Research Statement

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My research interests span the areas of applied econometrics, financial econometrics, nonlinear time series analysis, business cycles, interdisciplinary research (statistical physics & econometrics), financial networks and systemic risk analysis.

Background and Current Work

The global financial crisis of 2007–2009 and the 2011 sovereign & banking risks in the euro area have created renewed interest to develop a better understanding of systemic risk. The financial system has become considerably more complex and interconnected over the past two decades.

My current research aims at capturing linkages and vulnerabilities of the financial system. This includes identifying potential threats to financial stability and detection of early warning signals to provide prescriptions on the appropriate policy measures to prevent and manage such risks. In this respect, my current working paper centres on a novel information theoretic approach and time series graphs for the identification and quantification of causal dependencies on multivariate time series. This proposed approach identifies linkages, transmission channels, assess strength of such connections and in particular, provide lag of causal dependencies. A comprehensive analysis of the feasibility of the proposed approach is provided via simulated data and real data on financial institutions. The paper has been submitted to be considered for publication. However, a very preliminary version of the work has been published as working paper of the EU Systemic Risk (SYRTO) project:

- "The kiss of information theory that captures systemic risk".
  - In this work, we provide a new approach to understanding systemic risk tomography in finance and insurance sectors. The analysis is achieved by quantifying causal coupling strength, which identifies the existence of causal dependencies between two components of a multivariate time series and assesses the strength of their association by defining a meaningful coupling strength. The measure of association is general, causal and lag-specific, reflecting a well interpretable notion of coupling strength and is practically computable. A comprehensive analysis of the feasibility of this approach is provided via simulated data and then applied to the monthly returns of hedge funds, banks, broker/dealers, and insurance companies.

My next area of research focus on exploring the relationship between sovereign - banks and other financial intermediaries. Aside studying the interconnections between and within these sectors, the work will centre on using multivariate nonlinear signal-based & econometrics approach to extract information useful as early warnings for predictive prospets. The idea is to develop and employ techniques that may reveal the vulnerable parts of the financial systems to give risky scenarios arising due to close interconnections with sectors/countries that are directly exposed to unforeseen events. In addition, the incorporation of some modern signal processing and machine learning techniques in learning the structure and interactions within and between variables will be very useful in policy-making, since it facilitates the selection of appropriate processing methods, suggested by the data itself. Moreover, the identification of transmission channels and how the network structure of the financial system change over time will aid in drawing meaningful conclusions for appropriate policy-making. In this respect, my research will help policy makers safeguard the reputation of central banks and the financial system in today's globalized economy.

In a nutshell, the current focus of my research is analysing multivariate time series to detect the relevant financial & economic linkages as a channel for propagation of shocks. Thus I will make use of multivariate nonlinear econometric models/techniques for signal analysis, information theory and other modern interdisciplinary approaches that may be relevant in studying systemic risk.

PhD Research Contributions

The main contributions from my doctoral thesis were to introduce modern non-linear interdisciplinary and open-minded approaches for data analysis in economics and Finance with special attention on business cycles and financial crisis. Here is an outline of the contributions made via publications:

1. **Addo, P. M.**, Billio, M., Guégan, D. (2013). *"Nonlinear Dynamics and Recurrence Plots for Detecting Financial Crisis"*, The North-American Journal of Economics and Finance, Volume 26, December 2013, Pages 416–435. http://dx.doi.org/10.1016/j.najef.2013.02.014.

    - This study centers on the detection and characterization of financial crisis. Identification of financial bubbles and crisis is a topic of major concern since it is important to prevent collapses that can severely impact nations and economies. Our analysis deals with the use of the recently proposed 'delay vector variance' (DVV) method, which examines local predictability of a signal in the phase space to detect the presence of determinism and nonlinearity in a time series. Optimal embedding parameters used in the DVV analysis are obtained via a differential entropy based method using wavelet-based surrogates. We exploit the concept of recurrence plots to study the stock market to locate hidden patterns, non-stationarity, and to examine the nature of these plots in events of financial crisis. In particular, the recurrence plots are employed to detect and characterize financial cycles. A comprehensive analysis of the feasibility of this approach is provided. We show that our methodology is useful in the diagnosis and detection of financial bubbles, which have significantly impacted economic upheavals in the past few decades.

2. **Addo, P. M.**, Billio, M., D. Guégan (2014). *"The Univariate MT-STAR Model and a new linearity and unit root test procedure"*. Computational Statistics & Data Analysis (CSDA), Volume 76, Pages 4–19. http://dx.doi.org/10.1016/j.csda.2013.12.009.

    - In this work, a novel procedure to test for unit root in a nonlinear framework is proposed by first introducing a new model – the MT-STAR model – which has similar properties as the ESTAR model but reduces the effects of the identification problem and can also account for cases where the adjustment mechanism towards equilibrium is not symmetric. The limiting non-standard asymptotic distributions of the proposed unit root test is then derived. Finally, the power of the test is evaluated through a simulation study and some empirical illustrations are given at the end.

3. **Addo, P. M.**, Billio, M., D. Guégan (2014). *"Nonlinear Dynamics and Wavelets for Business Cycle Analysis"*. In Marco Gallegati and Willi Semmler (Eds.), "Wavelets Applications in Economics and Finance", Dynamic Modeling and Econometrics in Economics and Finance Volume 20, pp 73–100. Springer Series. http://dx.doi.org/10.1007/978-3-319-07061-2_4.

    - This study provides a signal modality analysis to characterize and detect nonlinearity schemes in the US Industrial Production Index time series. The analysis is achieved by using the recently proposed 'delay vector variance' (DVV) method, which examines local predictability of a signal in the phase space to detect the presence of determinism and nonlinearity in a time series. Optimal embedding parameters used in the DVV analysis are obtained via a differential entropy based method using Fourier and wavelet-based surrogates. A complex Morlet wavelet is employed to detect and characterize the US business cycle. A comprehensive analysis of the feasibility of this approach is provided. The results coincide with the business cycles peaks and troughs dates published by the National Bureau of Economic Research (NBER).

4. **Addo P.M.**, M. Billio, D. Guégan (2014), *"Turning point chronology for the Euro–Zone: A Distance Plot Approach"*. Journal of Business Cycle Measurement & Analysis. http://dx.doi.org/10.1787/jbcma-2014-5jxwz80d73q8.

    - The paper proposes a transparent way of establishing a turning point chronology for the Euro-zone business cycle. Our analysis is achieved by exploiting the concept of recurrence plots, in particular distance plots, to characterize and detect turning points of the business cycle. Firstly, we apply

the concept of recurrence plots on the US Industrial Production Index (IPI) series: this serves as a benchmark for our analysis since it already exists a reference chronology for the US business cycle, provided by the Dating Committee of the National Bureau of Economic Research (NBER). This concept is then used to construct a turning point chronology for the Euro-zone business cycle. In particular, study shows that this approach permits to detect turning points and study the business cycle without *a priori* assumptions on the statistical properties of the underlying economic indicator.

5. Addo P.M., *"Multivariate Self–Exciting Threshold Autoregressive Models with eXogenous Input"*. Papers 1407.7738, arXiv.org (2014)

    - A preliminary version of a work in progress on a multivariate nonlinear model. This study defines a multivariate Self–Exciting Threshold Autoregressive with eXogenous input (MSETARX) models and present an estimation procedure for the parameters. The conditions for stationarity of the nonlinear MSETARX models is provided. The efficiency of an adaptive parameter estimation algorithm and LSE (least squares estimate) algorithm for this class of models is investigated via simulations. The modeling procedure for the MSETARX models and problems of estimation are briefly considered.

Selected Conference and Seminar Presentations

- Meeting of the Consortium for Systemic Risk Analytics (CSRA), Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts on December 15 th 2014, USA.
- 34th International Symposium on Forecasting (ISF 2014), Rotterdam, Netherlands, June 29 – July 2, 2014.
- 7th CSDA International Conference on Computational and Financial Econometrics (CFE 2013), Senate House, University of London, UK, 14–16 December 2013.
- EBIM-EDEEM-Paris1 Doctoral School Jamboree at the Center for Operations Research and Econometrics (CORE), Université Catholique de Louvain (UCL), Louvain-La-Neuve, Belgium, 8–10 July 2013.
- 6th CSDA International Conference on Computational and Financial Econometrics (CFE 2012), Conference Centre Oviedo, Spain, 1–3 December 2012.
- 20th International Conference on Computational Statistics (COMPSTAT 2012), Amathus Beach Hotel, Limassol, Cyprus, 27–31 August 2012.
- EBIM-EDEEM-Paris1 Doctoral School Jamboree, Université Paris 1 Panthéon-Sorbonne, 11–12 July, 2012.
- Econometrics Internal Seminar at the *Center for Operations Research and Econometrics* (CORE), Université Catholique de Louvain (UCL), Louvain-La-Neuve, Belgium, 30 May, 2012.
- Fifth International MAF 2012 Conference – Mathematical and Statistical Methods for Actuarial Sciences and Finance, Venice, Italy, 10–12 April, 2012.
- Second International Symposium in Computational Economics and Finance (ISCEF 2012), El Mouradi Gammarth, Tunis, Tunisia, March 15–17, 2012.
- 5th CSDA International Conference on Computational and Financial Econometrics (CFE 2011), Senate House, University of London, UK, 17–19 December 2011.
- Université Paris 1, Panthéon Sorbonne, Maison des Sciences Economiques (MSE), MMEF-QEM-EDEEM Graduation Ceremony (2011), Chaired by Edward C. Prescott, July 8, 2011.

Other research activities

- **Co-organiser of PhD student lunch seminars, Axe Finance at CES, Université Paris 1, Panthéon-Sorbonne, France**
- **Reviewer** for *Economic Modelling*, *Studies in Nonlinear Dynamics & Econometrics*, *Journal of Business Cycle Measurement & Analysis*, *Computational Economics*.
- **Professional Networks**: *Member, International Institute of Forecasters (IIF), April 2014–Present. Member, Euro Area Business Cycle Network (EABCN), 2013–Present. Member, ERCIM WG on Computational and Methodological Statistics (CMStatistics), 2013–Present. Member, Computational and Financial Econometrics Network (CFEnetwork), 2013–Present. Member, The Statistics and Probability African Society (SPAS), 2012–Present. Member, Erasmus Mundus Students and Alumni Association (EMA), 2009–Present.*