Granger causality, transfer entropy for financial time series – role of crises

Ewa M. Syczewska, Warsaw School of Economics (Warsaw),
Zbigniew R. Struzik, The University of Tokyo (Tokyo),

FENS 2019, NCBJ, Otwock – Świerk, 3-5 July 2019

1. Motivation for the research
2. Financial crises – detection, dating, differences.
   -- Asian crisis, Russian default crisis, the global crisis
3. Exchange rate behavior
4. Results: linear and nonlinear causality for log returns, and conditional variances;
5. Conclusions

Motivation:

In our earlier research causal relationship between financial variables has been shown for returns of bilateral exchange rates and stock indices (see Syczewska and Struzik (2014)).

The Granger causality was tested with use of both linear VAR test and nonlinear Dicks-Panchenko method;

Differences in causality direction for subperiods covering the global crisis (2007-2010) and other periods.

Aim: The causality tests are applied to extended time series, to check if similar effect exists for other financial crises.

- Causality between log returns of the instruments;
- Causality between volatilities (conditional variance estimates based on the GARCH(1,1) models with skewed t Student distribution).

We are interested in testing causality

(1) between log **returns**:

$$r_t = \log P_t - \log P_{t-1}$$

(2) between their **conditional variance**, estimated with GARCH models.

- Variance or standard deviation is a measure of risk;
- Causality of variances indicates contagion.

Financial crises:

Berger, Bouwman (2016): existing approaches to define and date financial crisis are based on the use of policy interventions or focus on liquidity shocks;

-- no single set of rules for defining financial crisis,

-- some crises "are generated by banking and market shocks, do not involve liquidity problems".

Kohler (2010): "Exchange rate movements during the global financial crisis of 2007-09 were unusual. Unlike in two previous episodes – the Asian crisis of 1997-98 and the crisis following the Russian debt default in 1998 – in 2008 many countries that were not at the centre of the crisis saw their currencies depreciate sharply".

Similarities and differences:

the Asian crisis, the Russian default crisis, the global crisis:

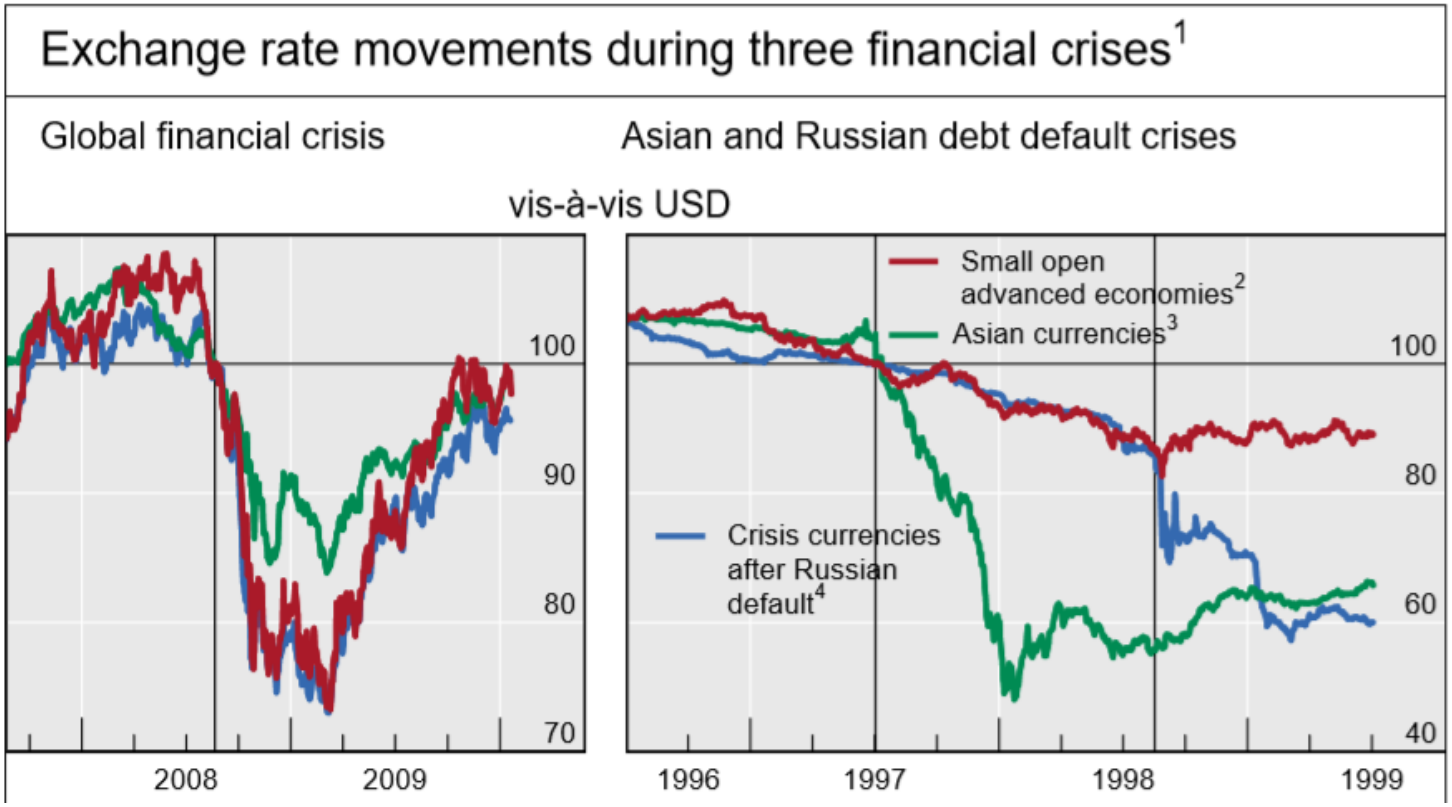
- **Exchange rate regimes:** The Asian crisis and the Russian default crisis involved speculative attacks that forced a number of countries **to abandon fixed exchange rate regimes** (Kohler, p. 40), during the global crisis most countries have **floating or managed exchange rates**.
- **Contagion**:
  Asian crisis – influences the local area;

  Russian default crisis – influenced emerging markets in similar situation (e.g., Brasil);

  2008 crisis – had global influence.

Our additional assumption:

The Russian default crisis have had a strong influence on the Central European economies, including Poland. This should be seen in the results of causality testing.



Source: Kohler (2010), graph 1 p. 41, where:

Red line: average of AUD, CAD, NZD, NOK, SEK exchange rates;
Blue line: average of exchange rates for Brazil, Chile, Russia and South Africa
Green line: average of exchange rates for Indonesia, Korea, Malaysia, Thailand and the Phillipines.

Exchange rates:

- related to rise and fall in uncertainty and risk aversion;
- depend of interest rates differential.

We are interested in testing causality between log returns and between conditional variances, estimated with use of GARCH models.

- Variance or standard deviation is a measure of risk;
- Causality of conditional variances for two instruments indicates contagion (increase of risk for one market/ instrument influences the other area or instrument).

Dating of crisis:

Olbryś, J., E. Majewska (2014) Procedia Economics and Finance, Special issue: International Conference on Applied Economics;
Claessens, S., M. Ayhan Kose: Financial Crises: Explanations, Types and Implications, IMF 2013.

Data set and span:

We use daily observations of the EURPLN exchange rates; indices: DAX representing Euro area, WIG20 representing the WSE; closing daily data, common time zone.
(use of corresponding indices of the two countries can improve quality of bilateral exchange rate models)

- The Asian crisis: July 1997-August 1997;
- The Russian default crisis: July 1998-August 1998.

Difference between crisis – non-crisis results for the global crisis:

(Syczewska, Struzik, 2017, table 3): ld denotes logarithmic difference of prices, i.e., returns for an instrument: $r_t = \ln P_t - \ln P_{t-1}$; returns are stationary in mean.

Pair of variables	Before the crisis	During the crisis
ldDAX to ldEURPLN	0.550 [0.731]	0.217 [0.95]
ldEURPLN to ldDAX	1.521 [0.180]	1.032 [0.397]
ldWIG20 to ldEURPLN	0.880 [0,494]	0,771 [0.571]
ldEURPLN to ldWIG20	**1.648 [0.145]**	**3.660 [0,0027]*** **
ldDAX to ldWIG20	0.984 [0.427]	1.502 [0.187]
ldWIG20 to ldDAX	0.469 [0.800]	0.283 [0.923]

Source: own computations

The Diks-Panchenko test statistics: nonlinear causality

Pair of variables	Before the crisis	During the crisis
No ldDAX to ldEURPLN	0.479 [0.316]	2.697 [0.0035]***
No ldEURPLN to ldDAX	-0.661 [0.746]	3.506 [0.00023]***
No ldDAX to ldWIG20	1.541 [0.062]*	3.598 [0.0017]***

Source: own computations

During the global crisis, lack of causality is strongly rejected for all pairs of variables.

Before the global crisis, the test does not indicate causal relationship for logarithmic returns.

Asian crisis: Subsample July 2nd 1997 – October 31st 1997

Pair of variables	Before the Asian crisis	During the Asian crisis
ldDAX to ldEURPLN	0.632 [0.676]	0.519 [0.681]
ldEURPLN to ldDAX	1.669 [0.153]	0.625 [0.681]
No ldEURPLN to ldWIG20	0.634 [0.674]	0.415 [0.837]
ldWIG20 to ldEURPLN	0.409 [0.841]	0.432 [0.825]

Source: own computations

Pair of variables	Before the Russian default crisis	During the Russian default crisis
ldWIG20 to ldEURPLN	0.7993 [0.554]	0.9825 [0.435]
ldEURPLN to ldWIG20	**0.7734 [0.572]**	**2.341 [0.0501]****
ldDAX to ldEURPLN	0.44495 [0.816]	0.6854 [0.636]
ldEURPLN to ldDAX	**0.2101 [0.957]**	**2.1414 [0.070]***
ldWIG20 to ldDAX	1.5127 [0.197]	1.2095 [0.3135]
ldDAX to ldWIG20	**0.3596 [0.875]**	**1.9507 [0.0965]***

Source: own computations

Tests for volatilities (from GARCH(1,1) model, with skewed t Student distribution):

Pair of variables	Asian crisis	Before Russian default	Russian default crisis
hWIG20 to hEURPLN	0.755 [0.585]	**0.812 [0.448]**	**30.112 [0.0000]*** **
hEURPLN to hWIG20	1.661 [0.156]	**3.710 [0.029] ** **	**1.061 [0.351]**

Source: own computations

- Same pattern of causality between volatility of WIG20 and of EURPLN exchange rate before and during the Asian crisis;
- In contrast with the Russian default crisis – change in before-crisis and during-crisis test results.

Dicks-Panchenko test:

http://research.economics.unsw.edu.au/vpanchenko/#software

Diks, C., V. Panchenko (2006) A new statistics and practical guidelines for nonparametric Granger causality testing, Journal of Economic Dynamics and Control, 30, 1647-1669

Nonlinear; H_0: X does not GC Y

Diks and Panchenko use the estimator based on index function:

$$T_n(\varepsilon) = \frac{(2\varepsilon)^{-d_X-d_Y-d_Z}}{n(n-1)(n-2)} \sum_i \left[\sum_{k,k\neq i} \sum_{j,j\neq 1} \left(I_{ik}^{X,Y,Z} I_{ij}^{Y} - I_{ik}^{XY} I_{ij}^{YZ} \right) \right]$$

where n – number of observations, d_X – number of elements of the X vector, etc.

$I_{ij}^{W} = I(||W_i - W_j|| < \varepsilon) = 1 if ||W_i - W_j|| < \varepsilon, 0$ otherwise.

Comparison of the Diks-Panchenko causality test for returns:

a) Before the Asian crisis

ldDAXPreAC ldEURPLNPreAC	0.766 [0.222]
ldEURPLNPreAC ldDAXPreAC	-0.297 [0.617]
ldWIG20PreAC ldEURPLNPreAC	-0.208 [0.582]
ldEURPLNPreAC ldWIG20PreAC	-0.274 [0.608]

Source: own computations

b) During the Asian crisis

ldDAXAC ldEURPLNAC	-0.712 [0.762]
ldEURPLNAC ldDAXAC	0.628 [0.265]
ldEURPLNAC ldWIG20AC	-0.659 [0.745]
ldWIG20AC ldEURPLNAC	0.014 [0.494]

Source: own computations

The Asian crisis did not seem to influence pattern of causality between the returns for the EURPLN exchange rate and the two corresponding stock indices;

The Diks-Panchenko causality test between volatilities::

During the Russian default crisis, at least for some pairs of variables, the null of no causality is rejected:

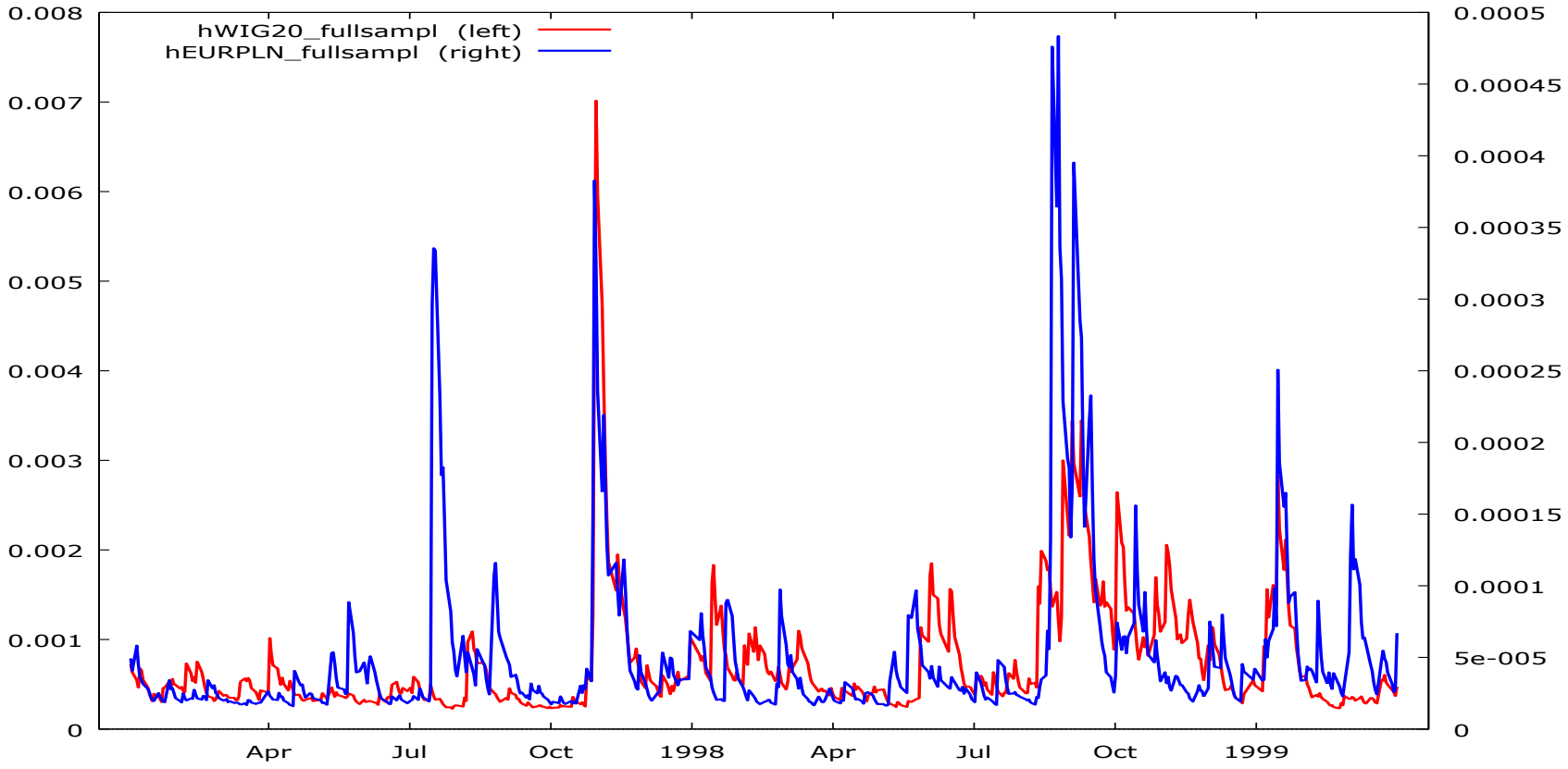
hDAX hEURPLN	**1.779 [0.03763]****
hEURPLN hDAX	0.965 [0.16716]
hDAX hWIG20	0.946 [0.17203]
hWIG20 hDAX	0.545[0.29290]
hEURPLN hWIG20	0.752 [0.22612]
hWIG20 hEURPLN	**1.296 [0.09751]***

Source: own computations

The behavior of estimated volatilities is shown on the following graphs:

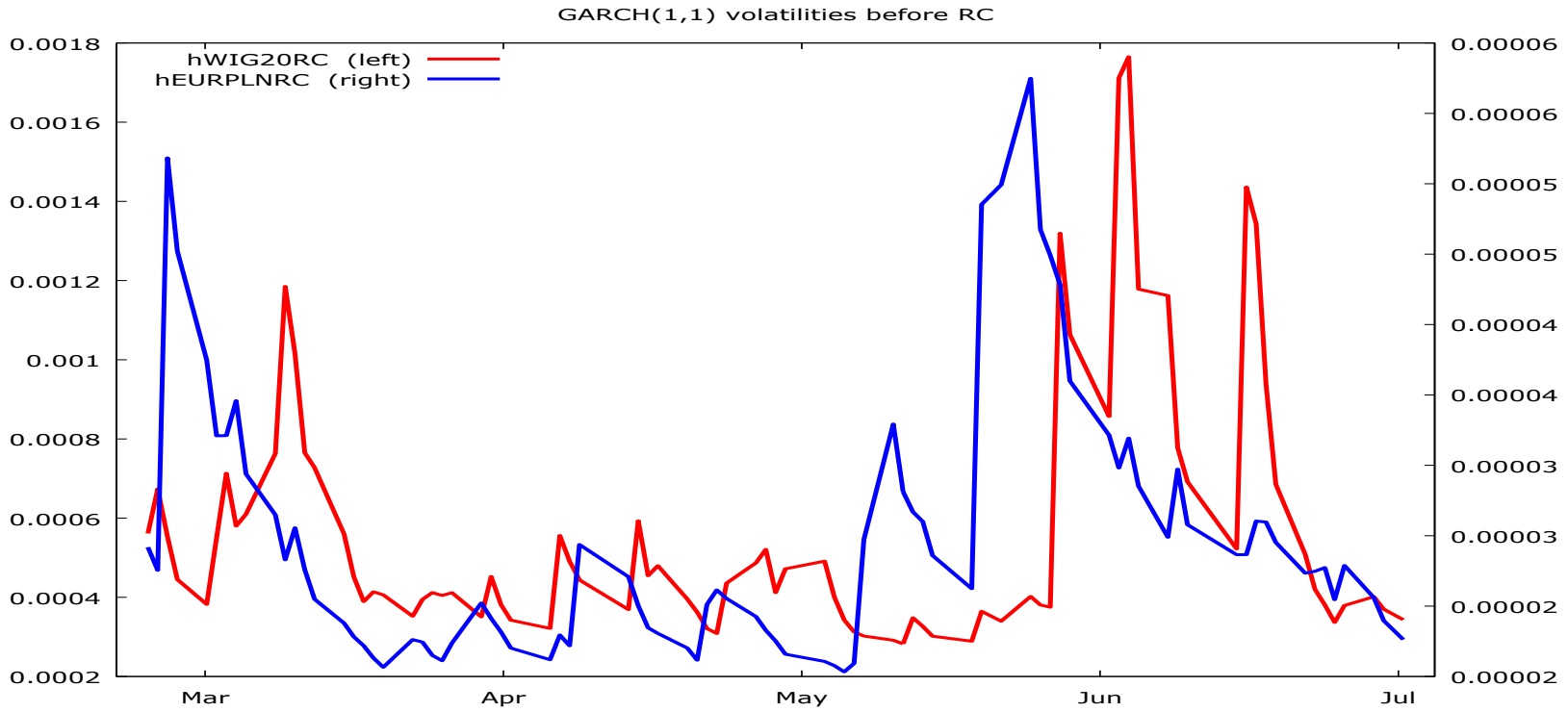
(A) Changing patterns based on the whole sample results
(B) Increases in the stock exchange index volatility seem to follow the similar changes in exchange rate volatility, when estimated before the crisis;
(C) There is increase in volatilities for the three instruments (can be interpreted as increase in perceived risk) in the result of the Russian default crisis.

(A) Graph of volatilities for the whole sample



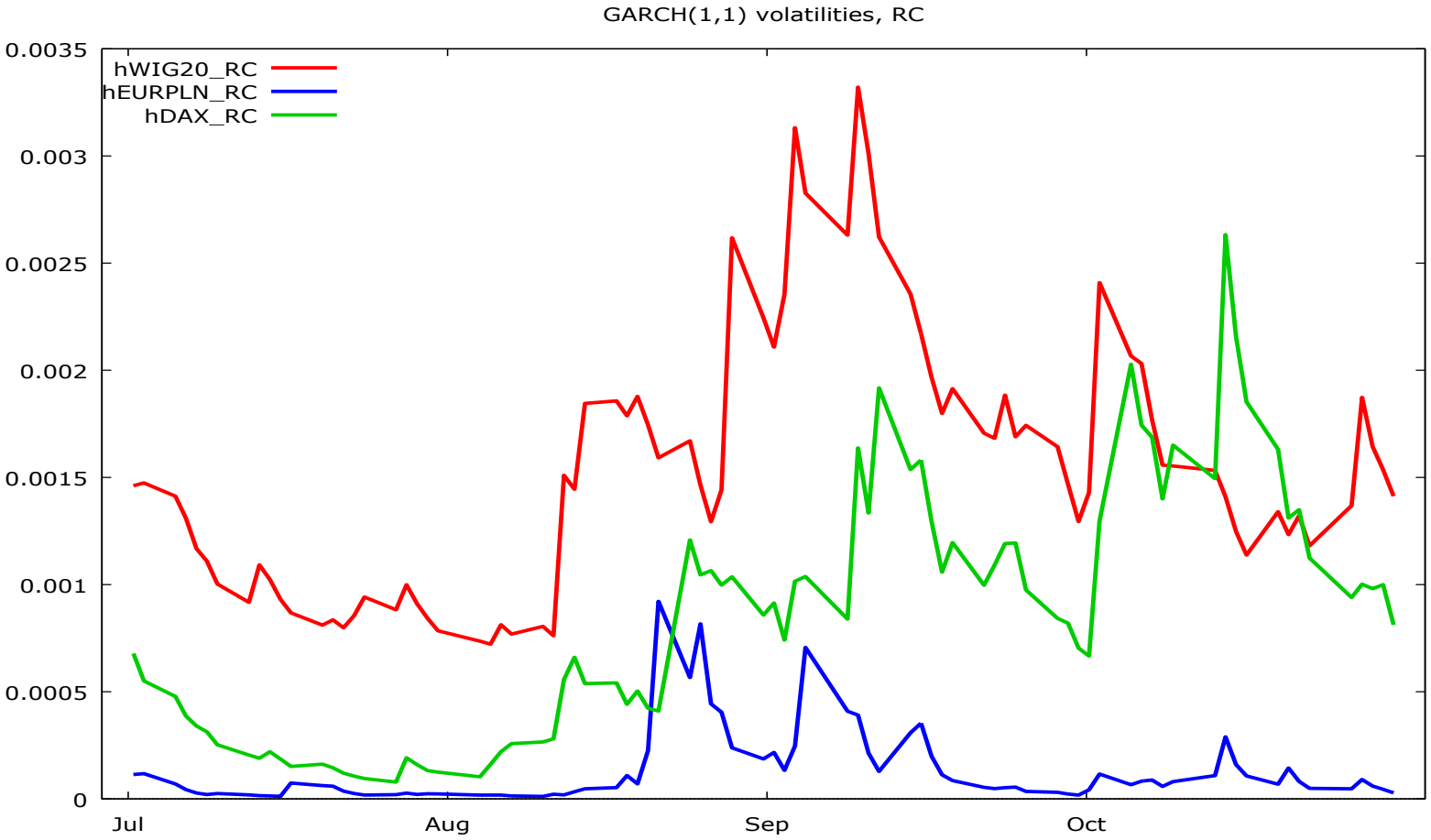
Source: own computations

(B) Graph of volatilities before the Russian default crisis



Source: own computations

(C) Graph of volatilities during and after the Russian default crisis.



Source: own computations

Conclusions:

- Both linear and nonlinear tests show differences in Granger type causality between the three crises:
- -The Asian 1997 crisis had no impact on causality test results for EURPLN exchange rate, the DAX and the WIG20 indices.
- -We have shown that the Russian default crisis impact is shown in changes of causality test results for Poland.
- The global crisis has a marked influence on causality tests both for EURPLN, DAX, WIG20 and for USDPLN, S&P500, WIG20 (as shown in previous research)
- The TE results will be presented in full version of the paper.

Thank you for your kind attention

References:

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