Interbank Interest Rate Interdependencies Using the MST Approach

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Abstract

The paper analyses mutual relations among chosen interbank interest rates. It is demonstrated via the minimum spanning tree methodology that interbank interest rates in question do not depend only on usual economic fundamentals, i.e. determinants in line with economic theory. Interest rate evolution is often implied by integration factors, political situation, position of a country in a world region, etc. Using the minimum spanning tree representation we have identified core and peripheral positions of studied interest rates. We confirmed our initial hypothesis on the euro area interbank rate having core position and consequently crucial impact on evolution of other rates. We have partially confirmed our second hypothesis that Slovak interbank interest rate was more implied by the euro area rate than by other regional interest rates of countries in transition. Consequently, evolution of interest rates often does not reflect real economic background and economic agents should be ready to abrupt interest rate changes especially in times of crises. Interest rate behaviour is often outcome of biased and deformed signals in financial markets. The paper was elaborated within the project 1/0892/13.

Key words: interbank interest rate, minimum spanning tree approach, central and peripheral positions, interdependence, transmission.

JEL Classification: E40, F30

1 Introduction

The objective of the paper is to underline that interest rates often do not reflect evolution of relevant macroeconomic indicators and determinants in line with theory. They are rather influenced by psychological effects, geographical position of a country, membership of a particular country in an integration group, etc. Investors tend to perceive a country within a group of several economies and consider the group as a homogenous area. They do not distinguish between countries´ particularities. Consequently, they attribute almost identical level of interest rates to various countries which is not compatible with real economic background.

However, crisis helps us to reveal important differences. Very famous is example of 10-year government bonds interest rates in the euro area (see Figure 1). Prior to creation of the European Economic and Monetary Union in 1999 investors took into account particular evolution in each country. After 1999, the euro area member countries were considered as a homogeneous region. Nevertheless, financial and economic crisis led to disparities in interest rates setting. Though, gradually in time, investors forget impacts of crisis and again tend to neglect evolution of

economic fundamentals. We can observe transmission effect among countries in one region and in one integration group.

In the center of interest of the paper will be an analysis of interbank interest rates behaviour because of several reasons. Firstly, interbank interest rates influence evolution of other interest rates in economy. Secondly, interbank interest rates are convenient proxy indicators expressing actual monetary policy setting in a country. Finally, specific evolution of 10-year government bonds interest rates is a very well known example studied by several authors (e.g. Fonseca, 2014), nevertheless, we assume that interbank interest rate is also often a victim of illusion in financial markets and does not sufficiently reflect reality.

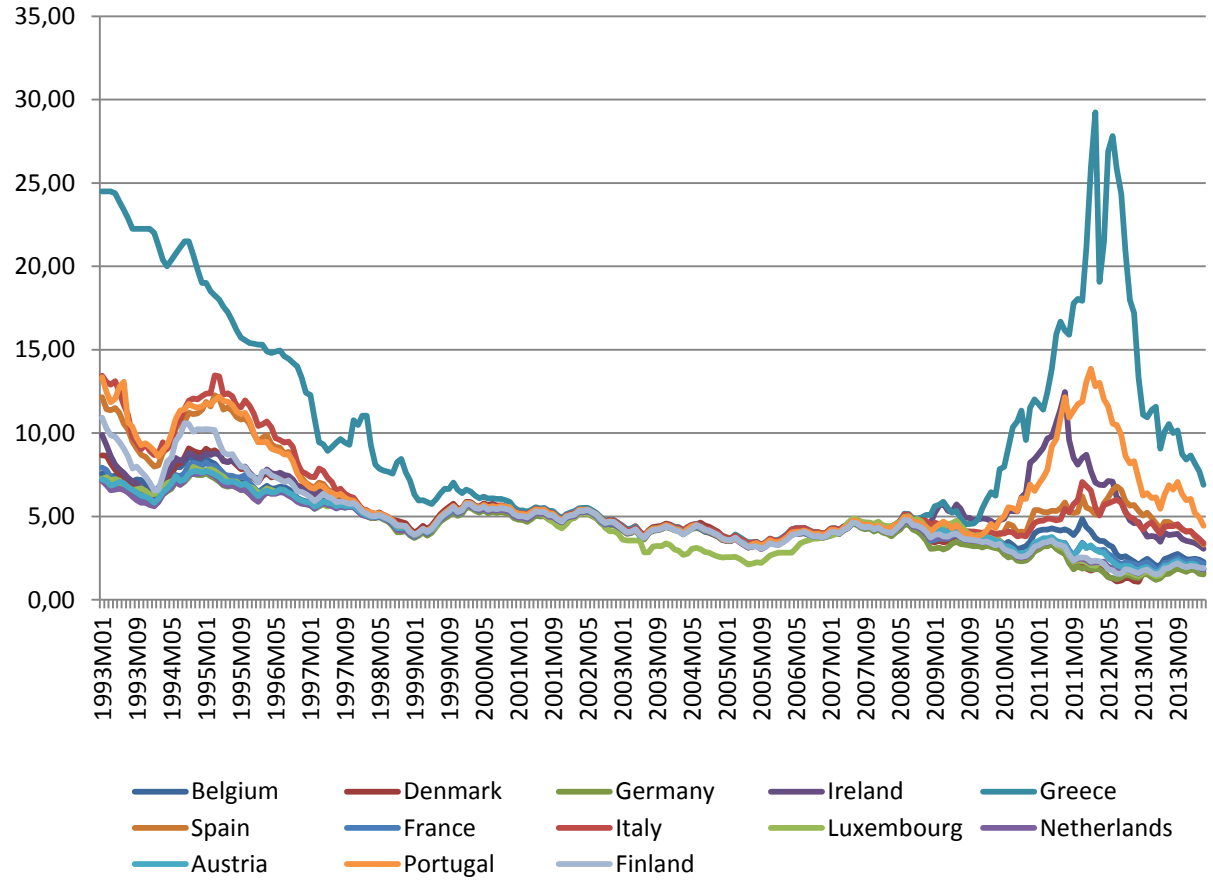


Fig. 1 10-year government bond yield, 1993-2013
Source: own representation according to the Eurostat

Therefore, objective of the paper is to find out whether regional transmission among certain interbank interest rate evolution can be observed. Consequently, we would like to identify central and peripheral positions of particular interest rates and to determine which rates influence behaviour of other rates.

2 Literature Overview and Theory

Interbank (i.e. short-term) interest rate determinants were explained e.g. in the works by Taylor (1999) and McCallum (1999) within monetary rules topics. Gaspar et al. (2004) constructed a theoretical model of money market to shed more light into this topic. Their model is able to demonstrate the most obvious features that characterise the overnight interest rates in the euro area. Relevant features include reserve requirements, length of reserve maintenance periods, standing facilities applications, maturities and frequency of open market operations, etc. Analogical analyses for the U.S. interest rates were performed e.g. by Hamilton (1996), Furfine (2000) and Bartolini, Bertola, and Prati (2001, 2002). The authors underline importance of a "corridor system" that implies evolution of interest rates within a band for credit and deposit rates. The corridor system is not crucial only in the US but in the euro area as well.

Interbank interest rates are crucial also for calculation of Taylor-type rules (Sauer, Sturm, 2003). These overnight interbank interest rates as e.g. EONIA in the euro area are proxy variables for monetary policy setting. They aggregate naturally via financial markets restrictive or expansionary monetary policy conditions. In addition, interbank interest rates play important role in monetary transmission mechanism as explained by Mirdala (2009), Bartóková and Ďurčová (2013) in the case of the EMU countries and the Visegrad 4 group respectively.

3 Methodology and Data

Unlike other researches (e.g. Mirdala, 2009; Bartóková and Ďurčová, 2013) on interest rate analysis, which employed vector error correction model or vector autoregression, we will apply the *minimum spanning tree* (MST) methodology to identify positions of chosen interbank interest rates mutually and in relation to common euro area interbank rate (EONIA) in particular.

3.1 Methodology

Originally, the MST methodology was applied in the case of stock returns in financial markets (Mantegna, 1999). Mantegna was a pioneer in the MST implementation. He suggested recording of stock returns into graph nodes and relations among stocks are demonstrated using graph edges. Edges are weighted via Pearson correlation coefficient among particular pairs of stock returns. Classical correlation does not fulfil assumption of the Euclidean distance. Thus correlations among stocks are transformed into Euclidean distances.

Mantegna´s approach has inspired other authors (Bonanno et al., 2003; Micciche et al., 2003) who applied the MST methodology in stock markets with smaller modifications. Recently, the methodology has been used to analyse the evolution of exchange rates (Rešovský et al., 2013).
One advantage of the methodology is that it enables us to visualise complex and complicated market relations using a very obvious manner. Another strength is that neither stationarity, autocorrelation, heteroskedasticity nor other standard econometric diagnostic tests have not to be performed as the MST results are not sensitive into these phenomena.

On the other hand, its weakness stems from the construction principle of the graph, thus it is never possible to create a cycle or an isolated point which would demonstrate independence of

one time series from other series. In reality such an independence or cyclical relation is possible but it will not appear in the MST graph representation. Consequently, it is not reasonable to try to interpret each position in the graph. However, we can assume that in general, most of studied relations are expressed correctly.

We will analyse mutual interactions (correlations) among *n* interest rates. From logarithmic returns (IR-interest rates)

$$r_i^t = \ln IR_i^t - lnIR_i^{t-1} \quad (1.1)$$

of IR_i^t in month *t* we will compute Pearson cross correlations between *n* x *n* interest rate pairs

$$\rho_{ij} = \frac{\langle r_i r_j \rangle - \langle r_i \rangle \langle r_j \rangle}{\sqrt{(\langle r_i^2 \rangle - \langle r_i \rangle^2)(\langle r_j^2 \rangle - \langle r_j \rangle^2)}} \quad (1.2)$$

Where $\langle ... \rangle$ represents an average for observed period. Coefficients ρ_{ij} stand for square variance-covariance matrix. Consequently, correlation matrix is transformed to distance matrix involving the elements

$$d_{ij} = \sqrt{2(1 - \rho_{ij})} \quad (1.3)$$

Matrix is symmetric $d_{ij} = d_{ji}$ with null values on diagonal axes. This matrix is fundamental to derivate minimum spanning tree graph consisting of *n* nodes (points) and *n-1* edges.

3.2 Data

We will study 16 overnight interbank interest rates from January 2000 to December 2008 with monthly frequency. We assume that interbank interest rates mentioned in Table 1 have more or less relevant relation to the euro area interbank interest rate. We will have 108 observations at our disposal for each interest rate. We will work with first differences. As we would like to focus on Slovak interbank interest rate, too, our observations end in December 2008. Slovakia has been applying common European interbank interest rates since January 2009 due to the introduction of euro in the country.

Table 1: List of analysed countries

EA	Euro area	**HR**	Croatia	**PL**	Poland	**UK**	Great Britain
BG	Bulgaria	**LV**	Latvia	**RO**	Romania	**TR**	Turkey
CZ	Czech Republic	**LT**	Lithuania	**SK**	Slovakia	**US**	United States
DK	Denmark	**HU**	Hungary	**SE**	Sweden	**JP**	Japan

4 Results and Discussion

We can set two basic hypotheses:
H1: The euro area interbank interest rate should be in central position in relation to other rates.
H2: Slovak interbank interest rate should be rather under influence of the euro area than of other Central European countries in transition due to Slovak integration ambitions.

Slovak economy was during analysed period closer to other countries in transition especially within Visegrad group (Czech Republic, Hungary, Poland, and Slovakia). These economies shared similar transformation process, situation in banking sphere, on financial markets, macroeconomic indicators, etc. Therefore analogical evolution among these interest rates would be more rational. However, our above mentioned experience of 10-year government bonds interest rates in the euro area leads us to assumption that Slovak rates were more influenced by evolution in the euro area. This fact can be explained by Slovak preparations for the introduction of euro in 2009.

The MST methodology enables us to identify central and peripheral positions of interest rates in world markets as it is depicted in Figure 2 for period from 2000 to 2008.

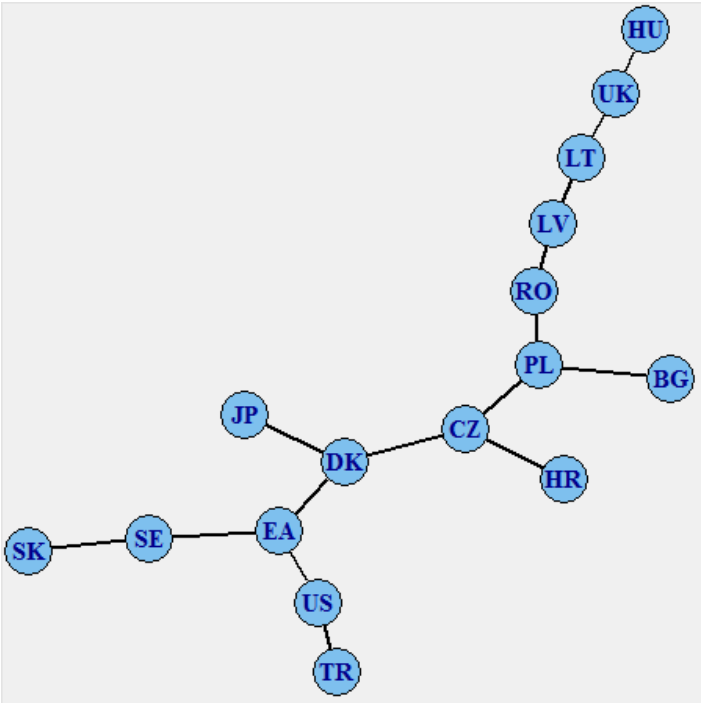
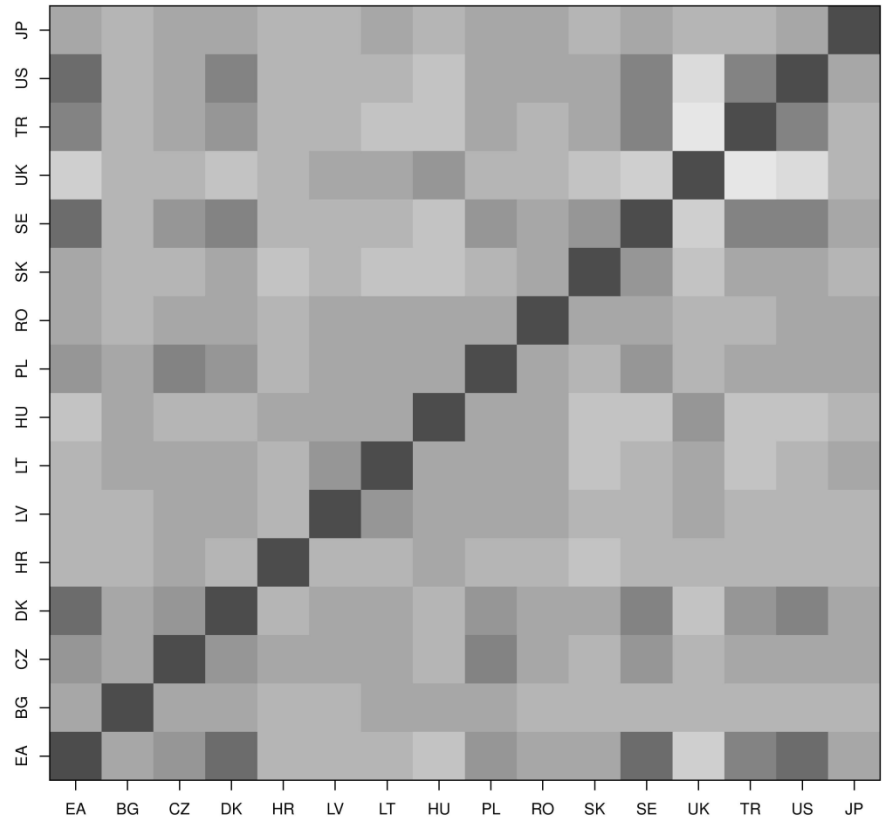


Fig. 2 The MST of interbank interest rate, 2000-2008
Source: own representation according to the Eurostat

Interest rates with central position have a key impact on evolution of the other rates. On the contrary, interest rates with peripheral role have only minimal impact on the other rates. Interest rates with the node degree higher than two (i.e. with more than two edges – relations) have central position. It is the case of the euro area, Denmark, Poland and Czech Republic in our analysis.

Peripheral position and thus minimal impact on the other countries is evident in the case of Bulgaria, Croatia, Japan, Hungary, Turkey and Slovakia. The node degree of these interest rates is only one as they have only one edge. Slovak rate is in the sphere of the euro area and not in the group of Visegrad countries. Consequently, our both hypotheses were confirmed via standard MST graph.

However, the basic MST representation does not allow us to determine the strength of correlations among interest rates. Figure 3 captures a correlation matrix of logarithmic returns where the importance of relations between interest rate pairs is depicted by colour. The higher is the correlation, the darker colour is used in the figure.

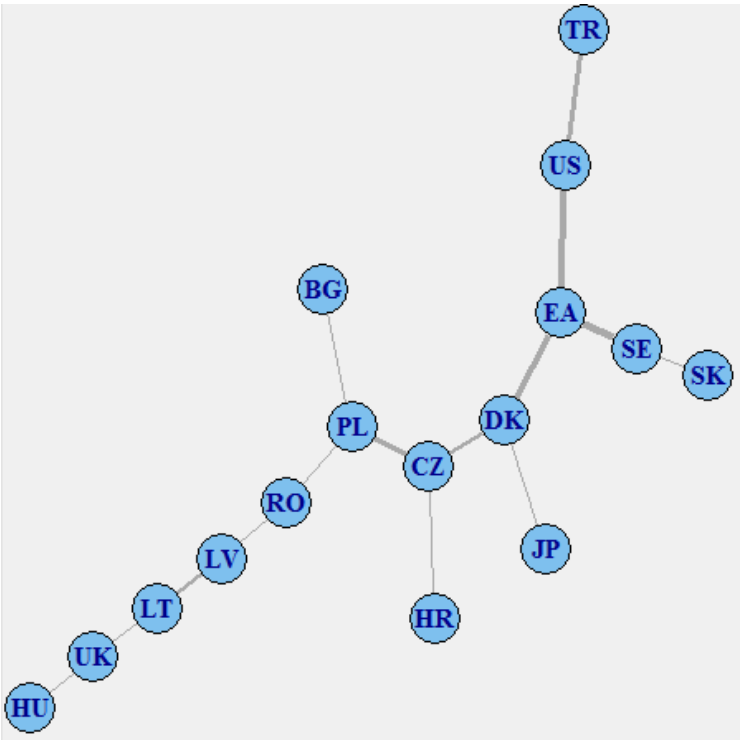


N.B.: The higher is the correlation, the darker colour is used in the figure.

Fig. 3 Correlation matrix of mutual interbank interest rate relations, 2000 – 2008
Source: own representation according to the Eurostat

The correlation matrix implies that the relation is important mainly among interest rates in the euro area, Denmark, Sweden, the U.S. and Turkey. Correlation between interest rates in the euro area and Slovakia is not so strong. This finding slightly decreases validity of our hypothesis H2.

Combination of the classical MST representation and correlation matrix leads us to Figure 4. Significance of relations is expressed through the thickness of edges.



N.B.: The higher is the correlation between interest rates; the ticker is the MST edge.

Fig. 4 The MST and strength of interest rates relations, 2000 – 2008
Source: own representation according to the Eurostat

The Figure confirms statistically important correlations among interest rates in the euro area, Denmark, Sweden and the U.S. Impact of the euro area interest rate on the Slovak one is only minor. The mutual relation between interest rates in the Czech Republic and Poland is also obvious. Position of Slovak interbank interest rate stays peripheral.

5 Conclusions

Interbank interest rate behaviour is not always implied by economic fundamentals but depends significantly on integration process of a country, how is the economy perceived by investors in international markets, and what is the economic situation in a region as a whole. Our analysis based on minimum spanning tree methods confirms central position of the euro area interbank interest rates on evolution of other rates regardless real economic situation in a country. Slovak interbank interest rates were more influenced by the euro area interest rates and evolved in a different way as interest rates in other countries in transition with similar economic conditions as Slovak ones. The impact of the euro area interest rate on Slovak rates was little but still more important as impact of other countries in transition. Consequently, we can conclude that interbank interest rate evolution is more dependent from expectations, impressions, and illusions and is much less dependent from economic fundamentals.

Acknowledgements

We would like to thank to *professor Patrick Musso* from the University of Nice who significantly enriched our research and to the *VUB Foundation* which financed his teaching mobility at the Faculty of Economics, Technical University of Košice and his participation at the 5th Central European Conference for Regional Science within Open Grant Scheme for *Education 2013 – Foreign Guest Professor*.

References

BARTÓKOVÁ, Ľ., ĎURČOVÁ, J. 2013. Interest rate transmission mechanism in V4 countries. In: *Journal of Applied Economic Sciences.* Vol. 8, No. 4, pp. 426-443.

BARTOLINI, L., BERTOLA, G., PRATI, A. 2001. Banks' Reserve Management, Transactions Costs, and the Timing of Federal Reserve Intervention. In: *Journal of Banking and Finance.* No. 25, pp. 1287-1318.

BARTOLINI, L., BERTOLA, G., PRATI, A. 2002. Day-to-Day Monetary Policy and the Volatility of the Federal Funds Rate. In: *Journal of Money Credit and Banking*, Vol. 34, No. 1, pp. 137-159.

BONANNO, G., CALDARELLI, G., LILLO, F., MANTEGNA, R. N. 2003. Topology of Correlation-based Minimal Spanning Trees in Real and Model Markets. In: *Physical Review.* Vol. 68., no. 4., pp. 1-4.

FONSECA, J. S. da. 2014. Yield curve changes effect on Euro area bond indexes: a partial durations approach. In: *International Journal of Monetary Economics and Finance.* Vol. 7, No. 1 pp. 28-39.

FURFINE, C. H. 1999. The Microstructure of the Federal Funds Market, Financial Markets. *Institutions and Instruments.* Vol. 8, No. 5, pp. 24-44.

GASPAR, V., PÉREZ-QUIRÓS, G., MENDIZÁBAL, H. R. 2004. Interest rate determination in the interbank market. *Banco de Espana Working Papers*. Vol. 7, No. 4, pp. 1-32.

HAMILTON, J. 1996. The Daily Market for Fed Funds. *Journal of Political Economy*, pp. 26-56.

MANTEGNA, Rosario N. 1999. Hierarchical Structure in Financial Markets. *The European Physical Journal B.* vol. 11, pp. 193-197.

McCALLUM, B. 1999. *Issues in the Design of Monetary Policy Rules,* in J. Taylor and M. Woodford (eds.), Handbook of Macroeconomics, Vol. 1C, Amsterdam, North-Holland, chapter 23.

MICCICHÉ, S., BONANNO, G., LILLO, F., MANTEGNA, R. N. 2003. Degree Stability of a Minimum Spanning Tree of Price Return and Volatility. In: *Physica A.* Vol. 324, pp. 66–73.

MIRDALA, R. 2009. Interest rate transmission mechanism of monetary policy in the selected EMU candidate countries. In: *Panoeconomicus.* Vol. 56, No. 3, pp. 359-377.

REŠOVSKÝ, M., HORVÁTH, D., GAZDA, V., SINIČÁKOVÁ, M. 2013. Minimum Spanning Tree Application in the Currency Market. In: *Biatec.* Vol. 21, no. 7, pp. 21-23.

SAUER, S., STURM, J.-E. 2003. Using Taylor Rules to Understand ECB Monetary Policy. *CESifo Working Paper*, No. 1110, pp. 1-33.

TAYLOR, J. 1999. *Monetary Policy Rules*. Chicago, University of Chicago Press.