A FRAMEWORK FOR THE TREATMENT OF FINANCIAL CONTAGION EFFECTS IN THE CONTEXT OF THE ACTUAL EUROPEAN TURBULENCES

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Abstract
There is still a debate regarding a possible restoring of the confidence in European financial markets because there are still underlying problems from the super-sized finance that actually worsened. Anti crisis strategy efficiency and future costs of real reform make analysts more prudent in forecasts. In addition, a possible reduction risk appetite and the loss of confidence will fuel a negative perspective regarding the recovery of emerging economies, extreme fragile to regional or global contagion effects.
In modern financial crises, the events spiral out of control, panic and contagion come very fast. Greek debt crisis is the most serious extreme financial event in the Eurozone, with severe contagion features. An analysis of Eurocontagion effects in the context of Greece crisis by using a dynamic version of the Hawkes jump-diffusion model is suggested.

Keywords: financial crisis, contagion, **Greek debt crisis (GDC), Economic and Monetary Union (EMU), Stability and Growth Pact (SGP)**

JEL Classification: G01, G21, C59

1. Introduction

Despite of the signs of recovery after the global crisis Romanian economy is not capable to sustain the recovery and the public debt and deficit problems raised concerns about the risks of debt sustainability. The actual environment in Europe is characterized by disparities in the process of recovery and countries like Greece, Portugal and Spain could trigger a new debt crisis in the entire Euro zone, with severe contagion features.
The incomplete and questionable database and the lack of transparency could affect negatively the investors, and the possible downgrading of the international rating agencies will raised the prime risk with negative consequences that could not be anticipated.
In modern financial crises, the events spiral out of control and panic comes very fast. Some analysts observed that the development of the problems in some European countries (Greek debt crisis is only one example) could build dangerous spiral of bad events, with a quick contagion on all European financial systems.
An analysis of possible European contagion effects in the context of Greece crisis is very important and very actual.

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A dynamic version of the Hawkes jump-diffusion model for the analysis of the contagion effects in Romanian financial markets is proposed. Mutually exciting jump processes added to a continuous Brownian component with possibly stochastic volatility as well as a drift, represents a Hawkes jump-diffusion processes capable to generate observed time-varying correlations and maximal correlations around crisis times, due to the systematic jumps.

It is important to understand that Eurozone countries have to meet and maintain the macro economic convergence criteria (Maastricht): an inflation rate no more than 1.5% higher than the average of the three lowest inflation rates in the previous year; long-term interest rates must not exceed by more than 2% the lowest inflation rates; is required to join the exchange-rate mechanism (ERM II) for two years; a budget deficit not over 3% of GDP; a gross debt to GDP ratio not over 60%. But things that began out of rules could explode.

To understand why the problems is so critical we should mention that in 2001, Greece public debt to GDP was already high (101.5%) and the management to lower it to the 60% limit was questionable. The monetary policy was based on a low level of interest rates, capable to manage the public debt financing under convenient conditions and to encourage the expenditure, capable to fuel an economic growth at an average of 4%. Since the GDP was high, the ratio of public debt regarding to national revenue was acceptable and this prevented the visibility of the structural weakness of the financial equilibrium. In this case is obvious that the existence of strong financial policies for the good functioning is essential and the monitoring based on the Stability and Growth Pact (SGP), a framework with rules for coordinating national financial policies within the EMU, is so critical.

The strategy to prevent excessive budget deficit is based on a preventive (with two policy instruments: early warning and policy advice/ recommendations) and a dissuasive (related to the excessive deficit procedure (EDP) with actions and sanctions) approach.

The EU-IMF negotiations with the Greek government have induced a real yield bubble on Greek debt (in this pyramid of speculation the two-year bonds soared towards 20% at the time of negotiations). The contagion spread out to Portugal where the borrowing costs jumped, to Spain where debt was downgraded, and Italy came worryingly close to a failed debt auction. All European financial markets have slumped and the euro falls to its lowest level in the last four years against the dollar and this trend will continue.

In the aftermath of the EU-IMF Greek aid package, other successive downgrades of Greece, Portugal, and Spain's debt exacerbated the fears of Euro-contagion. Indeed, the analysts and some researchers demonstrate that investors do not believe in the capacity of the country to implement the austerity plan negotiated with the EU and IMF. At the same time, all three major credit rating agencies have downgraded Greece's credit rating, between January and April, 2010.

2. Some critical aspects in the treatment of financial contagion effects

In the modern literature (Calvo, Mendoza, 2000; Chang, Velasco, 2001; Caramazza, 2004; Dornbusch, 2000; Dungey, Gonzalez-Hermosillo, 2005; Dungey, Martin, 2007; Fry, 2009; Rigobon, 2003; Glick, Rose, 1999; Kaminsky, Reinhart, 1998; Kaminsky, Reinhart, 2000; Nikitin, Smith, 2008; Pavlova, Rigobon, 2008; Rijckeghem, Weder, 2001), is demonstrated that the traditional theory of crises (Krugman, 1979; Gerlach, Smets, 1995; Eichengreen, 1996; Obstfeld, 1996), triggered by Brownian statistics is not capable to analyze quantitatively the short time dynamics of multiple markets and the contagion between regions/ segments of markets. There is a lively debate in the literature regarding the meaning to give to the term "financial contagion," whether it should be distinguished from spillovers (Forbes, Rigobon, 2000). In a broad sense, financial contagion is a complex process with both the cross-region transmission of shocks and the increase in the likelihood of successive shocks over time in the affected regions/ markets following an initial shock. While contagion in this definition can take place both during

normal periods as well as during crisis periods, the contagion phenomenon is more prevalent during crisis times.
A first possibility is to study the impact of time varying correlations and jumps on portfolio choice in a framework without mutual excitation (Ang, Bekaert, 2002). In this case it is consider a regime-switching model, with a first regime with low correlations and low volatilities and a second one with higher correlations and volatilities but lower conditional means. In this case, the existence of a higher volatility bear market regime does not nullify the benefits of international diversification, as long as the investor dynamically rebalances the portfolio. Das, Uppal (2004) demonstrate that the loss reduction in diversification due to transmission across markets is not substantial. Ang, Sahalia (2009) derive a closed-from solution to the portfolio choice problem with standard systematic, not mutually exciting, jumps across asset returns.

3. A framework for the analysis of contagion effects by using Merton-Hawkes model

It is possible a simple, but very intuitive treatment of the contagion in crisis periods, by using a dynamic version of the Hawkes jump-diffusion model, equipped with a drift component, a volatility component and mutually exciting jumps. Hawkes processes were originally proposed as mathematical models to represent the transmission of contagious diseases in epidemiology. They have also found applications in neurophysiology and in the modeling of earthquake occurrences (Brillinger, 1988; Ogata, Akaike, 1982). In market microstructure, Bowsher (2007) employs them to jointly model transaction times and price changes at high frequency. Self-exciting models are now also being employed to model joint defaults in portfolios of credit derivatives (Azizpour, Giesecke, 2008). Hawkes processes have also been proposed in the literature on social interactions to model the viral propagation of some phenomena (Crane, Sornette, 2008).
In the literature, mutually exciting processes are special cases of path-dependent point processes (Hawkes, 1971; Hawkes, Oakes, 1974; Oakes, 1975). The intensities of mutually exciting process depend on the paths of the point process and the jump intensities are stochastic processes; the couple jump process-intensity is a Markov process. In the Merton-Hawkes model, the jumps are mutually exciting and this permits a good capture of the contagion phenomenon: a jump raises the likelihood of getting a jump in another place/ segment in the near future.
In crisis periods, intra-day fluctuations are extremely pronounced with an extended range of intraday returns. In this case, from the point of view of the time series, the properties of observed returns should be defined not only by the initial jump, but using the amplification that takes place subsequently and effects on other markets.
A jump in one region/ segment of the market increases the intensity of jumps in the same region (self-excitation) or in other regions/ segments (cross-excitation). Jump processes can be used to analyze the large movements in markets, typical for crisis periods but the interplay between the various jump terms (across markets and over time) is not trivial, and standard specifications are unable to replicate the patterns. Adverse shocks increase the probability of successive adverse shocks in the market and also in other markets.
One of the most important aspects of jumps is related to the fact that they are clustered in time and tend to contaminate (cross-sectional) other regions/ markets. Jump clustering in time is a strong effect in the data.
The actual time series models for financial crises could not generate together the dynamic and the cross-sectional features. The modeling of this propagation of jumps over time and across markets is possible by using a class of Levy jumps, dedicated to driving processes. Levy processes, have independent increments and do not allow for any type of serial dependence, and is necessary a model for asset return dynamics that captures the cross-sectional and serial dependence observed across global markets.
Basically, in a Hawkes process, a jump somewhere raises the probability of future jumps both in the same region and elsewhere. Jumps in asset returns therefore "self-excite" both in space and in

time. In order for the asset returns process to be stationary, we then make the degrees of excitation of the various jumps, or jump intensities, mean revert until the next jump.
The jumps are equipped with a self- and cross-excitation and this introduces a feedback characteristic. The interest is to model the feedback and the amplification process: jumps lead to larger jump intensities, which then produce further jumps; after finishing the excitation, jump intensities revert to the steady state.
In this framework, let m point processes $N_{it}, i=1,...,m,$ and a jump process $N_{i,t}$ for each region. Hawkes process is defined by its intensity $\lambda_{i,t}$ which describes the F_t – conditional mean jump rate per unit of time:

$$\begin{cases} P[N_{i,t+\Delta} - N_{i,t} = 0 \mid Ft] = 1 - \lambda_{i,t}\Delta + o(\Delta) \\ P[N_{i,t+\Delta} - N_{i,t} = 1 \mid Ft] = \lambda_{i,t}\Delta + o(\Delta) \\ P[N_{i,t+\Delta} - N_{i,t} > 1 \mid Ft] = o(\Delta) \end{cases} \tag{1}$$

with dynamic jump intensities:

$$\lambda_{i,t} = \lambda_{i,\infty} + \sum_{j=1}^{m} \int_{-\infty}^{t} g_{i,j}(t-s)\, dN_{j,s}, \qquad i=1,...,m. \tag{2}$$

with (N, λ), a Markov process; the distribution of the jump $N_{j,s}$ is determined by that of the intensities $\lambda_{j,s}$. Equation (2) could be rewritten:

$$\lambda_i = \lambda_{i,\infty} + \sum_{j=1}^{m} \lambda_j \int_{-\infty}^{t} g_{i,j}(t-s)\, ds = \lambda_{i,\infty} + \sum_{j=1}^{m} \left(\int_0^{\infty} g_{i,j}(u) du \right) \lambda_j \tag{3}$$

or in vector form: $\Lambda = \Lambda_\infty + \Gamma \cdot \Lambda$; it results $\Lambda = (I - \Gamma)^{-1} \Lambda_\infty$
In the mutually exciting jump process let assume that asset log-returns follow the semimartingale dynamics:

$$dX_{i,t} = \mu_i dt + \sigma_i dW_{i,t} + Z_{i,t} dN_{i,t}, \qquad i=1,...,m, \tag{4}$$

which consists of a drift term, a volatility term, and mutually exciting jumps.
In an extended model we allow for stochastic volatility:

$$dX_{i,t} = \mu dt + \sqrt{V_{i,t}}\, dW_{i,t}^{x} + Z_{i,t} dN_{i,t}, \tag{5}$$

with the instantaneous variance expressed by:

$$dV_{i,t} = k_i(\theta_i - V_{i,t})dt + \eta_i \sqrt{V_{i,t}}\, dW_{i,t}^{V} \tag{6}$$

In this case the model allows for correlations between the individual Brownian motions and is capable to capture the leverage effect, typical in contagion effects analysis.
In the case of an exponential decay:

$$g_{i,j}(t-s) = \beta_{i,j} e^{-\alpha_i (t-s)}, \quad s<t, \quad i,j=1,...,m, \tag{7}$$

a jump in asset prices causes the intensities to jump up, and then the intensity decays exponentially back: $\lambda_{i,t}$ jumps by $\beta_{i,j}$ whenever a shock in sector j occurs, and then decays back towards a level $\lambda_{i,\infty}$ at speed α_i.
In this prescription, the T matrix is given by

$$\Gamma = \begin{pmatrix} \frac{\beta_{11}}{\alpha_1} \cdots \frac{\beta_{1m}}{\alpha_1} \\ \frac{\beta_{m1}}{\alpha_m} \cdots \frac{\beta_{mm}}{\alpha_m} \end{pmatrix} \tag{8}$$

and each jump intensity has the following dynamics

$$d\lambda_{i,t} = \alpha_i (\lambda_{i,\infty} - \lambda_{i,t}) dt + \sum_{j=1}^{m} \beta_{i,j} dN_{j,t}. \quad (9)$$

The setting of this model is based on dedicated specifications that could be proposed and it is possible to obtain the covariance density matrix and spectral density; the intensity may depend not only on the time for reaction but also on the size of past jump events.

4. Conclusions

The Greek debt crisis is a critical event in the entire Euro zone and could spread negative sentiments toward all countries in EMU, but also in the new admitted countries in the EU. In Romania it is a long run public sector debt with high budget deficit. In addition it is an excessive external debt and a massive current account deficit.

The problem of recovery after the global crisis is a difficult task because the severity of these turbulences was extreme and for Romania and other emerging economies it is necessary a different stimulating framework that should taking into account a lot of particularities. The actual crisis was totally different from the previous ones both as trigger mechanisms, but also the impact on institutions and financial intermediaries. The recovery after crisis should be considered from depending on the countries, because EU contains several categories of countries and the mechanisms to support the recovery of economies should be adapted to specific conditions in each European country.

Europe will face a long and difficult period of convalescence. Even in the absence of the speculative attack extension toward the weak elements of Euro zone, Greece, Spain, and Portugal, the future financial arrangement of 750 billions euro, signals, in fact, a long period of austerity on the continent. Convalescence of Europe is likely to initiate a deflationary shock. And European Central Bank will not hesitate to flood money markets with massive amounts of euros, took over from the Federal Reserve the mantra of exceptionally low interest rates for an extended period of time in a time when other central banks are preparing to retire quantitative monetary relaxation stake. In this context, the Euro currency will remain extreme vulnerable in the fight with other major currencies.

A new concept of the way that contagion effects could be analyzed is presented. Indeed, the modern literature demonstrates that the traditional theory of crises it is not capable to analyze quantitatively the short time dynamics of multiple markets and the contagion between regions/ segments of markets. There is a lively debate in the literature regarding the meaning to give to the term "financial contagion," whether it should be distinguished from spillovers.

In a broad sense, financial contagion is a complex process with both the cross-region transmission of shocks and the increase in the likelihood of successive shocks over time in the affected regions/ markets following an initial shock. The contagion phenomenon is more prevalent during crisis times.

A simple, but very intuitive way to analyze the contagion effects in crisis periods was presented. The proposal is linked to a dynamic version of the Hawkes jump-diffusion model, equipped with a drift component, a volatility component and mutually exciting jumps. In the literature, the applications of Hawkes processes have used them as pure point processes and the paths of the variables of interest are piecewise constant. In the applications regarding contagion effects in crisis periods the focus is on the return dynamics.

References

1. Ait-Sahalia, Y., J. Cacho-Diaz, and T. R. Hurd, 2009, “Portfolio choice with jumps: a closed-form solution”, The Annals of Applied Probability 19, 556-584.
2. Ang, A. and G. Bekaert, 2002, “International asset allocation with regime shifts”, Review of Financial Studies 15, 1137 – 1187.

3. Azizpour, S. and K. Giesecke, 2008, "Self-exciting corporate defaults: Contagion vs. frailty", Working Paper, Stanford University.
4. Brillinger, D. R., 1988, "Maximum likelihood analysis of spike trains of interacting nerve cells", Biol. Cybern. 59, 189-200.
5. Calvo, G. and E. Mendoza, 2000, "Rational contagion and the globalization of securities markets", Journal of International Economics 51, 79-113.
6. Caramazza, F., L. Ricci, and R. Salgado, 2004, "International financial contagion in currency crises", Journal of International Money and Finance 23, 51-70.
7. Chang, R. and A. Velasco, 2001, "A model of financial crises in emerging markets" Quarterly Journal of Economics 116, 489-517.
8. Crane, R. and D. Sornette, 2008, "Robust dynamic classes revealed by measuring the response function of a social system", Proceedings National Academy Science USA 105, 41, 15649.
9. Dornbusch, R., Y. Park, and S. Claessens, 2000, "Contagion: understanding how it spreads", The World Bank Research Observer 15, 177-197.
10. Dungey, M. and B. Gonzalez-Hermosillo, 2005, "Empirical modeling of contagion: a review of methodologies", Quantitative Finance 5, 9-24.
11. Dungey, M. and V. Martin, 2007, "Unravelling financial market linkages during crises", Journal of Applied Econometrics 22, 89-119.
12. Eichengreen, B., A. Rose, and C. Wyplosz, 1996, "Contagious currency crises: First tests", Journal of Economics 98, 463-484.
13. Forbes, K.J. and R. Rigobon, 2002, "No contagion, only interdependence: Measuring stock market comovements", The Journal of Finance 57, 2223-2261.
14. Gerlach, S. and F. Smets, 1995, "Contagious speculative attacks", European Journal of Political Economy 11, 5-63.
15. Glick, R. and A. Rose, 1999, "Why are currency crises regional?" Journal of International Money and Finance 18, 603-617.
16. Hawkes, A.G., 1971, "Spectra of some self-exciting and mutually exciting point processes", Biometrika 58, 83–90.
17. Hawkes, A.G. and D. Oakes, 1974, "A cluster representation of a self-exciting process", Journal of Applied Probabilities 11, 493–503.
18. Kaminsky, G. and C. Reinhart, 1998, "Financial crises in Asia and Latin America: Then and now", American Economic Review 88, 444-448.
19. Krugman, P., 1979, "A model of balance of payments crises", Journal of Money, Credit, and Banking 11, 311-325.
20. Merton, R. C., 1976, "Option pricing when underlying stock returns are discontinuous", Journal of Financial Economics 3, 125144.
21. Nikitin, M. and R. Smith, 2008, "Information acquisition, coordination, and fundamentals in a financial crisis", Journal of Banking and Finance 32, 907-914.
22. Obstfeld, M., 1996, "Models of currency crises with self-fulfilling features", European Economic Review 40, 1037-1047.
23. Ogata, Y. and H. Akaike, 1982, "On linear intensity models for mixed doubly stochastic Poisson and self-exciting point processes", Journal of the Royal Statistical Society, Series B, Vol. 44, No.1, 102-107.
24. Pavlova, A. and R. Rigobon, 2008, "The role of portfolio constraints in the international propagation of shocks", Review of Economic Studies 75, 1215-1256.
25. Prelipcean G., Popoviciu N., and M. Boscoianu., 2008, "The role of predictability of financial series in emerging market applications", Proceedings of the 9th WSEAS International Conference on Mathematics & Computers in Business and Economics (MCBE'80), 203-208.
26. Rijckeghem, C. V. and B. Weder, 2001, "Sources of contagion: Is it finance or trade?", Journal of International Economics 54, 293-308.
27. Rigobon, R., 2003, "On the measurement of the international propagation of shocks: Are they stable?", Journal of International Economics 61, 261-283.