Curriculum Vitæ

Personal information

Surnames, first name	**CARRO PATIÑO, Adrián**
Nationality, date of birth	Spanish, 14/01/1987
Postal address	Banco de España, Calle de Alcalá, 48, 28014 Madrid, Spain
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Online academic IDs	ORCID: 0000-0001-9838-3027 ResearcherID: F-7290-2016
	ResearchGate: Adrian_Carro Google Scholar: Adrián Carro

Research fields

Topics	Macroeconomics, real estate, macroprudential policy, financial stability, systemic risk
Methods	Agent-based modelling, network science, data science, complexity science

Work experience

Oct. 2019 – present	**Banco de España**, Financial Stability and Macroprudential Policy Department, Macroprudential Policy Division: Research Economist
Oct. 2016 – Sep. 2019	**University of Oxford**, Institute for New Economic Thinking (INET) at the Oxford Martin School: Postdoctoral Research Officer
Oct. 2016 – Sep. 2019	**University of Oxford**, Oxford Martin School: Oxford Martin Fellow
Nov. 2017 – Sep. 2019	**Bank of England**, Macro-Financial Risks Division: Visiting Fellow

Education

2011 – 2016	**PhD in Physics**, Universitat del les Illes Balears – CSIC, Institute for Cross-Disciplinary Physics and Complex Systems (IFISC). Advisors: Prof. Raúl Toral, Prof. Maxi San Miguel Thesis: Individual-based models of collective dynamics in socio-economic systems
2010 – 2011	**MSc in Theoretical Physics of Complex Systems.** Université Pierre et Marie Curie (Paris 6) and École Normale Supérieure. Advisor: Prof. Gérard Weisbuch Thesis: Sustainable development & spatial inhomogeneities: the role of transportation cost
2005 – 2010	**BSc in Physics.** Universidade de Santiago de Compostela

Research projects and working papers

Sep. 2020 – present

Prudential regulation of the UK banking and housing sectors (with Bardoscia, M., Hinterschweiger, M., and Uluç, A., Popoyan, L., Napoletano, M., Roventini, A.)

In collaboration with the Bank of England, the University of Pisa and the Scuola Superiore Sant'Anna, we are coupling an existing macroeconomic agent-based model, populated by heterogeneous firms, consumers and banks, with our own agent-based housing market model. Joining these two models will allow us to expand on our previous study of borrower-based macroprudential measures in different ways. First, by endowing banks with consistent balance sheets, we will be able to consider also capital requirements, including sectoral buffers (mortgage vs corporate). Second, by endogenising consumption and wages, the model will capture the equilibrium effects of macroprudential policies, such as those linked with the decrease in consumption when households have to save for larger deposits. Finally, it will allow us to study the interaction between the business cycle and the house price cycle, including potential spillovers from policies aimed at containing one or the other.

Feb. 2020 – present

Systemic risk in the Spanish interbank network (with Stupariu, P.)

We consider two extensions of an existing dynamical model of financial contagion in interbank markets via the credit quality channel (Battiston et al, 2012). This model focuses on the increase of the probability of default of banks directly affected by some external shock, which leads to an increase in the expected loss of the credit portfolio of their creditors. This, in turn, produces a deterioration of the equity (net worth) of these creditors and an increase of their own probability of default, which sets on a new round of financial contagion. This iterative process continues until a fixed point is reached, which can be proved to maximise individual and total equity values. As opposed to the original model, characterised by a linear transmission of shocks, and to later extensions, which considered only nonlinear functional forms unrelated to the bank's characteristics, we propose here a nonlinear functional form akin to a logistic function with a threshold dependent on the bank's initial capital ratio. In this way, for a given relative equity loss, banks with a lower capital ratio will see their probability of default increase more than better capitalised banks. Furthermore, in order to model the incomplete information that banks have about the internal state of their counterparties, we introduce uncertainty in each bank's assessment of the probability of default of its borrowers. Using data from the official credit register of the Bank of Spain, we find that the effects of uncertainty are most important around levels of stress for which the system switches from stability to instability. Thus, taking uncertainty into account becomes relevant precisely at the point when policy decisions need to be made.

Nov. 2017 – present

Macroprudential policy in an agent-based model of the UK housing market (with Hinterschweiger, M., Uluç, A. and Farmer, J. D.)

In collaboration with the Bank of England, we have been developing an agent-based model of the UK housing market to study the impact of macroprudential policies on key housing market indicators. This approach enables us to tackle the heterogeneity in this market by modelling the individual behaviour and interactions of first-time buyers, home owners, buy-to-let investors, and renters from the bottom up, and observe the resulting aggregate dynamics in the property, rental and credit markets. The model is calibrated using a large selection of micro-data, including data from the leading UK real estate online search engine as well as loan-level regulatory data. We perform a series of comparative statics exercises to investigate the impact of (i) a hard loan-to-value limit, and (ii) a soft loan-to-income limit, allowing for a limited share of unconstrained new mortgages. We find that, first, housing policies tend to mitigate the house price cycle by reducing credit availability and therefore leverage. Second, a policy targeting a specific risk measure may also affect other risk metrics, necessitating a careful calibration of the policy to achieve a given reduction in risk. Third, policies targeting the owner-occupier housing market can spill over to the rental sector, as a compositional shift in home ownership from owner-occupiers to buy-to-let investors affects the supply of and demand for rental properties.

Publications

Peer-reviewed journals (10)

Glavatskiy, K. S., Prokopenko, M., Carro, A., Ormerod, P., Harré, M. (2021). Explaining herding and volatility in the cyclical price dynamics of urban housing markets using a large-scale agent-based model. *SN Business & Economics, 1*(76)

[Journal Citation Reports, 2017; Scimago Journal Rank, 2017]

Yang, J., Carro, A. (2020). Two tales of complex system analysis: MaxEnt and agent-based modeling. *The European Physical Journal Special Topics, 229*, 1623-1643
[Impact Factor: 2.210; Rank: 2nd quartile journal in miscellaneous physics and astronomy]

Artime, O., Carro, A., Fernández-Peralta, A., Ramasco, J. J., San Miguel, M., Toral, R. (2019). Herding and idiosyncratic choices: Nonlinearity and aging-induced transitions in the noisy voter model. *Comptes Rendus Physique, 20*(6), 262
[Impact Factor: 2.892; Rank: 1st quartile journal in miscellaneous physics and astronomy]

Fernández-Peralta, A., Toral, R., Carro, A., San Miguel, M. (2018). Stochastic pair approximation treatment of the noisy voter model. *New Journal of Physics, 20*, 103045
[Impact Factor: 3.579; Rank: 1st quartile journal in miscellaneous physics and astronomy]

Fernández-Peralta, A., Toral, R., Carro, A., San Miguel, M. (2018). Analytical and numerical study of the non-linear noisy voter model on complex networks. *Chaos: An Interdisciplinary Journal of Nonlinear Science, 28*, 075516
[Impact Factor: 2.415; Rank: 18th journal in statistical and nonlinear physics]

Carro, A., Toral, R., San Miguel, M. (2016). Coupled dynamics of node and link states in complex networks: A model for language competition. *New Journal of Physics, 18*, 113056
[Impact Factor: 3.579; Rank: 1st quartile journal in miscellaneous physics and astronomy]

Carro, A., Toral, R., San Miguel, M., (2016). The noisy voter model on complex networks. *Scientific Reports, 6*, 24775
[Impact Factor: 4.122; Rank: 5th journal in multidisciplinary science]

Carro, A., Toral, R., San Miguel, M. (2015). Markets, Herding and Response to External Information. *PLoS ONE, 10*(7), e0133287
[Impact Factor: 2.766; Rank: 1st quartile journal in agricultural and biological sciences]

Carro, A., Vazquez, F., Toral, R., San Miguel, M. (2014). Fragmentation transition in a coevolving network with link-state dynamics. *Physical Review E, 89*(6), 062802
[Impact Factor: 2.284; Rank: 9th journal in statistical and nonlinear physics]

Carro, A., Toral, R., San Miguel, M. (2013). The role of noise and initial conditions in the asymptotic solution of a bounded confidence, continuous-opinion model. *Journal of Statistical Physics, 151*(1-2), 131-149
[Impact Factor: 1.496; Rank: 10th journal in statistical and nonlinear physics]

Peer-reviewed conference proceedings (1)

Taghawi-Nejad, D., Tanin, R. H., Del Rio Chanona, M. R., Carro, A., Farmer, J. D., Heinrich, T., Sabuco, J., Straka, M. J. (2017). ABCE: A python library for economic agent-based modeling. *International Conference on Social Informatics*, 17-30

Policy briefs and technical reports

Lord, A., Dunning, R., Dockerill, B., Burgess, G., Carro, A., Crook, T., Watkins, C., Whitehead, C. (2018). The Incidence, Value and Delivery of Planning Obligations and Community Infrastructure Levy in England in 2016-17. *Ministry of Housing, Communities and Local Government*

Conferences and workshops

Jun. 2019 — **WEHIA'19, 24th Workshop on Economic Science with Heterogeneous Interacting Agents, City, University of London, UK.** Talk: *The impact of transport infrastructure on housing markets: An agent-based modelling approach*

Jun. 2018 — **Seminar at the OECD, Paris, France.** Invited seminar: *Agent-based modelling for public policy: A housing market example*

Jun. 2018 — **Oxford Summer School on Economic Networks, University of Oxford, UK.** Invited lecture: *Network structure in simple agent-based models: analytical approaches*

Jun. 2018 — **Modelling Complex Urban Environments, University of Waterloo, Canada.** Invited lecture: *Emergence of boom and bust cycles in an agent-based model of the housing market*. Talk: *The impact of transport infrastructure on housing markets: An agent-based modelling approach*

Sep. 2017 — **Heterogeneous Agents and Agent-based Modelling: The Intersection of Policy and Research, Department of the Treasury, Washington, D.C., USA.** Organised by the Office of Financial Research (OFR), Brandeis University, and the Bank of England.

Sep. 2017	**Course on agent-based modelling for policy (within the "10 years from the crash" programme), London, UK.** Invited talk: *Agent-based modelling for policy design: two housing market examples*
Jul. 2017	**Urban Analytics Data Dive, Alan Turing Institute, London, UK.** Team awarded second place for the challenge "Where could we build more houses?"
Feb. 2017	**Seminar at the Financial Computing & Analytics group, UCL, London, UK.** Invited talk: *Herding behaviour and financial markets: the role of topology and external information*
Jan. 2017	**Industrial and Infrastructure Strategy post Brexit: Understanding the Issues and Managing the Risks and Uncertainty, London, UK.** Invited talk: *Using agent-based modelling to evaluate the benefits of infrastructure systems*
Sep. 2016	**CCS'16, Conference on Complex Systems, Amsterdam, The Netherlands.** Talk: *The noisy voter model on complex networks*. Talk: *Coupled dynamics of node and link states: A model for language competition*
Sep. 2015	**EC2015, Econophysics Colloquium, Prague, Czech Republic.** Talk: *Network effects on an agent-based market model with herding behavior*
Jun. 2015	**IC2S2, International Conference on Computational Social Science, Helsinki, Finland.** Poster: *Markets, herding and response to external information*. Poster: *Coupled dynamics of node and link states: a model for language competition*
Jun. 2013	**WEHIA'13, 18th Workshop on Economic Science with Heterogeneous Interacting Agents, Reykjavík University, Iceland.** Poster: *Network effects on the local and dynamic properties of an agent-based herding model*
Jun. 2012	**WEHIA'12, 17th Workshop on Economic Science with Heterogeneous Interacting Agents, University of Pantheon-Assas Paris II, Paris, France.** Talk: *Stochastic resonance and diversity in an agent-based herding model*
Between 2011 and 2017	Apart from these, I also presented 8 posters, 9 talks, and 1 invited talk at 12 other national and international conferences and 4 summer schools (details available upon request)

Honours and awards

2012 – 2016	**Scholarship of the Training Programme for Academic Staff (FPU).** Funded by: Ministry of Education of Spain. Scholarship number: AP2012-0547. Personally awarded.
2009 – 2010	**Undergraduate Research Fellowship.** Funded by: Ministry of Education of Spain. Personally awarded.

Research visits

Jan. – Feb. 2019	**University of Sydney**, Centre for Complex Systems. Host: Prof. Mikhail Prokopenko
Jan. – Feb. 2018	**University of Cape Town**, African Institute of Financial Markets and Risk Management (AIFMRM). Host: Dr. Co-Pierre Georg
Apr. – Jun. 2016	**University of Oxford**, Institute for New Economic Thinking (INET) at the Oxford Martin School. Host: Prof. Doyne Farmer

Other professional activities

Teaching experience	Teaching Assistant for Statistical Mechanics (4th year undergraduate level), Universitat de les Illes Balears, Spain.
	Supervision of 4 students on different undergraduate and postgraduate research projects, University of Oxford, UK.
Refereeing	Advances in Complex Systems, Environment and Planning B - Urban Analytics and City Science, Journal of Statistical Mechanics: Theory and Experiment, Language Dynamics and Change, Physica A, SocInfo2017 - International Conference on Social Informatics
Conference organisation	Co-organiser of the workshop "Young Researchers at the Crossroads" (2017), linked to the conference "Crossroads in Complex Systems", Universitat de les Illes Balears, Spain.

Computer skills

Programming languages: **Fortran, C/C++, Java, Python**
Data analysis and graphing software: Python (Matplotlib, networkX, pandas)
Simulation methods: Molecular Dynamics, Monte Carlo, Agent-Based Simulation
Text processing and office packages: LaTeX, LibreOffice, Microsoft Office

Language skills

Mother tongue — **Spanish**

Foreign languages — **English:** C2 Proficient user **French:** C1 Proficient user **German:** A1 Basic user

Feb. 2013 — **DALF C1 test (Diplôme Approfondi de Langue Française).** Score: 69.5 / 100
Alliance Française, Palma de Mallorca, Spain

Aug. 2008 — **IELTS test (International English Language Testing System).** Band score: 7.5 / 9
Sheffield Hallam University, Sheffield, United Kingdom