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Analysing bank real estate portfolio management by using impulse response function, Mahalanobis distance and financial turbulence

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Abstract

During the financial crisis that had its peak a few years ago, one of the interesting questions was raised. Does there exist a possibility that the aforementioned crisis will repeat. As real estate management took one of the key roles in the post-crisis period, it was expected that the lessons that crisis brought with itself, were learnt. Despite lagging effect that the aforementioned turbulence had on Western Europe, real estate prices kept rising and exhibited accelerating growth, although some of the countries didn't react to the stock price movement and real estate growth. This paper will try to address the aforementioned problem by analysing real estate portfolio management by using impulse response function. Afterwards, it will try to implement results obtained from Impulse response function and financial turbulence, by calculating possible correlations between stock prices for EURO area and real estate prices in Germany, Switzerland and Austria. Data was taken from St.Louis FED database. In order to analyse banking portfolio management, it was assumed that state of the art methods are used. Portfolio management is modelled by using Mahalanobis distance and financial turbulence index was analysed. As financial turbulence index was calculated for the total real estate share prices by taking the data from St. Louis FED database, interesting results were obtained. It was proved that real estate prices kept rising in Germany and Switzerland despite the warning foreshadowed by the financial crisis, however Austria real estate prices remained stable. However growth in real estate prices in Switzerland was not caused by financial crisis because the growth is constant and doesn't have any drops.Financial turbulence analysis pointed out that the volatility of real estate prices in the aforementioned countries was highest in the mid-2011 and it still has a high value. This indicates that real estate price bubble is a real threat to the whole financial system of Western Europe, especially Germany as the leading economy.

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1. Introduction

Financial bubbles are a real threat to the system. The arousal of financial bubbles must be closely monitored as there is a possibility to cause havoc in financial systems. In order to analyse the financial bubbles, nonlinearities and illogical movement of correlated time series must be observed. One of the newly introduced tools in the aforementioned time series analysis are impulse response functions.

Impulse response function demonstrate how the endogenous variables react to shock through tume. Although impulse response functions are related to SVAR and VAR models (Pfaff et al.), their observation independently can be very useful as they serve as a perfect tool to observe illogical movement between time series. By observing impulse response functions, it could come to a conclusion that illogical movement could act as a predictor of real estate bubbles, If the link between real estate movement and other macroeconomic variables is broken, it could be said that variables start to follow random walk which is characteristic in the financial theory. At the same time, if variables are correlated in the way that economic and financial theory cannot explain, then the threat of the financial contagion and financial crisis is high. In order to analyse the portfolio management, Mahalanobis distance(Hanke et al. 2013) was introduced. Mahalanobis distance is a well-known tool in mathematical statistics and it is widely used in detection of outliers. At the same time, it is used in calculation of financial turbulence index which demonstrates period of high volatility which could foreshadow possible economic and financial problems.This combination of tools could prove innovative in risk management modelling (Ricardo Rebonato et al. 2010). In the next part of the paper, theory behind the analysis will be introduced.

2. Background and theory

Impulse response functions are part of the VAR and SVAR models (Pfaff et al.). The aforementioned models will be briefly introduced.
VAR model is used to detect interdependencies in the linear interdependent model. It has the following formation(Hamilton James et al. 1994):

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + e_t \quad (1)$$

where the l-periods back observation y_{t-1} is called the l-th lag of y, c is a $k \times 1$ vector of constants (intercepts), A_i is a time-invariant $k \times k$ matrix and e_t is a $k \times 1$ vector of error terms. The thing that must be noted is that all variables must be of the same order of integration. For our analysis, the time series that we observe are Markovian time series and martingale processes that follow Brownian motion(Hacker, R. S. et al . 2008) One of the theorems will be used. The theorem states that:

T.1. One of the continuous martingale process with stationary increments is Brownian motion (Dung N.T et al, 2010).

At the same time there exist other martingale processes but it is assumed that those processes are not observed. In this way, VAR model functions really well and impulse response function can be observed.
Now the SVAR models will be introduced. Structural VAR model is defined with the following equation (Hamilton James et al. 1994):

$$B_0 y_t = c_0 + B_1 y_{t-1} + B_2 y_{t-2} + \cdots + B_p y_{t-p} + \check{\eta}_t \quad (2)$$

Because of the parameter identification problems, SVAR models cannot be estimated by using ordinary least squares method, but they can be solved by using reduced VAR models. Choleski decomposition takes one of the leading factors in reducing VAR models using lower- or upper- triangular matrix(Priestley M.B et al. 1991)

Impulse response functions is widely used in signal processing (Priestley M.B et al. 1988). It demonstrates the response of the dynamical function to the external signal. In economics impulse response function are used in order to analyse how the function reacts to exogenous shocks. In this paper, all variables are observed as exogenous and their mutual interaction is observed. Although the approach is not innovative, it captures well the movement of real estate in correlation to the other variables.

Mahalanobis distance and financial turbulence

After having introduced the external aspect of the analysis, the Mahalanobis distance will be analysed and its relation to financial turbulence.

Mahalanobis distance is introduced as

$$D_M(x) = \sqrt{(x-\mu)^T S^{-1}(x-\mu)} \qquad (3)$$

The Mahalanobis distance of an observation $x = (x_1, x_2, x_3, \ldots, x_N)^T$ from a group of observations with mean $\mu = (\mu_1, \mu_2, \mu_3, \ldots, \mu_N)^T$ and covariance matrix S. Mahalanobis distance is ideal for the portfolio management as it is multivariate, unitless and scale-invariant and it takes into consideration the correlations between the variables. The aforementioned distance will be used in analysis of the financial turbulence index.

Financial turbulence describes the volatility of the model as well as its complexity(Gonçalves, C.P et al . 2012). It will be graphically presented and analysed. The analysis is conducted in the R environment by using ROC curves and Mahalanobis distance. The next part will present the results of the research.

3. Methodology and modelling

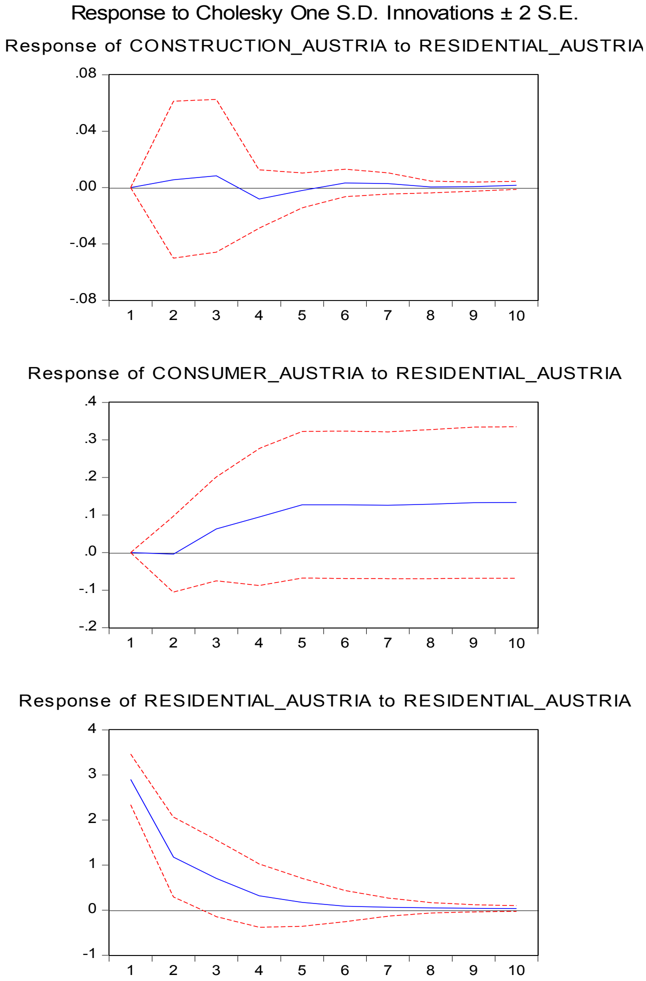
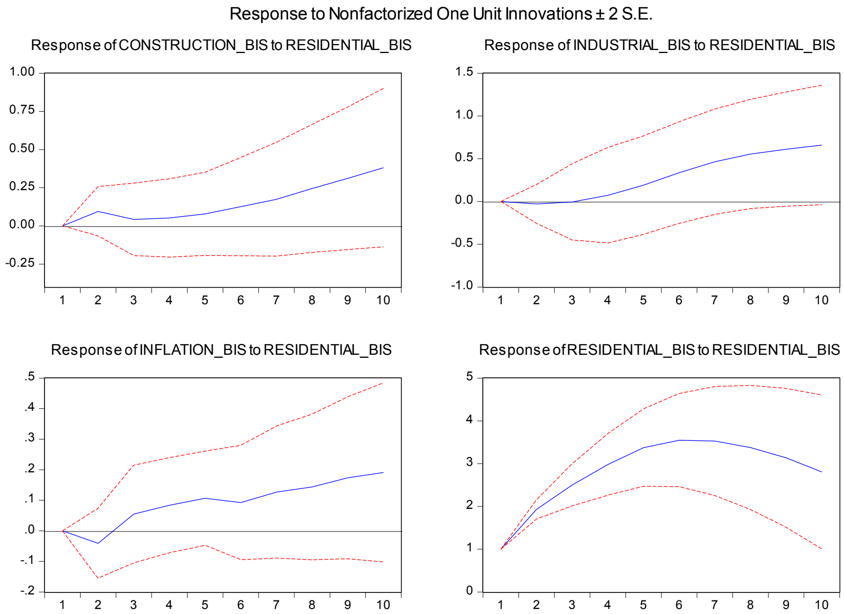


Fig. 1. Impulse response function for Austria
Own calculation

The impulse response function for Austria pertaining in that sense to residential estate price which was taken from St.Louis FED database demonstrates the possible cooling on the increment in residential estate prices. At the same time inflation and construction indices are following the aforementioned trend. Next country that will be considered is Germany.



(1)

Fig 2. Impulse response function for Germany residential, Own calculation

Impulse response functions when analysed in the case of Germany exhibit unpredictable behavior. Although residential increment is falling down, the other three variables exhibit constant growth. It means that the link between residential and other variables is broken and it could be a sign of a possible bubble. In order to analyse the further movement of the time series, author suggests that Hurst exponent is calculated as this provides further research in the aforementioned direction. Now the Switzerland will be analysed.

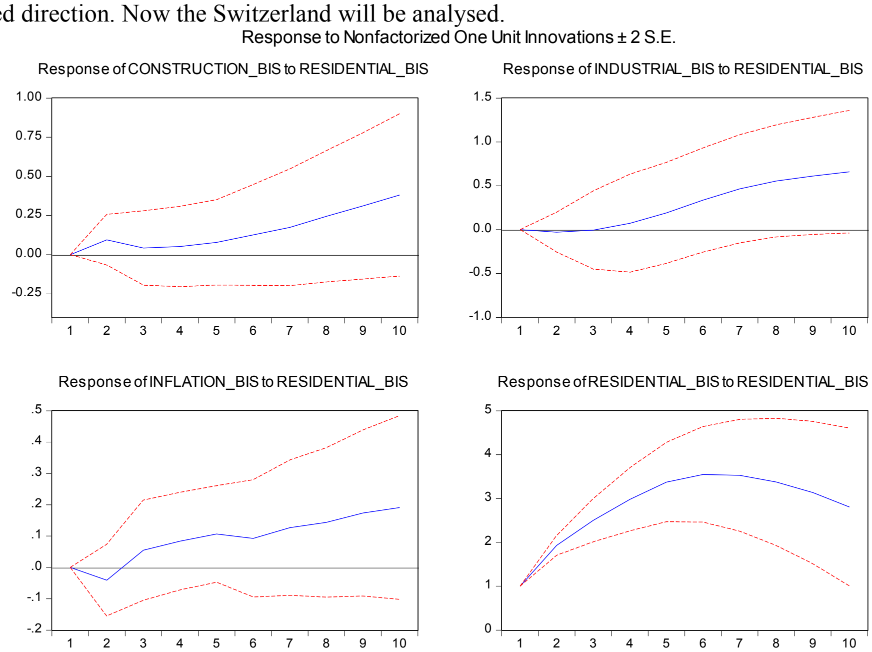


Fig. 3. Impulse response function for Switzerland, Own calculation

The Switzerland exhibits increasing real estate prices. At the same time, other variables are constant therefore there is no danger of possible bubble. It is proved that correlation between variables is random

3.1. Financial turbulence

After having analysed one aspect of real estate, next analysis will follow financial turbulence. By using Mahalanobis distance and ROC curve, financial turbulence is calculated. It is presented in the graphs below.

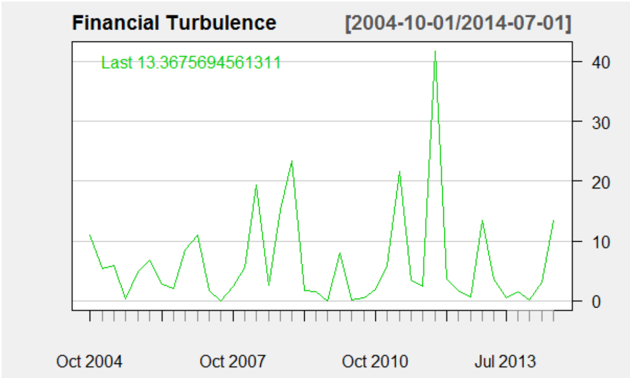


Fig. 4. Financial turbulence (volatility and percentage change) of portfolio of real estate prices of Germany, Austria and Switzerland (Own calculation)

Financial turbulence demonstrates that the biggest shock of the crisis was felt in 2011 for the aforementioned countries. It means that the crisis is lagging in the aforementioned countries and it is still present because the financial turbulence index has a value of 13,367 that is still high. In the next graph autocorrelation of financial turbulence will be given.

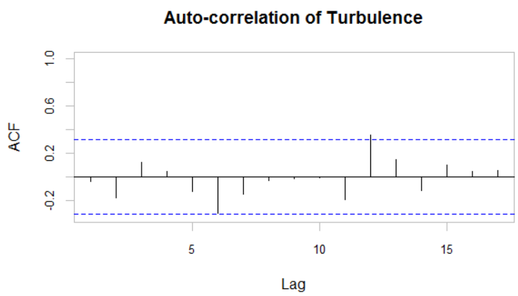


Fig. 5. Autocorrelation of turbulence, Own calculation

Autocorrelation exhibits non importance of lags therefore it confirms that the aforementioned series follows random walk and stationarity of series is confirmed.

4. Conclusion

After having introduced the impulse response function and Mahalanobis distance, it was proved that the next financial crisis is close to happening. Germany as the leading EURO country exhibits illogical behavior according to its macroeconomic variables. As Germany is one of the leading EURO countries, possible financial bubble would cause its demise, therefore it is important that its state is closely monitored. High financial turbulence in 2011 for the aforementioned countries indicates that the financial crisis is lagging and that it could cause problems if the crisis occurs in USA or some of the other countries. Austria and Switzerland seem safe, however portfolio management of banks is of great importance. Mahalanobis distance in that case plays a key role as it can detect possible financial turbulence and it should be implemented in every risk software.

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