Time value of the money and contagions on the bond markets[1]

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Abstract
The yield curve should reflect the time value of the money to maintain the maturity transformation of the banking system. A tightened gap between the 3 month and 10 year yields on the bond market indicates liquidity shortage. This paper analyzes such liquidity shortages at the Euro area as well as at the US bond markets with their impact on the common movements of their Czech, Hungarian and Polish counterparts. Contagion is defined as a significant difference in the correlations under special or normal circumstances; therefore this paper applied GARCH-based dynamic conditional correlation on the daily closing data.

Keywords: contagion, yield curve, monetary policy, DCC APARCH
JEL codes: G15, G01, C32, E44, E58

1. Introduction

Nowadays the bond markets has crucial role in the stability of the banking sector due to their increasing importance in the maturity transformation (Ondo-Ndong 2010). These markets became more highlighted by the current Euro-area crisis, while the level of market convergence as well as occurrence of cross-market contagions increased in the last decades (Chen-Zhang 1997, Goezman et al. 2005, Bonano et al. 2001, Campbell et al. 2002, Van Royen 2002, Stavárek 2009). Therefore it is hard to talk about a monetary autonomy in the case of CEE countries, if their yield curve is affected by external factors as international liquidity flows.

Contagions could be broadly defined as the cross-country transmission of shocks or the general cross-country spillover effects, which does not need to be related to crises. This paper uses the World Bank's very restrictive definition[2] on the contagions, as a cross-country correlations increase during "crisis times" relative to correlations during "tranquil times". We can talk about interdependence, when the difference between correlations under extreme and normal conditions is insignificant.

Definition 1: Contagion occurs between $m_k m_j$ markets, when the $\rho^{m_k m_j}$ cross-market correlation became significantly higher due to a shock derived from one market ($r_{n/x}^{m}$) to others or other external factors (Forbes-Rigobon 2002, Campbell et al. 2002, Bekaert et al. 2005):

$$r_{n/x}^{m_i}\begin{cases} r_n^{m_i}, \rho_n^{m_i m_1} \dots \rho_n^{m_k m_j} \\ r_x^{m_i}, \rho_x^{m_i m_1} \dots \rho_x^{m_k m_j} \end{cases}, \rho_n < \rho_x.$$

Definition 2: Interdependence occurs between $m_k m_j$ markets, when the $\rho^{m_k m_j}$ cross-market correlation not became significantly different, but the level of correlation is constantly high (Forbes-Rigobon 2002):

$$r_{n/x}^{m_i}\begin{cases} r_n^{m_i} \\ r_x^{m_i} \end{cases}, \rho^{m_i m_1} \dots \rho^{m_k m_j}, \rho_n < \rho_x .$$

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[2] see: http://go.worldbank.org/JIBDRK3YC0, cited also by Forbes, Rigobon (2002) and Kaminsky et al. (2003)

Definition 3: Divergence occurs between $m_k m_j$ markets, when the $\rho^{m_k m_j}$ cross-market correlation became significantly lower due to a shock derived from one market ($r_{n/x}^{m}$) to others or other external factors (Forbes-Rigobon 2002, Campbell et al. 2002, Bekaert et al. 2005):

$$r_{n/x}^{m_i}\begin{cases} r_n^{m_i}, \rho_n^{m_i m_1} \dots \rho_n^{m_k m_j} \\ r_x^{m_i}, \rho_x^{m_i m_1} \dots \rho_x^{m_k m_j} \end{cases}, \rho_n > \rho_x.$$

Central East European countries have an own model for capitalism as Farkas (2011) summarizes her results. This paper analyzes the contagious relations between the US, the Euro-zone, the Hungarian, the Czech and the Polish bond markets – focusing only on the daily closing value of the 3 month and the 10 year maturities under the January 1 2002 and August 31 2011 period – and has two main research questions:

- (1) Are contagions able to occur between the bond markets of the sample countries?
- (2) Is the strength of cross-market correlations situation dependent on the sample?

After a short summary about the yield curve theories, the scale of market efficiency and two applied ways to detect contagions will be described in the methodology chapter. The different characteristics of the 3M and 10Y markets will be visible in the results chapter, than the concluding remarks take place.

2. Theoretical background of yield curves

To understand the motivation behind financial market actors' reaction is a key element to explain financial dependence between markets. Many notions are behind the scene with their interactions as input in a function. To get a clear view about the happenings it is crucial to identify rules governing market players' action.

The basis of banks and financial companies' activity is **maturity transformation** which implies a positively sloping yield curve. This means that assets with longer maturities generally have higher yields than assets with shorter maturities. In academic literature the spread between the interests rates on the ten-year Treasury note and the three-month Treasury bill used as the yield curve. Maturity transformation makes possible to non-financial sectors to hold short term assets (deposit account) and long-term liabilities (mortgage).

From the profitability point of view of the financial industry the positively sloping yield curve is fundamental. But yield curve inverted several times during the past that is short term yields grew above that of long term yields. Therefore to understand the possible explanations behind the phenomenon of negative spread is crucial.

Cwik in his dissertation (Cwik, 2004) gives a nice summery about the empirical and theoretical research about the **yield curve**. The three empirical facts of the yield curve are:

(1) a persistent positive slope,

(2) the tendency for long-term and short-term rates to move together,

(3) long rates tend to remain stable relative to short rates.

The main question the yield curve literature facing is, "*In a world with well functioning arbitrage markets, why does the yield curve tend to have a positive slope?*" Four theories emerged that attempt to respond this question, they are the following: the Expectations Hypothesis, the Liquidity Preference Hypothesis, the Segmented Markets Theory, and the Preferred-Habitat Theory.

The assumption of the **Expectations Theory** is that all financial instruments along the yield curve are perfectly substitutable. Present short interest rates and expected future short rates shape the yield curve. But this theory cannot give explanation why the long and short rates have tendency to move in lockstep. Long rates are derived from the expected rates of future inflation, but it does not explain the origin of the short rate.

The father of the **Liquidity Preference Hypothesis** (LPH) is Keynes and Hicks. Money, the most liquid asset, has no interest rate and less liquid instruments yield interest rates. The core of the theory is based on interest rate risk. The rise of interest rates inflicts on investors capital losses, and when interest rates fall, investors are subject to lower reinvestment rates. To hold cash is less risky than to hold a bond. To assuage the aversion toward bonds, a liquidity premium is attached to the financial instrument. This premium diminishes as the maturities increase, i.e., its first derivative is positive, while its second is negative. The hypothesis explains the general tendency of the yield curve to be positively sloped, and why the long and short rates tend to move together. However, it cannot shed light on why the long rate is relatively more stable than the short rate.

The **Segmented Markets Theory** attributed to Culbertson (1957). The starting point of this theory is that investors are risk adverse and financial instruments are not substitutable. Different market participants act in specific segments of the yield curve in accordance with their investment horizon. For example, pension funds and life insurance companies have long outlooks on the financial market and they have a preference to invest at the long-term end of the yield curve. Matching maturities of assets and futures expected liabilities creates a natural hedge of the investment position. The roll-over strategy would expose the investor to a reinvestment risk from period to period. Mutual money funds and commercial banks, faced with short notice liquidity requirements, require short term investment opportunities. Thus, the yield curve can be segmented according to the participants' investment horizon.

The **Preferred-Habitat Theory** (also called the institutional demand theory) by Modigliani and Sutch (1966) attempts to combine the three different theories. Despite it success to answer the three empirical facts of the yield curve has its shortcomings. The theory assumes an underlying interest rate and fails to explain the origin of this initial rate.

Financial instruments in this theory are assumed partially substitutable, investors are assumed to prefer short-term securities relative to long-term securities, and the investors do not view the financial instruments as perfect substitutes and will not buy instruments outside of their preferred habitat without an inducement. In addition, the arbitrage process is also hampered by transaction costs. Therefore, a term premium is added to compensate investors for having to invest in a less preferred maturity.

The **modified Preferred-Habitat Theory** by Cwik (2004), building on the Böhm-Bawerk's time-preference theory, gives answers to the questions left behind by the former ones. Simply put, time-preference is the preference of having a good sooner rather than later can be defined as the opportunity cost of waiting. It states that the time-preference alone is a necessary and sufficient condition for the formation of an interest rate.

To explain the recession forecasting ability of the yield curve is Cwik's another important contribution to the yield curve theory. The root cause of the inversion of the yield curve is the malinvestments caused by monetary injections.[3]

Nowadays **market-based institutions** overtook the dominant role in the supply of credit from **commercial banks**. Market-based institutions (Investment banks, hedge funds, broker dealers used in the literature) and shadow banks' aggregated balance sheet toped in the second quarter of 2007 at 16 trillion dollar compared to commercial banks' and saving institutions' 13 trillion. These market participants throughout in their operation use mark-to-market accounting rules, VaR risk management, repurchase agreements. The use of these tools deeply influences not only the market agents but the whole market as well. As risk management practices, accounting rules and portfolio choices are similar among investment companies their reaction functions becomes alike.

In compliance with the **mark-to-market accountings rule** the value of market traded assets or liabilities (which are not classified as held-to-maturity securities) are accounted for by the current market price. This effect is fortified by mark-to-market accounting rule which entails that balance sheets across companies are tied together.

Equity appears to be the forcing variable driving financial companies' action. Leverage and balance sheet size grow hand-in-hand with each other. Forming investment and leverage decisions banks and other leveraged financial institutions follow **Value-at-Risk** (VaR) as a guide. VaR is defined as the upper limit, or threshold value, that the marked-to-market loss on the portfolio over the given time horizon may exceed with no trading in the portfolio. Information about risk policy and VaR easily available only for US investment banks as stock exchange listed companies are obliged to disclose their estimates in their regulatory filings with the US Securities and Exchange Commission in

[3]The effect of additional liquidity is sometimes called the Wicksell effect, the Fisher effect is the change in interest rates caused by changes in the expectations of future inflation. The Wicksell effect and the Fisher effect are opposing forces. The Wicksell effect tends to lower interest rates while the Fisher effect tends to raise them.

their 10-K and 10-Q forms. The relationship between balance sheets and measured risk is negative, meaning that when measured risk is low balance sheets are large (Adrian – Shin, 2008).
Correlations in returns can materialize even when underlying fundamental shocks are independent. When risk-neutral traders operate within the limits of Value-at-Risk, market conditions display signs of variable risk appetite and intensification of shocks through feedback effects. The recent financial crisis has exposed clearly the weakness of VaR in stressful financial environment. As Acerbi and Finger (2010) points out, in a certain sense the failure of classical VaR to address liquidity stems from its reliance on mark-to-market accounting rule for valuation. To address this issue the concept of mark-to-liquidity has introduced using statistical tools from VaR to the portfolio's mark-to-liquidity value.

To make the model clear, financial companies use **liquidity policy** (LP) which sets constraints that the portfolio manager must always be ready to comply with. LP can formulate like be prepared to raise 10M, or 10% of the portfolio in cash. The mark-to-liquidity value is calculated by finding the optimal way to satisfy the constraints lied down in the LP. Selling part of the portfolio creates liquidity impact meaning that the mark-to-market accounting gives an overly optimistic view about the valuation. This liquidity impact is the difference between the mark-to-market and mark-to-liquidity value. To raise cash by selling from the portfolio the optimal way is to use the most liquid stocks and markets with lower volatility. The cash can be generated at a relatively little cost, but the structure of the portfolio has been completely transformed in the process. Instead of having a diverse set of holdings the cash rising produce a concentrated set of positions in less liquid and more volatile assets. As a consequence the risk of the remaining portfolio measured by Value-at-Risk of the increases markedly. This outlined process means that the portfolio requires ongoing management to keep the investment profile (Acerbi - Finger, 2010).

Liquidity defines **funding liquidity risk** as the possibility that over a specific horizon the bank or financial company will become unable to settle obligations with immediacy (Drehmann – Nikolaou). Commercial banks are more resilient to liquidity shocks due to diverse source of funding possibilities like deposit. But investment banks or broker-dealers4 primarily use repurchase agreements (repo) to finance their investment operations.5 while commercial banks' short term funding is through money (i.e. checking and savings deposits). Investment banks pass on part of the repo funding to other leveraged institutions such as hedge funds in the form of reverse repos and one part is invested in longer term, less liquid securities (Adrian – Shin, 2008). In 2008 roughly half of investment bank assets were funded using repo markets, with additional exposure due to off-balance sheet financing of their customers, like hedge funds. To protect the creditor against changing market prices so called "haircut" applied in a repo transaction. Haircut is the difference between the current market price and the price at which the security is sold and are of paramount importance to leveraged institution as they determine the degree of funding available to investment banks. For example, a 2% haircut means that for 100 dollars worth of securities pledged the borrower can get 98 dollars. In this case the equity is only 2 dollars and the maximum permissible leverage is 50 (Adrian – Shin, 2008).

Endogenous responses from market participants give momentum to **crisis episodes**. In parallel with worsening financial conditions, market participants' risk taking capacity evaporates. Unwinding exposures creates negative spillovers on other market participants and other markets. As a result prices fall, measured risks (volatility) rise and previous correlations break down. The recent 2007−8 global financial crisis served gave opportunity to gain plentiful experience observing similar episodes (Danielsson - Shin – Zigrand, 2009).

An **exogenous shock** reaching the financial system creates uncertainty and can have multiple effects. Uncertainty is the common influencing factor determining VaR and haircuts which by their own part directly determine market participants' risk taking ability and have effect on market conditions. Doubts generating market volatility give rise to growing VaR and haircuts. This phenomenon results in a vicious circle in which investors react by further cutting exposures.

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[4] Do not confuse with shadow banks which were funded in the commercial paper market and held assets like asset- (ABS) and mortgage backed securities (MBS).
[5] In a repo transaction, the borrower sells a security at day "t" at a price below the market price on the understanding that it will buy it back in the future at a pre-agreed price.

Yield curve inversion wreaks havoc to financial institutions' maturity transformation ability. The simple flattening of the yield curve means impetuous for financial companies to hunt yields abroad, made possible by globalised financial world. Globalisation gives rise to the nascent of a global-wide maturity transformation, and investment strategy: borrow home, invest abroad. This is a carry trade strategy to exploit the difference between homeland and foreign yields. As far as foreign exchange risk, sovereign risk, liquidity related market risk is compensated by foreign yields the domestic investor goes abroad.

One way to guard against market liquidity risk is use bigger, more liquid markets. From the American funds' point of view every market is relatively small let alone the Eastern European ones. It can make sense to instead of considering single national markets to look at them as a group. This group of countries share similar economical and political traits but every one with its own stock and bond markets. In the investment strategy certain share is dedicated to a group of countries from the whole fund. To further allocate this fund between the member countries each one's market size, market liquidity, economical prosperity and other factors can be considered. The keep the investment profile unchanged transaction decisions have to happen at the same time in the group member countries.

Times of turbulence gives opportunity to discover different type of investors' preferred market segments. In accordance with the Segmented Markets Theory pension funds and life insurance companies prefer to invest at the long-term end of the yield curve as they keep assets till maturity and are not exposed to changing market values. In case of positively sloped yield curve short term investors may prefer to invest at the short end of the yield curve chasing a simple carry trade strategy as short term assets are more liquid. This can be the case especially in Eastern European markets where market sizes are much smaller than that of the Americans. To invest in short term treasuries were further motivated in Hungary where the yield curve was inverted for an extended period. If this is the case, in stressful times short term yields produce more hectic variance than longer term yields as speculators with a short term focus build down positions.

This way contagion between countries does not necessitate economical relationship. Contagion happens only because investors look to a number of countries as a group of markets with similar characteristics. The goal of the empirical research of this paper is to confirm or to refuse this hypothesis. Additional result is contribution to the contagion crisis literature.

2. Methodology

To prove the existence of contagions it is necessary at first to weaken the efficiency of the selected markets. To meet the efficiency requirements, markets have to look like as the random walk and Wiener-process describes them – the distribution of returns should be normal, without autocorrelation, heteroscedasticity and unit root. The rejection of market efficiency allows us to estimate contagions trough GARCH-based method as dynamic conditional correlation.

According to the very restrictive definition of contagion, significant increase in the correlation has to detect between some kind of "ordinary" and "extreme" intervals. There is no general rule to define the turning point between extreme and ordinary, so this study applies two methods: the first selection based on the fat tailness of the distribution, while the second selection compares different time windows of the ECB's monetary policy.

2.1 Tools of market efficiency evaluation

To prove the existence of contagions it is necessary at first to weaken the efficiency of the selected markets. To meet the efficiency requirements, markets have to look like as a random walk process (1) describes it:

$$r_t=\omega+r_{t-1}+\varepsilon_t, \qquad (1)$$

where r_t is the current change of the market value, ω is a constant term, r_{t-1} denotes the previous change of the market value, while ε_t symbolize a normal distributed white noise.

The **normal distribution** of the logarithmic returns (2) is the precondition of efficient market hypothesis – the exponential shape means fast falloff of the returns and the central tendencies are close together (Jentsch et al. 2006). Therefore extreme amplitudes are very improbable (Kóbor 2003).

$$f(r) = \frac{1}{\sigma\sqrt{2\pi}}^{[-\frac{1}{2}\frac{(r-\mu)^2}{\sigma^2}]} \quad (2)$$

This study applies Jarque-Berra test according Wong-Li (2010), where P<5% value means the rejection of normality.
The null hypothesis of ADF(q) test is non-stationary against the alternative that is stationary (3).

$$H_0: R_t \sim I(1) \text{ vs. } H_1: R_t \sim I(0) \quad (3)$$

This test based on an autoregressive process (AR(1)), with the assumption that $\rho_1=1+\beta$ (4).

$$r_t=\alpha+\rho_1 r_{t-1}+ \rho_2 r_{t-2}+\ldots +\rho_v r_{t-v}+\varepsilon_t) \quad (4)$$

There is a unit root, if $\beta=0$ and ρ_1 is not inside the unit circle. We include as many (q) dependent variables as necessary to remove any autocorrelation in the residuals (5).

$$\Delta r_t=\alpha+\beta r_{t-1}+\gamma_2\Delta r_{t-1}+\ldots+ \gamma_q\Delta r_{t-q}+\varepsilon_t) \quad (5)$$

Thus if the value of test statistic is higher than the prescribed critical region at 1%, 5% and 10% confidence levels, we cannot reject the null hypothesis, so our time series is non-stationary.

A *k*th level of **autocorrelation** (6) occurs, if we find correlation between series on *k* distance from each other:

$$\rho_k = \frac{c(Y_t, Y_{t+k})}{\sigma_{Y_t}\sigma_{Y_{t+k}}}, \quad (6)$$

where $c(Y_t,Y_{t+k})$ is the covariance of Y_t and Y_{t+k} variables on (t=1,2,…,n-k), as well as σ_{Y_t} and $\sigma_{Y_{t+k}}$ are their variances. Current study applies Ljung-Box test as Tsay (2005) and Kuper-Lestano (2007) suggest proving autocorrelations in the residuals. The null hypothesis of the test is there is no autocorrelation.

ARCH LM tests for ARCH effects with the null hypothesis of no conditional **heteroscedasticity** in the residuals. The rejection of both H_0 supports the idea of volatility clustering, which bias could be ruled out by GARCH models (Lütkepohl 2004).

2.2 Tools of market contagion detection

Under the assumption of weak market efficiency time series are mostly biased by autocorrelation and heteroscedasticity due to the fat tails of the return distributions and volatility clustering. The different versions of Bollerslev's (1986) **Generalized Autoregression and Heteroscedasticity (GARCH)** models are widely used methods to provide homoscedastic standardized residuals, which is necessary to estimate Engle's (2002) Dynamic Conditional Correlation (DCC).

The Asymmetric Power GARCH (APARCH)[6] model (7) by Ding, Granger and Engle (1993) is maybe the most powerful tool to handle the bias of heteroscedasticity due to the asymmetric, fat-tailed assumptions of the distribution:

$$\sigma_t^\delta = \omega + \sum_{i=1}^{p} \alpha_i(|\varepsilon_{t-i}| - \gamma_i\varepsilon_{t-i})^\delta + \sum_{j=1}^{q} \beta_j\sigma_{t-j}^\delta , \quad (7)$$

where ω is the constant term, α denotes the impact of news, $-1<\gamma_i<1$ is responsible for the asymmetry function and β is the level of volatility persistence as well as δ>0 provides nonlinearity. There parameters of APARCH have to be defined, "p" and "q" determines the lag number of residuals and volatility, while "o" is a non-negative scalar integer representing the number of asymmetric innovations. Further advantage of the APARCH model is the flexibility – it is easy to convert both on GJR GARCH and TARCH as well as the basic GARCH form too. The lag length was optimized on a 1-to-4 scale and selected according to the estimation's Akaike Information Criteria (AIC).

Ordinary cross-correlation is not the suitable tool to specify the common movement of markets due to the heteroscedasticity as Forbes and Rigobon (2002) suggest. Cointegration is ruled out too, because it is better to analyze long-term processes, so BEKK-GARCH or DCC-GARCH could be an adequate solution after the APARCH step.

This study applies **DCC-GARCH**[7] following Kuper-Lestano (2007) and Wong-Li (2010), to analyze the daily common movements of the selected markets. The DCC model assumes that the

[6]The estimation based on the UCSD toolbox, developed by Kevin Sheppard: http://www.kevinsheppard.com/wiki/UCSD_GARCH

returns from k assets, r_t, are conditionally multivariate normally distributed with zero expected value (8) and covariance matrix H_t (9).

$$r_t \parallel \Phi_{t-1} \sim N(0, H_t), \quad (8)$$

$$H_t \equiv D_t R_t D_t, \quad (9)$$

where r_t is a $k \times 1$ vector, H_t the positive definite conditional covariance matrix, R_t the $k \times k$ time-varying correlation matrix, and all available information up to $t-1$ is contained in Φ_{t-1}. These returns can be residuals from filtered time series. D_t is the $k \times k$ diagonal matrix of time-varying standard deviations from univariate GARCH models with $\sqrt{h_{it}}$ as the ith element of a diagonal. D_t is obtained from the following univariate GARCH specification (10):

$$h_{it} = \omega_i + \sum_{p=1}^{P_i} \alpha_{ip} r_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq} h_{it-q}^2. \quad (10)$$

Dividing each return by its conditional standard deviation $\sqrt{h_{it}}$, one obtains the vector of standardized returns, $\varepsilon_t = D_t^{-1} r_t$ where $\varepsilon_t \sim N(0, R_t)$. This vector may be used to write Engle's (2002) specification of a dynamic correlation structure for set of returns (11, 12):

$$Q_t = (1 - \sum_{m=1}^{M} \alpha_m - \sum_{n=1}^{N} \beta_n)\bar{Q} + \sum_{m=1}^{M} \alpha_m (\varepsilon_{t-m} \varepsilon'_{t-m}) + \sum_{n=1}^{N} \beta_n Q_{t-n}, \quad (11)$$

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1}, \quad (12)$$

where $\bar{Q}$ is the unconditional covariance of the standardized residuals resulting from the first stage estimation and Q_t^* a diagonal matrix composed of the square root of the diagonal elements of Q_t. The elements of R_t will be of the form $\rho_{ijt} = q_{ijt} / \sqrt{q_{iit} q_{jjt}}$, where q_{ijt}, q_{iit} and q_{jjt} are the elements of Q_t corresponding to indices. For R_t to be positive definite the only condition that needs to be satisfied is that Q_t is a positive definite.

Cross market correlation is compared with Ansari-Bradley test, because this variance test is not based on the assumption of normal distribution – as happens in the case of the widely used t-tests. The Ansari-Bradley test of the hypothesis that two independent samples, in the vectors x and y, come from the same distribution, against the alternative that they come from distributions that have the same median and shape but different variances. The result is h = 0 if the null hypothesis of identical distributions cannot be rejected at the 5% significance level, or h = 1 if the null hypothesis can be rejected at the 5% level.

Before the Ansari-Bradley test of significant variance difference of the ordinary and extreme correlation intervals, it is necessary to run a Fischer-transformation (13) on the computed correlations for later two sided t-tests as Lukács (1999) suggests:

$$z_i = 0{,}5 * \ln \frac{1 + rho_i}{1 - rho_i}, \quad (13)$$

After the identification of market common movements, it is necessary to separate them on the ground of the hub return's extremity or normality.

2.2.1 Selection by fat tails

How can we separate the "extreme" and "ordinary"? Jentsch et al. (2006) defined extreme events by their impact and probability – so we have to find a suitable threshold or milestone to form both groups. There are multiple solutions, see Campbell et al. (2002), but this study focus on the fatness of tails, therefore it is obvious to cut the empirical distribution with a fitted theoretical normal distribution on it.

This process was done in Matlab on the base logic of a QQ plot. QQ plots are common tools of visualizing the normal distribution of the time series with a straight line which represents the normal distribution and dots of the empirical distribution. Normal distribution of the empirical data is observable, if dots are fitting on the line, but most financial data has an "S" shape on the QQ plot – suggesting a power-law distribution and fat-tails (Clauset el al. 2007). Therefore it is reasonable to define the tails trough QQ plot, where the **turning point of extremity** is defined as the first empirical data in the lower quartile right from the normality line on the positive side and left from the normality line on the negative side.

This solution uses the markets as their developments would be the source of the shock or contagion. Therefore a rank of contagiousness could be defined between three CEE the US and Euro-

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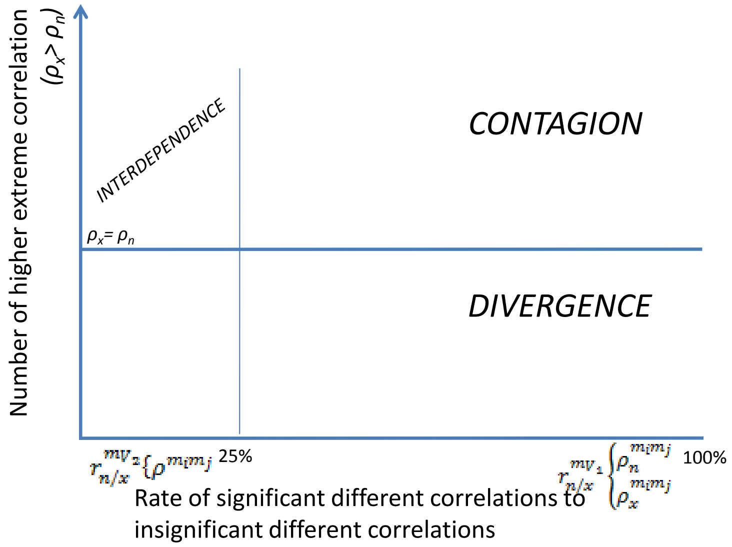
[7]The estimation based on the Oxford MFE toolbox, developed by Kevin Sheppard: http://www.kevinsheppard.com/wiki/MFE_Toolbox

zone markets were they could be scored according to the number of correlations divided into significantly different parts, as well as the extreme correlation should be higher. The results can be easily visualized on the following way: on the "x" axis lays the rate of significantly different and non different correlations, while on the "y" axis the number of correlations are observable, which extreme value is higher than the normal.

Figure 1: Mapping the difference between contagion and interdependence



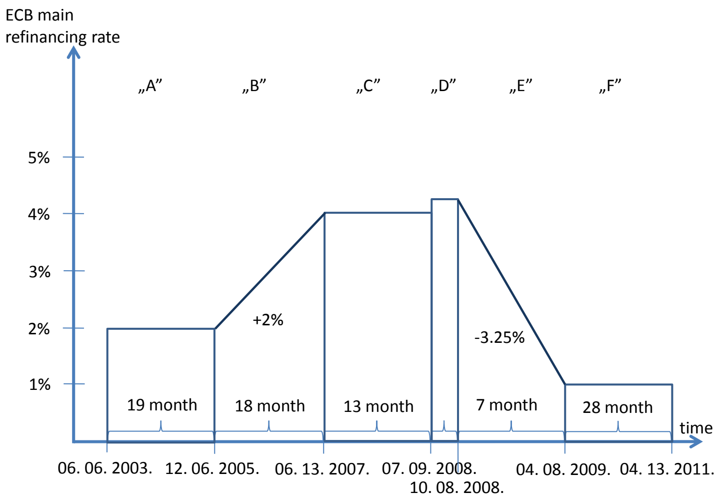
Source: own construction

2.2.2 Selection by the ECB monetary policy

The previous selection was used to detect the general existence of contagions on the 3M and 10Y markets, but handles the entire timeline homogenously, where extreme events are suddenly occur and form clusters – without any assumptions about the current monetary policy.

This alternative solution aims to analyze the cross market correlations under the frames of the European Central Bank's **monetary policy** to show 3M and 10Y market behavior under near zero, increasing, high and decreasing main refinancing rates. Contagion could be defined as the time variance of the cross market correlations under these terms. According to the changes in the main refinancing interest rates of the ECB, six intervals could be defined with different market conditions as figure 2. suggest.

Figure 2: Changes of the ECB main refinancing rate



Source: European Central Bank

Period “A” denotes the reconstruction phase after the dot-com crisis of the millennia with constantly low interest rates for 19 months. Period “B” reflects on the increasing economic activity in the middle of the decade with increasing raw material prices for 18 months. Period “C” was the top of housing boom both in the US and in the EU, with increasing spreads and liquidity shortage. Period “D” denotes the curious 3 months with bankruptcy of the Lehman Brothers, which was followed by an activist monetary policy in the period “E”. Period “F” was characterized by nearly zero interest rates for 28 months with a poor reconstruction phase before the Euro-crisis.

3. Results

It is necessary to study the slope of the yield curves at first (see table 1) – the relation of 3M and 10Y yields were rational, except the inflation expectation biased Hungarian case. The path of the ECB main refinancing rate was not totally followed by the Central East European markets, moreover Hungary and Poland had to face with increasing yields after the fall of Lehman Brothers – 3M yields not decreased in the “E” period, as well as the mean of 10Y yields remained the same both in “D”, “E” and “F” period. So we can say, the relative high level of risk premiums were crucial for the selected new member states to maintain the liquidity demand on their bond markets[8].

Table 1: Descriptive statistics of the 3M and 10Y markets

	MEAN									
	3M					10Y				
	US	EU	HU	CZ	PL	US	EU	HU	CZ	PL
"A"	1,926763957	2,027223926	9,216733129	2,170352761	5,60440184	4,22946319	3,834233129	7,366625767	4,285444785	6,092960123
"B"	4,840246465	3,108686869	7,129646465	2,395176768	4,165126263	4,748106061	3,864671717	7,003611111	3,833989899	5,246212121
"C"	2,963532143	3,927107143	7,804392857	3,762285714	5,504785714	4,168107143	4,220821429	7,325285714	4,698464286	5,877607143
"D"	1,390070769	4,132769231	8,567384615	3,892769231	6,470769231	3,813538462	4,222769231	7,940615385	4,547692308	6,107076923
"E"	0,217050769	1,594692308	9,995846154	3,359307692	5,547	2,926076923	3,278538462	9,813384615	4,578846154	6,017076923
"F"	0,119440762	0,45152381	6,353657143	1,551790476	3,987847619	3,315314286	3,037142857	7,797409524	4,222266667	6,015542857
	VARIANCE									
	3M					10Y				
	US	EU	HU	CZ	PL	US	EU	HU	CZ	PL
"A"	1,067524528	0,00277861	4,49105183	0,079165313	0,544620686	0,074636117	0,16444534	0,761721623	0,406542198	0,792097369
"B"	0,087848891	0,280669664	0,725525444	0,062984526	0,016015427	0,049488809	0,073456348	0,122578572	0,059093407	0,062222071
"C"	1,558837558	0,011961135	0,315998913	0,158649237	0,388297445	0,245461996	0,05668857	0,522337552	0,032005877	0,069489953
"D"	0,234314898	0,144195337	0,02172899	0,017620337	0,003654087	0,031560721	0,041204712	0,046493365	0,044580529	0,053342885
"E"	0,049401932	0,498149129	0,844626023	0,585839052	1,039639767	0,295774413	0,111457537	1,658808611	0,18242734	0,207323172
"F"	0,001824983	0,03179691	1,950554539	0,153888773	0,046484099	0,147011972	0,133518539	0,996360834	0,301853822	0,075847272
	10Y-3M MEAN					10Y-3M VARIANCE				
	US	EU	HU	CZ	PL	US	EU	HU	CZ	PL
"A"	2,302699233	1,807009202	-1,850107362	2,115092025	0,488558282	1,050730545	0,172984129	1,87073624	0,238214892	0,524215123
"B"	-0,092140404	0,755984848	-0,126035354	1,438813131	1,081085859	0,087959782	0,149931433	0,7520569	0,061378081	0,082032489
"C"	1,204575	0,293714286	-0,479107143	0,936178571	0,372821429	0,686598923	0,037699416	0,077927157	0,11721581	0,168650434
"D"	2,423467692	0,09	-0,626769231	0,654923077	-0,363692308	0,170372972	0,103340625	0,026525337	0,026431635	0,055436154
"E"	2,709026154	1,683846154	-0,182461538	1,219538462	0,470076923	0,190318191	0,278568038	1,683944281	1,034585832	1,143662785
"F"	3,195873524	2,585619048	1,443752381	2,67047619	2,027695238	0,15365369	0,134691076	0,386679213	0,084858361	0,03202006

Source: author’s calculations

The basic statistics (see table 2) supported the idea of weak effectiveness – logarithmic differentials of the yields were non normal distributed as p=0% results of Jarque-Bera test suggested, while only the Czech and Polish 3M remained homoscedastic, while the entire sample is characterized by autocorrelation. According to their negative skewness, extreme events occurred on the negative (increasing liquidity) side of the EURO, Czech and Polish 3M markets, as a sign of the central bank activities. Both the US and Hungarian 3M market was characterized by fat tails or extreme events on the positive (of liquidity shortage) side, as well as happened on the entire 10Y sample (except Czech).

[8] However, Hungary and Poland requested an additional liquidity support from the joint program of the IMF and ECB too.

Table 2: Testing the efficiency of the 3M and 10Y markets

analyzed markets	skewness	kurtiosis	Normal distribution (Jarque-Bera)	Statonarity (ADF-test) 1 lag		Heteroscedastivity (ARCH-LM) 2 lag	Autocorrelation (Ljung-Box) 6 lag	
			p	t statistic	critical value	p	p	p (squared)
US 3M	0,2208	6,3743	0,001	-55,462 *	-1,9416	0	0	0
EURO 3M	-0,0126	38,9098	0,001	-51,2232 *	-1,9416	0	0	0
HU 3M	1,7436	83,4966	0,001	-50,2077 *	-1,9416	0	0	0
CZ 3M	-3,3173	60,212	0,001	-46,9896 *	-1,9416	0,9395 **	0	0,9985 ***
PL 3M	-0,94	47,801	0,001	-44,1657 *	-1,9416	0,0784 **	0	0,2001 ***
US 10Y	0,3285	8,6655	0,001	-52,3948 *	-1,9416	0	0,0001	0
EURO 10Y	0,0234	4,8633	0,001	-46,9331 *	-1,9416	0	0,0019	0
HU 10Y	0,3544	14,6128	0,001	-47,6824 *	-1,9416	0	0,0421	0
CZ 10Y	-1,8222	67,864	0,001	-49,1197 *	-1,9416	0	0,0135	0
PL 10Y	0,594	14,7558	0,001	-42,2279 *	-1,9416	0	0	0
*: stationer time series; **: homoscedasticity; ***: lack of autocorrelation								

Source: author's calculations

The observed autocorrelation and heteroscedasticity was the reason to involve the different forms of GARCH (APARCH) models (see table 3), to provide homoscedastic standardized residuals which is necessary for the DCC estimation (Bali-Engle 2010). There was no general rule about the right model or lag numbers, so the applied AIC based optimization seemed to be useful.

Table 3: Fitting the best GARCH model

analyzed markets	AIC	GARCH model	parameters								residuals ARCH-LM
US 3M	2,4777	aparch221	0,0105 ω	0,1925 α(1)	0,0236 α(2)	-0,6257 γ(1)	0,9995 γ(2)	0,7836 β(1)	2,0406 δ		1*
EUR 3M	1,6261	aparch112	0,0210 ω	0,1985 α(1)	-0,2413 γ(1)	0,2612 β(1)	0,5401 β(2)	2,1090 δ			1*
HU 3M	1,3282	aparch222	0,2087 ω	0,2031 α(1)	0,2864 α(2)	0,3180 γ(1)	-0,3249 γ(2)	0,0000 β(1)	0,5103 β(2)	0,7890 δ	1*
CZ 3M	1,2870	aparch111	0,0547 ω	0,0157 α(1)	-0,9995 γ(1)	0,9371 β(1)	0,4887 δ				1*
PL 3M	0,7049	aparch112	0,1502 ω	0,3115 α(1)	-0,2915 γ(1)	0,1940 β(1)	0,3894 β(2)	0,6995 δ			1*
US 10Y	1,8623	gjr111	0,0055 ω	0,0173 α(1)	0,0360 γ(1)	0,9639 β(1)					1*
EUR 10Y	1,5155	gjr111	0,0036 ω	0,0115 α(1)	0,0403 γ(1)	0,9666 β(1)					1*
HU 10Y	1,5723	aparch112	0,0836 ω	0,2116 α(1)	0,2014 γ(1)	0,2997 β(1)	0,4807 β(2)	1,4632 δ			1*
CZ 10Y	1,4797	aparch112	0,5358 ω	0,0056 α(1)	0,9994 γ(1)	0,0502 β(1)	0,4051 β(2)	3,9999 δ			1*
PL 10Y	0,9395	garch23	0,0001 ω	0,2796 α(1)	0,0000 α(2)	0,2645 β(1)	0,0807 β(2)	0,3750 β(3)			1*
*: no heteroscedasticity											

Source: author's calculations

3.1 Detection of market contagion trough fat tails

After the definition of the most efficient GARCH estimation, it was easy to calculate the dynamic conditional correlation between the selected markets. Our first method to detect market contagions based on the fat tailness of the logarithmic differentiated yields to see the impact of market mood on the bond markets. This QQ plot spin off solution was able to sign the difference between "quasi-normal" (ordinary) and "extreme positive" and "extreme negative" variables. The statistical properties of extreme yield changes are characterized by their completely rare but irresistible impact as Jentsch el al. (2006) suggest. Only a marginal number of yield changes were delineated by the selected turning points (see table 4).

Table 4: Extreme value properties

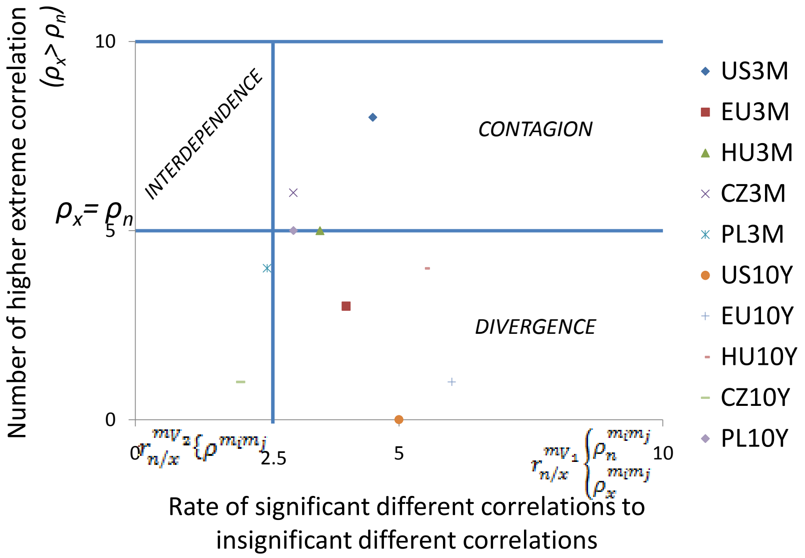
analyzed markets		US 3M	EUR 3M	HU 3M	CZ 3M	PL 3M	US 10Y	EUR 10Y	HU 10Y	CZ 10Y	PL 10Y
extreme "+"	No	36	60	73	23	60	100	103	91	33	85
	%	*1,44%*	*2,40%*	*2,92%*	*0,92%*	*2,40%*	*4,00%*	*4,12%*	*3,64%*	*1,32%*	*3,40%*
	r	44,79	6,201	3,054	2,278	1,192	3,235	2,144	2,559	2,628	1,57
ordinary		2431	2395	2399	2457	2356	2335	2334	2357	2439	2344
extreme "-"	No	36	48	31	23	87	68	66	55	31	74
	%	*1,44%*	*1,92%*	*1,24%*	*0,92%*	*3,48%*	*2,72%*	*2,64%*	*2,20%*	*1,24%*	*2,96%*
	r	-43,27	-6,694	-3,164	-2,028	-1,143	-3,569	-2,433	-2,895	-2,647	-1,616

Source: author's calculations

The detected contagions, divergences and interdependences are summarized on figure 3 (more details at Annex 1). The **extremity** of the US and the Czech 3M market seemed the best **indicator of contagions** for this sample –however the Czech benchmark indicated only contagions between CEE countries as well as the Hungarian 3M. The reason of usefulness in the case of the US 3M comes obviously from the weight of this market's on the global liquidity transmission. The main advantage of the Czech indicator derives from its relative stability – the smallest number of extreme changes was detected here, so this market falls if the others are long ago in red. It was hard to indicate contagions for 10Y markets; none of them had enough power to reach at least six significant high correlations, which is necessary for contagion detection.

Therefore we can talk **mostly** about **divergences** on the markets. This result is remarkable; because of contagions occurred only on the monetary policy affected 3M markets, while 10Ys contrary **desynchronized**. National characteristics as inflation and budgetary conditions obstructed the CEE bond markets from high common movements – only the 10Y US-EURO market pair reached higher correlation than 50%, as well as the 10Y EURO-CZ market stepped across the 30%.

Figure 3: Map of possible contagions, divergence and interdependence



Source: author's calculations

3.2 Detection of market contagion trough the ECB main refinancing rate

Six different market periods were defined according to the ECB main refinancing rate to study, the impact of monetary policy on bond market common movements. The "A" and "F" crisis periods were characterized by near zero interest rates, while "B" represented a recovery with tightening spreads (3M is increasing while 10Y remains the same). Yields are increasing under "C" and "D" periods, while markets fell apart in the "E" period (reduced 3M on the developed markets and increasing 3M and 10Y on the CEE markets).

The 3M market proved to be more contagious again (see table 5); significant higher correlation was observed in the comparison of "A-to-F" (7) and "A-to-C" (6) periods. The first ("A-to-F") result suggests that the second crisis had more intensive impact on the market connections – markets behave more synchronized and due to this form of homogenization, moving closer together. The second ("A-to-C") result showed also increased convergence among the different US, EURO, HU, CZ, PL market pairs. A strong interdependence was detected on the "A-to-B" and "B-to-E" relations – their 5 market pairs were not enough to fit for contagion criteria. The uniqueness of "D" period is remarkable; it was hard to detect any contagions due to the sudden changes in the risk appetite. The unregulated **10Y** markets remained **divergent** under this composition; market participants recognized their **heterogeneity** arise from their fundamental differences.

Table 5: Detected contagions

	3M									
	US-EU	US-HU	US-CZ	US-PL	EU-HU	EU-CZ	EU-PL	HU-CZ	HU-PL	CZ-PL
Significant difference between "A" and "B" periods (5)*	0	1	1	1	1	1	1	0	1	1
mean DCC ("A" period)		-0,0498	0,0080	-0,0125	-0,0164	0,0141	-0,0127		0,0715	0,0461
mean DCC ("B" period)		-0,0487	-0,0141	-0,0125	-0,0152	0,0161	-0,0138		0,0772	0,0504
Significant difference between "A" and "C" periods (6)*	1	1	0	1	1	1	0	1	1	1
mean DCC ("A" period)	0,0287	-0,0498		-0,0125	-0,0164	0,0141		0,0225	0,0715	0,0461
mean DCC ("C" period)	0,0287	-0,0483		-0,0125	-0,0176	0,0082		0,0356	0,0728	0,1282
Significant difference between "A" and "D" periods (4)*	0	1	1	1	1	1	1	1	0	1
mean DCC ("A" period)		-0,0498	0,0080	-0,0125	-0,0164	0,0141	-0,0127	0,0225		0,0461
mean DCC ("D" period)		-0,0494	0,0038	-0,0125	-0,0267	-0,0069	-0,0173	0,0457		0,1346
Significant difference between "A" and "F" periods (7)*	1	1	1	1	1	1	1	1	1	1
mean DCC ("A" period)	0,0287	-0,0498	0,0080	-0,0125	-0,0164	0,0141	-0,0127	0,0225	0,0715	0,0461
mean DCC ("F" period)	0,0287	-0,0489	-0,0283	-0,0125	-0,0165	0,0148	-0,0101	0,0228	0,0733	0,0373
Significant difference between "B" and "C" periods (1)*	0	0	0	0	0	1	0	0	1	1
mean DCC ("B" period)						0,0161			0,0772	0,0504
mean DCC ("C" period)						0,0082			0,0728	0,1282
Significant difference between "B" and "D" periods (2)*	0	0	1	0	1	1	0	0	1	1
mean DCC ("B" period)			-0,0141		-0,0152	0,0161			0,0772	0,0504
mean DCC ("D" period)			0,0038		-0,0267	-0,0069			0,0749	0,1346
Significant difference between "B" and "E" periods (5)*	0	0	1	0	0	1	1	1	1	1
mean DCC ("B" period)			-0,0141			0,0161	-0,0138	0,0334	0,0772	0,0504
mean DCC ("E" period)			-0,0106			0,0324	-0,0095	0,0625	0,0662	0,1458
Significant difference between "C" and "D" periods (2)*	0	0	1	0	1	0	0	0	0	1
mean DCC ("C" period)			-0,0245		-0,0176					0,1282
mean DCC ("D" period)			0,0038		-0,0267					0,1346
Significant difference between "C" and "E" periods (4)*	0	0	1	0	0	1	0	1	1	1
mean DCC ("C" period)			-0,0245			0,0082		0,0356	0,0728	0,1282
mean DCC ("E" period)			-0,0106			0,0324		0,0625	0,0662	0,1458
Significant difference between "C" and "F" periods (4)*	0	0	1	1	0	1	1	0	1	1
mean DCC ("C" period)			-0,0245	-0,0125		0,0082	-0,0126		0,0728	0,1282
mean DCC ("F" period)			-0,0283	-0,0125		0,0148	-0,0101		0,0733	0,0373

	10Y									
	US-EU	US-HU	US-CZ	US-PL	EU-HU	EU-CZ	EU-PL	HU-CZ	HU-PL	CZ-PL
Significant difference between "A" and "B" periods (5)*	1	0	1	0	1	1	1	1	0	1
mean DCC ("A" period)	0,5637		0,1780		0,0832	0,3981	0,2266	0,0891		0,1620
mean DCC ("B" period)	0,5704		0,2242		-0,0148	0,4026	0,2160	0,0894		0,2130
Significant difference between "A" and "C" periods (2)*	0	0	1	1	1	0	1	0	1	1
mean DCC ("A" period)			0,1780	0,1341	0,0832	0,3981	0,2266		0,2411	0,1620
mean DCC ("C" period)			0,1951	-0,0340	-0,0681	0,5067	0,0552		0,2125	0,1238
Significant difference between "A" and "D" periods (3)*	0	0	1	1	1	1	1	1	1	0
mean DCC ("A" period)			0,1780	0,1341	0,0832	0,3981	0,2266	0,0891	0,2411	
mean DCC ("D" period)			0,1838	0,0106	-0,1080	0,4718	0,2463	0,0520	0,2227	
Significant difference between "A" and "F" periods (1)*	1	0	1	0	1	1	1	1	0	0
mean DCC ("A" period)	0,5637		0,1780		0,0832	0,3981	0,2266	0,0891		
mean DCC ("F" period)	0,5649		0,0710		-0,1249	0,1616	0,0242	0,0756		
Significant difference between "B" and "C" periods (1)*	1	0	1	1	1	1	1	0	0	0
mean DCC ("B" period)	0,5704		0,2242	0,1849	-0,0148	0,4026	0,2160			
mean DCC ("C" period)	0,5579		0,1951	-0,0340	-0,0681	0,5067	0,0552			
Significant difference between "B" and "D" periods (4)*	1	1	1	1	1	0	1	1	1	1
mean DCC ("B" period)	0,5704	-0,0501	0,2242	0,1849	-0,0148		0,2160	0,0894	0,2367	0,2130
mean DCC ("D" period)	0,5763	-0,0501	0,1838	0,0106	-0,1080		0,2463	0,0520	0,2227	0,2513
Significant difference between "B" and "E" periods (0)*	1	0	1	1	1	1	1	1	0	0
mean DCC ("B" period)	0,5704		0,2242	0,1849	-0,0148	0,4026	0,2160	0,0894		
mean DCC ("E" period)	0,5457		0,0855	-0,0419	-0,1206	0,1127	0,0096	0,0588		
Significant difference between "C" and "D" periods (3)*	0	1	1	0	1	1	1	1	0	1
mean DCC ("C" period)		-0,0501	0,1951		-0,0681	0,5067	0,0552	0,0639		0,1238
mean DCC ("D" period)		-0,0501	0,1838		-0,1080	0,4718	0,2463	0,0520		0,2513
Significant difference between "C" and "E" periods (3)*	0	0	0	1	0	1	0	1	1	1
mean DCC ("C" period)				-0,0340	-0,0681	0,5067		0,0639	0,2125	0,1238
mean DCC ("E" period)				-0,0419	-0,1206	0,1127		0,0588	0,2498	0,1364
Significant difference between "C" and "F" periods (1)*	1	0	1	1	1	1	1	0	0	1
mean DCC ("C" period)	0,5579		0,1951	-0,0340	-0,0681	0,5067	0,0552			0,1238
mean DCC ("F" period)	0,5649		0,0710	-0,0368	-0,1249	0,1616	0,0242			0,0950

Source: author's calculations

4. Conclusion

Bond markets are **weak efficient** as the stock markets, but their role in banking and state finances is unquestionable. Contagions are defined as a significant increase in the cross-market correlation, while divergence is a significant decrease in this benchmark. This study applied two methods to capture such developments on the bond markets; the first based on the fat tailness in the changes of yields, the second selected according to the changes in the ECB refinancing rate. The sample covered the US and Euro-zone as well as three new member states. 3 month (3M) and 10 year (10Y) maturities were compared to characterize liquidity preferences of the investors and the latitude of the monetary policy.

Bond markets were analyzed from the recovery of the dot-com crisis until the break of current Euro-crisis. The maturities showed different behavior parallel to their liquidity – the **3M** markets were quite useful to detect **contagions**, while **10Y** yields were mostly **divergent**. We were able to detect both contagions and divergence with our two methods, so we are able to answer both research questions: contagions are able to occur on the bond markets, but they are mostly characterized by divergence under the current crisis – **market participants took more attention on country specific risk, instead of their previous homogenizing behavior**. This result is important for two reasons; on one hand it underlines, how the liquidity flows separate the markets from their fundamental background; on the other hand it reveals on the weaknesses of monetary policy.

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Annex 1

3M market							**10Y market**						
analyzed markets	DCC mean			Ansari-Bradley test		selector market	analyzed markets	DCC mean			Ansari-Bradley test		selector market
	ordinary	extreme (-)	extreme (+)	ord.-extr. (-)	ord.-extr. (+)			ordinary	extreme (-)	extreme (+)	ord.-extr. (-)	ord.-extr. (+)	
US-EU	0,028677	0,028677		1	0		US-EU	0,564011		*0,556625*	0	1	
US-HU				0	0		US-HU				0	0	
US-CZ	-0,01124	-0,00304	0,002375	1	1		US-CZ	0,167995	*0,128301*		1	0	
US-PL	-0,01245	-0,01245		1	0		US-PL	0,072363		*-0,02236*	0	1	
EU-HU				0	0		EU-HU	-0,01915	*-0,07611*	*-0,09858*	1	1	
EU-CZ	0,014142		0,018592	0	1		EU-CZ	0,354249		*0,242004*	0	1	
EU-PL	-0,01177		*-0,02092*	0	0		EU-PL	0,1383	*0,07064*	*0,025456*	1	1	
HU-CZ	0,029244	0,045725	0,041165	1	1		HU-CZ	0,081924	*0,06595*	*0,071592*	1	1	
HU-PL				0	0		HU-PL				0	0	
CZ-PL	0,055861	0,080874	0,075693	1	1	US3M (8)*	CZ-PL				0	0	US10Y (0)*
US-EU	0,028677	0,028677		1	0		US-EU	0,564433	*0,553349*		1	0	
US-HU				0	0		US-HU	-0,05007	-0,05007		1	0	
US-CZ	-0,01021	*-0,03017*		1	0		US-CZ	0,169106	*0,113486*	*0,109464*	1	1	
US-PL				0	0		US-PL	0,072601		*-0,02646*	0	1	
EU-HU	-0,01629	*-0,02217*	*-0,01977*	1	1		EU-HU	-0,01873	*-0,07809*	*-0,11019*	1	1	
EU-CZ	0,015126	*0,005752*	*-0,01866*	1	1		EU-CZ	0,356989		*0,206595*	0	1	
EU-PL				0	0		EU-PL	0,139418	*0,058512*	*0,004505*	1	1	
HU-CZ				0	0		HU-CZ	0,081034	*0,075366*		1	0	
HU-PL				0	0		HU-PL	0,23444	*0,231822*		1	0	
CZ-PL	0,05647	0,052434	0,062935	1	1	EU3M (3)*	CZ-PL				0	0	EU10Y (1)*
US-EU				0	0		US-EU	0,563608	0,568669		1	0	
US-HU				0	0		US-HU	-0,05007	-0,05007		1	0	
US-CZ				0	0		US-CZ				0	0	
US-PL				0	0		US-PL	0,070392	*0,027816*	*-0,01562*	1	1	
EU-HU				0	0		EU-HU	-0,021	*-0,05488*	*-0,08259*	1	1	
EU-CZ				0	0		EU-CZ				0	0	
EU-PL	-0,01181	-0,01657		1	0		EU-PL	0,135948	*0,095699*	*0,047051*	1	1	
HU-CZ	0,029704	*0,027491*	*0,026767*	1	1		HU-CZ	0,081744	*0,068773*		1	0	
HU-PL	0,072051	0,087983	0,129312	1	1		HU-PL	0,233754	0,242868	0,257441	1	1	
CZ-PL	0,056394	0,057552	0,063129	1	1	HU3M (5)*	CZ-PL				0	0	HU10Y (4)*
US-EU				0	0		US-EU				0	0	
US-HU				0	0		US-HU	-0,05007		-0,05007	0	1	
US-CZ				0	0		US-CZ				0	0	
US-PL				0	0		US-PL				0	0	
EU-HU				0	0		EU-HU				0	0	
EU-CZ	0,014051	0,031465	0,028715	1	1		EU-CZ	0,35219	*0,270643*	*0,209036*	1	1	
EU-PL	-0,01206		-0,00775	0	1		EU-PL				0	0	
HU-CZ	0,029548		0,037571	0	1		HU-CZ	0,08148	*0,071683*		1	0	
HU-PL	0,072837		0,075579	0	1		HU-PL				0	0	
CZ-PL	0,056215		0,07781	0	1	CZ3M (6)*	CZ-PL				0	0	CZ10Y (1)*
US-EU				0	0		US-EU	0,563898	*0,562995*		1	0	
US-HU				0	0		US-HU	-0,05007	-0,05007		1	0	
US-CZ				0	0		US-CZ				0	0	
US-PL	-0,01245	-0,01245	-0,01245	1	1		US-PL				0	0	
EU-HU				0	0		EU-HU	-0,02526	0,002388	-0,00046	1	1	
EU-CZ				0	0		EU-CZ				0	0	
EU-PL	-0,01222		-0,00329	0	1		EU-PL	0,129778		0,16207	0	1	
HU-CZ	0,029667		0,029827	0	1		HU-CZ				0	0	
HU-PL				0	0		HU-PL	0,234094	0,242034		1	0	
CZ-PL	0,0564	*0,0516*		1	0	PL3M (4)*	CZ-PL				0	0	PL10Y (5)*