ΔBbl Ind.	ΔECB bias	ΔBbl Ind.	ΔECB bias	ΔBbl Ind.	ΔECB bias
ΔBubble Ind. (-1)	1.16 (0.14,8.07)	-1.48 (2.61,-0.57)	0.89 (0.09, 9.81)	-0.89 (1.68, -0.53)	0.57 (0.14, 4)	-2.18 (2.13, -1.02)
ΔBubble Ind. (-2)	-0.46 (0.14, -3.21)	1.01 (2.59, 0.39)			0.46 (0.15, 3.12)	-1.16 (2.22, -0.52)
ΔBubble Ind. (-3)					-0.27 (0.14, -1.96)	1.89 (2.11,0.9)
ΔBubble Ind. (-4)			-0.15 (0.07, -2.12)	-0.03 (1.31, -0.02)		
ΔECB bias (-1)	0.01 (0.01, 1.43)	0.08 (0.16, 0.49)	0.00 (0.01, 0.29)	0.14 (0.15, 0.95)	0.00 (0.01, 0.17)	0.03 (0.17, 0.2)
ΔECB bias (-2)	-0.03 (0.01, -2.98)	0.2 (0.16, 1.24)			0.02 (0.01, 1.55)	0.16 (0.16, 0.97)
ΔECB bias (-3)					0.01 (0.01, 0.72)	0.07 (0.17, 0.43)
ΔECB bias (-4)			-0.02 (0.01, -2.23)	0.01 (0.17,-0.05)		
ΔOuput gap	-0.01 (0.01, -0.75)	-0.15 (0.16, -0.93)	0.00 (0.01, -0.17)	-0.2 (0.15, -1.32)	0.02 (0.01, 1.16)	-0.18 (0.2, -0.86)
Constant	0.01 (0, 1.98)	-0.04 (0.08, -0.54)	0.01 (0.01, 1.88)	-0.03 (0.11, -0.3)	0.01 (0.01, 1.8)	-0.06 (0.08, -0.7)
R-squared	0.77	0.11	0.77	0.07	0.66	0.13
Adj. R-squared	0.75	0.01	0.75	-0.03	0.60	0.00

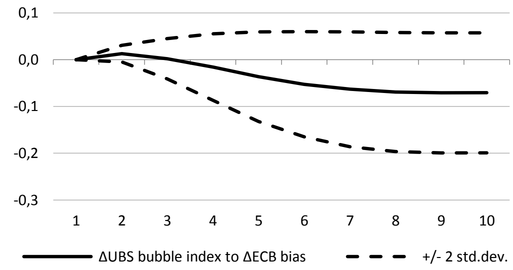
City:	Milan		Paris	
	ΔBbl Ind.	ΔECB bias	ΔBbl Ind.	ΔECB bias
ΔBubble Ind. (-1)	0.68 (0.11, 6.45)	-0.14 (2.06,-0.07)	0.34 (0.15, 2.18)	0.41 (1.1, 0.38)
ΔBubble Ind. (-2)			0.08 (0.16, 0.52)	-0.07 (1.13, -0.06)
ΔBubble Ind. (-3)			-0.31 (0.14, -2.21)	0.47 (1, 0.46)
ΔBubble Ind. (-4)				
ΔECB bias (-1)	0.00 (0.01, 0.28)	0.06 (0.16,0.39)	-0.02 (0.02, -0.74)	0.11 (0.15, 0.74)
ΔECB bias (-2)			-0.02 (0.02, -0.96)	0.19 (0.15, 1.32)
ΔECB bias (-3)			0.00 (0.02, 0.08)	0.07 (0.15, 0.48)
ΔECB bias (-4)				
ΔOuput gap	-0.01 (0.01, -0.65)	-0.32 (0.17, -1.9)	0.07 (0.04, 1.66)	-0.34 (0.29, -1.15)
Constant	0.00 (0, -1.12)	-0.13 (0.08, -1.6)	0.01 (0.01, 1.22)	-0.07 (0.08, -0.95)
R-squared	0.47	0.09	0.34	0.12
Adj. R-squared	0.44	0.03	0.24	-0.01

Source: Authors estimation.

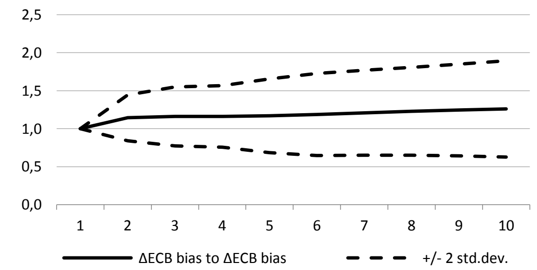
Table 3 – Accumulated impulse response functions – selected models.

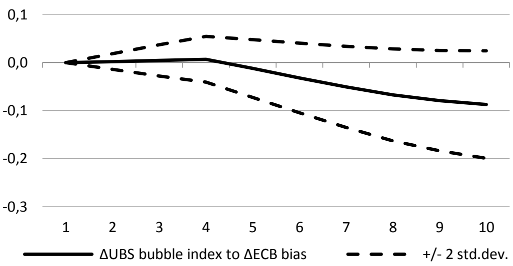
Model 1: Accumulated Response to Nonfactorized One Unit Innovations for Frankfurt



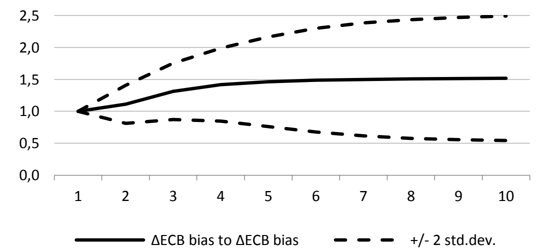


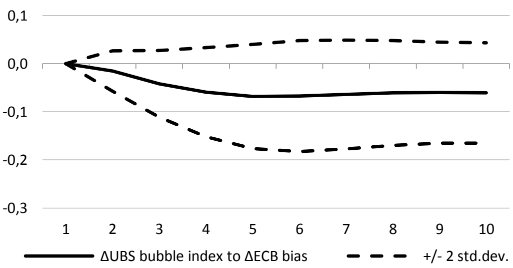
Model 2 Accumulated Response to Nonfactorized One Unit Innovations for Munich





Model 5: Accumulated Response to Nonfactorized One Unit Innovations for Paris





Source: Authors estimation.

Table 4: Portmanteau test for VAR autocorrelation.

	Lag (h)	Q-Stat	Prob.	Adj Q-Stat	Prob.	Df
Amsterdam	4	5.58	0.23	5.92	0.20	4
Frankfurt	3	7.59	0.11	7.89	0.10	4
Milan	2	3.39	0.50	3.51	0.48	4
Munich	5	24.07	0.02	25.71	0.01	12
Paris	4	2.12	0.71	2.26	0.69	4

Source: Author's calculation.
Null Hypothesis of the test assumes no residual autocorrelations up to lag h.

Table 5: LM autocorrelation tests.

Lag (h):	Amsterdam	Frankfurt	Milan	Munich	Paris
1	4.72 (0.32)	9.18 (0.06)*	2.1 (0.72)	3.25 (0.52)	1.53 (0.82)
2	2.42 (0.66)	15.33 (0.01)***	3.01 (0.56)	12.23 (0.02)**	3.13 (0.54)
3	8.66 (0.07)*	2.36 (0.67)		5.63 (0.23)	4.97 (0.29)
4	1.53 (0.82)				1.33 (0.86)

Source: Author's calculation.
Null Hypothesis of the test assumes no residual autocorrelations up to lag h.