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This article is a non-technical exposition of the paper Modeling Financial Contagion Using Mutually Exciting Jump Processes by Ait-Sahalia, Cacho-Diaz and Laeven (2010).

Introduction

Shocks in financial markets are infectious, as has been made painfully clear by the recent credit and banking crisis, as well as the current Euro zone debt crisis. Indeed, adverse financial shocks seem to increase the likelihood of new adverse financial shocks. This is true not only for the affected sectors, or regions of the world, but also for other sectors or regions of the world, which are not affected initially.

A very recent example is illustrated in Figures 1 and 2. Figure 1 plots the history of Standard and Poor's (S&P) sovereign ratings for Greece, Portugal and Spain over the period January 1, 2000 to June 3, 2010 (publication date of the most recent S&P report when this article is sent to press).

Figure 1 shows that there are long periods where hardly any rating changes are recorded, followed by periods with rating changes in close succession, as if infected. In January 2009, the S&P rating of Greece drops, five days later followed by a drop in the S&P rating of Spain, which in turn is followed in two days time by a downgrade of the S&P rating of Portugal. In December of 2009, the S&P rating of Greece is lowered further. On April 27, 2010, S&P decides to downgrade Greece's debt rating to below investment grade (that is, below BBB-). On the same day S&P downgrades Portugal by two notches. It is followed on April 28, 2010, by an S&P downgrade of Spain from AA+ to AA. It marks the true inception of a Euro zone sovereign debt crisis.

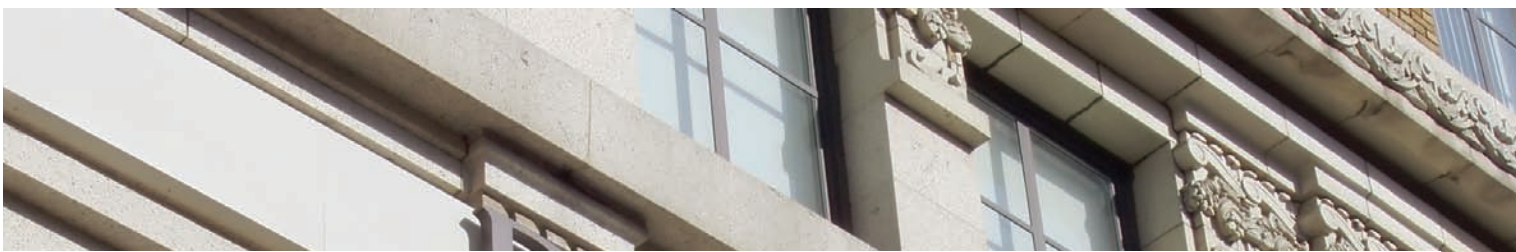
Figure 2 plots the corresponding cascade of downfalls experienced in the stock markets of Greece, Portugal and Spain over the period April 19, 2010 to May 21, 2010. Data are daily MSCI stock index data for the respective countries, normalized to 100 at the beginning of the sample period. The rating changes of April 27 and April 28, 2010, are clearly reflected in the equity markets. May 4, 2010, is the first day of strikes against austerity measures in Greece. On that day, equity markets around the world plumb sharply in fear of contagion. Over the weekend of May 8-9, 2010, the European leaders approved a \$100 billion bailout plan for Greece, the contours of which already became apparent a week earlier. It is supplemented by \$40 billion from the IMF. It leads to a short-term recovery in international equity markets. Finally, continued worries about European debt and stability of the Euro lead to further declines in equity markets in the week of May 10, 2010.

"Greece is teetering on the edge of the financial abyss. In a new low in the country's financial situation, its treasury bonds were given junk status by credit rating agency Standard & Poor's on Tuesday. Portugal, which also saw its government-backed securities downgraded, is in dire straits as well. Greece's new credit rating will render it unable to borrow money, as it is now required to pay astronomical 13 percent interest rates. Rates on Portuguese government loans are also on the rise. [...]"

"[...] A swift, massive, outside intervention seems to be the only way left to prevent an international bond crisis. Greece is no longer the only country in crisis; the entire eurozone is being contaminated." (NRC Handelsblad, International Edition, April 29, 2010).



Figure 1



“The mathematical models currently used by financial institutions, governments and regulatory authorities for developing their risk management strategies insufficiently account for the risk of financial contagion.”



Figure 2

There is no general consensus about how to define ‘contagion’. In this article I define ‘contagion’ as the within-and-between-country contamination of shocks. Contagion in this broad sense is present both under regular market conditions as well as in crises times. It is, however, more prevalent in the crises episodes than during regular market moves.

The mathematical models currently used by financial institutions, governments and regulatory authorities for developing their risk management strategies insufficiently account for the risk of financial contagion. There is a huge demand for improved models.

Appropriate models for financial contagion as well as appropriate inference techniques for those models are of utmost importance. This is so because the contagion phenomenon has a substantial effect

on key problems in financial economics such as risk management, valuation and portfolio choice for financial institutions, government agencies and supervisory authorities.

How to model financial contagion?

Modeling financial contagion is a complex problem, which requires the latest (as well as new) developments in econometrics. It is not only practically highly relevant as motivated in the introduction above, but also scientifically very challenging. By our definition, contagion is the contamination of extreme shocks to economies. It seems therefore natural to model the contagion phenomenon mathematically by means of so-called ‘jump processes’, where the jumps are mutually dependent, both in space (that is, between countries or regions of the world) and in time (that is, between various business days).

In our paper Ait-Sahalia, Cacho-Diaz and Laeven (2010), we propose to add to a standard model for financial markets in normal circumstances a jump model that allows for mutually dependent extreme market moves. In the model, upon the occurrence of a shock (jump) to the economy, the likelihood of having more jumps ramps up. Probabilistically, we say that the jump intensity that models the arrival rate of the jumps in the various sectors or regions of the world is a stochastic process itself and increases upon the arrival of shocks. In case no further jumps occur, the effect dies out in a short period time, while if further shocks do occur, the jump intensity further increases. The model generates time periods where multiple shocks occur as well as time periods where hardly any shocks are observed. This is consistent with empirical evidence of so-called ‘jump clustering’. See also Figures 1 and 2 discussed earlier.

In addition to proposing a model for financial contagion and investigating various applications of the model, we develop an econometric method to estimate our model from standard financial data. We also implement the method ourselves on international equity index data. We find that shocks to US equity markets tend to be highly infectious both for the US equity markets themselves as well as for other international equity markets. Also, we find that shocks to other non-US equity markets tend to be self-infecting. We further find that there is little evidence for infection from non-US equity markets to US equity markets.

Detailed formulas describing the proposed model and the proposed estimation methodology are documented in Ait-Sahalia, Cacho-Diaz and Laeven (2010) and Matlab code to implement the



estimation procedure is available from the authors upon request.

Applications of the model

Our model for financial contagion can be applied to various canonical problems in financial economics. A straightforward application of the model, once estimated from financial data, is to risk management and scenario generation. Due to the fact that the model generates clusters of jumps, it produces fatter tails than commonly adopted models for risk management and scenario generation do. Commonly adopted models include normal (Gaussian) models such as the Black-Scholes-Merton model familiar to financial economists, continuous diffusion models and simple (Poisson-type) jump models. None of these models (with realistic parameter values) can adequately generate the contagion phenomenon we are after. And while commonly adopted models underestimate the risk of contagion and the occurrence of multiple extremes in various markets over a short period of time, this is no longer true for the model we propose. This is important for the development of adequate risk management strategies as well as for stress testing in the insurance and financial industry.

A second key application of our model is to optimal portfolio choice for international investors. Traditionally, financial theory has emphasized the importance of international diversification when composing an investment portfolio. If, however, markets tend to drop in close succession, then there are obvious limits to the diversification benefits obtained by investing in different equity markets around the world. Contagion is one of the phenomena that may help explaining the so-called

'home bias'. Home bias is the stylized fact that investors have a tendency to invest more in domestic markets and less in foreign markets than traditional portfolio theory would prescribe them to do. If equity markets are strongly connected and shocks to the various markets are quite likely to contaminate, then the benefits of international diversification are moderate, and smaller than traditional models imply. When computing the optimal investment portfolio, it is important to adequately quantify the possible diversification benefits, in order to assess whether international diversification is still beneficial despite the possibly higher costs (transaction, monitoring,...) of investing in foreign equity.

A third and final application consists in measuring the degree of fear, or market stress, in financial markets. We argue that the jump intensity in our model, which models the arrival rate of the jumps (shocks) in the various sectors or regions of the world, is a good indicator of the degree of fear in the market place. It is different from the so-called 'volatility index' that is often used as measure of the degree of fear, and that aggregates both regular (moderate) moves and extreme moves. Our measure solely reflects extreme moves, as seems more natural. As such we think the jump intensity in our model may serve as a proper financial fear gauge.

References

Aït-Sahalia, Yacine, Julio Cacho-Diaz and Roger J. A. Laeven (2010). Modeling financial contagion using mutually exciting jump processes, Technical Report, Princeton University and Tilburg University, available from the webpage <http://center.uvt.nl/staff/laeven>.