November 2024

Gabriel Rodriguez-Rondon

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Education

Ph.D. Economics, McGill University	expected July 2025
M.A. Economics, McGill University	2019
B.A. Economics (Honours), Carleton University	2016

Fields of Interest

Econometrics, Macroeconomics and Monetary Economics, Finance, Machine Learning

Dissertation

Title: *Monte Carlo Test Methods for Markov Switching Models and Stochastic Volatility Models with Application in Macroeconomics and Finance*

Committee: Prof. Jean-Marie Dufour (Chair, McGill University), Prof. John Galbraith (McGill University), Prof. Zhongjun Qu (Boston University), Prof. Hafedh Bouakez (HEC Montreal)

Submitted Papers

1. "Estimation and Inference for Higher-order Stochastic Volatility Models with Leverage", with Jean-Marie Dufour & Md. Nazmul Ahsan, Discussion Paper, McGill University, 70 pages. Revised November 2024. Submitted to *Journal of Time Series Analysis* (revision requested).

2. "MSTest: An R-package for Testing Markov-Switching Models", with Jean-Marie Dufour, Discussion Paper, McGill University, 37 pages. Revised November 2024.

Conference Proceedings

3. "Simulation-Based Inference for the Synchronization of Business Cycles", with Jean-Marie Dufour, *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, December 2023, 12 pages.

4. "Simulation-Based Inference for Markov Switching Models", with Jean-Marie Dufour, *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, December 2022, 275-289.

Working Papers

5. "Monte Carlo Likelihood Ratio Tests for Markov Switching Models", with Jean-Marie Dufour, Discussion Paper, McGill University, 41 pages. Revised October 2024. (**Job Market Paper**)

6. "Underlying Core Inflation with Multiple Regimes", Discussion Paper, McGill University, 30 pages. Revised November 2024.

7. "Volatility Forecasting with Higher-order Stochastic Volatility Models", with Jean-Marie Dufour & Md. Nazmul Ahsan, Discussion Paper, McGill University, 35 pages. Revised August 2024.

8. "Joint Determination of Counterparty and Liquidity Risk in Payment Systems", with Jorge Cruz Lopez & Charles M. Kahn, 52 pages. Revised September 2024.

9. "mbreaks: R Package for Estimating and Testing Multiple Structural Changes in Linear Regression Models", with Linh Nguyen, Pierre Perron, & Yohei Yamamoto, 28 pages. Revised January 2023.

Policy & Technical Notes

10. "Measuring Underlying Inflation Post-COVID", with Mikael Khan & Luis Uzeda, *Canadian Economic Analysis Inquiry, Bank of Canada*, June 2024, 10 pages.

11. "The Government of Canada Debt Securities Dataset", with Jeffrey Gao & Francisco Rivadeneyra, *Bank of Canada Technical Report*, February 2018, 17 pages.

Work in Progress

12. "Identification Through Heteroskedasticity Using Multiple Structural Change Tests", with Pierre Perron.

13. "MNbreaks: An R Package for Estimating and Testing Multiple Structural Changes in Multivariate Linear Regression Models", with Pierre Perron & Zhongjun Qu.

14. "Practical and reliable estimation methods for high-dimensional multivariate stochastic volatility models with macroeconomic applications", with Jean-Marie Dufour & Md. Nazmul Ahsan.

15. "Monte Carlo Test for Factor Models with Markov switching".

Teaching Experience

(* Scheduled)

*Instructor, Financial Econometrics (MSc.), HEC Montreal	Winter 2025
Instructor, Econometrics II (Ph.D.), with Prof. Saraswata Chaudhuri, McGill University	Winter 2024
TA, Econometrics I (B.A. Honours), McGill University	Fall 2024
TA, Empirical Methods In Monetary Economics & Finance (Ph.D.), HEC Montreal	Winter 2024
TA, Econometrics II (Ph.D.), McGill University	Winter 2014
TA, Microeconomic Theory (M.A.), McGill University	Fall 2022, Fall 2023
TA, Macroeconomic Theory (M.A.), McGill University	Fall 2022, Fall 2023
TA, Economic Statistics (B.A. Honours), McGill University	Fall 2020, Winter 2021
TA, Economics of Information and Uncertainty (B.A.), McGill University	Winter 2020
TA, Economic Crises (B.A.), McGill University	Fall 2019
TA, Current Economic Problems (B.A.), McGill University	Winter 2019
TA, Microeconomic Analysis and Applications (B.A.), McGill University	Fall 2018

Research and Relevant Work Experience

RA for Prof. Jean-Marie Dufour, McGill University & CIRANO	Summer 2024, Fall 2024
RA for Prof. Philippe Goulet Coulombe, Université du Québec à Montréal	Fall 2024
Ph.D. Intern, Canadian Economic Analysis Department, Bank of Canada	Sep. 2023 – June 2024
Ph.D. Intern, International Economic Analysis Department, Bank of Canada	June 2023 – Sep. 2023
RA for Prof. Francesca Carrieri, McGill University	Summer 2023 & 2024
Visiting Student, Economics Department, Boston University	Jan. 2023 - May 2023
Research Data Scientist, R&D Team, Financial Network Analytics	Aug. 2019 - Jan. 2023
RA, Prof. Jean-Marie Dufour, McGill University	May 2019 - Aug. 2019
RA for Banking & Payments Department Research Team, Bank of Canada	Apr. 2016 - Aug. 2018

Grants and Awards

Fonds de Recherche du Québec - Société et Culture (FRQSC), PhD Fellowship	2021 - 2024
Graduate Excellence Award, McGill University	2021 - 2024
International Association for Applied Econometrics Travel Grant	2023
McGill Graduate Mobility Award	2022 - 2023
McGill Graduate Research Enhancement and Travel Awards	2022 - 2023
Canadian Economics Association Travel Grant	2022
Carleton Academic Scholarship	2012 - 2013

Papers Presented In Conferences and Seminars

"Monte Carlo Likelihood Ratio Tests for Markov Switching Models" (with Jean-Marie Dufour),

- CIREQ-McGill Lunch Seminar, Montreal, Quebec, October 8, 2024.
- 76th European meeting of the Econometric Society, Erasmus School of Economics, Rotterdam, Netherlands, August 26, 2024.
- New York Camp Econometrics XVIII, Lake Placid, NY, April 26, 2024.
- Carleton University Brown Bag Seminar, Ottawa, Ontario, October 19, 2023.
- NBER-NSF Time Series Conference, Department of Economics, Université du Québec à Montréal, Montreal, Quebec, September 23, 2023.
- International Association for Applied Econometrics (IAAE) Annual Conference, BI Norwegian Business School, Oslo, Norway, June 28, 2023.
- Boston University Econometrics Seminar, Boston, MA, February 24, 2023.
- 16th International Conference on Computational and Financial Econometrics, King's College, London, UK, December 18, 2022.
- Latin American Meeting of the Econometric Society (LAMES), Univesidad del Pacífico, Lima, Peru, November 3, 2022.
- Joint Statistical Meetings, American Statistical Association, Washington, D.C. August 9, 2022.
- 17th CIREQ Ph.D. Students' Conference, Concordia University, Montreal, Quebec, June 6, 2022.
- 56th Annual Meetings of the Canadian Economics Association, Carleton University, Ottawa, Ontario, June 3, 2022.

"Underlying Core Inflation with Multiple Regimes"

- Bank of Canada Conference on Real-Time Data Analysis, Methods and Applications in Macroeconomics and Finance, Ottawa, Ontario, October 17, 2024.

- International Association for Applied Econometrics (IAAE) Annual Conference, Thessaloniki, Greece June 27, 2024.
- Bank of Canada Brown Bag Seminar, Ottawa, Ontario, July 5, 2023.
- 57th Annual Meetings of the Canadian Economics Association, Winnipeg, Manitoba, June 3, 2023.

"Estimation and Inference for Higher-order Stochastic Volatility Models with Leverage" (with Jean-Marie Dufour & Md. Nazmul Ahsan)

- 39th Annual Meeting of the Canadian Econometrics Study Group (CESG), Toronto, Ontario, October 25, 2024.
- North American Summer Meeting of the Econometric Society, Vanderbilt University, Nashville, TN, June 13, 2024.
- 58th Annual Meetings of the Canadian Economics Association, Toronto Metropolitan University, Toronto, Ontario, May 31, 2024.
- 63e Congrès de la Société Canadienne de Science Économique, Montreal, Quebec, May 15, 2024.
- CIREQ Econometrics Conference in Honor of Eric Ghysels, Montreal, Quebec, May 10, 2024.

"Joint Determination of Counterparty and Liquidity Risk in Payment Systems" (with Jorge Cruz Lopez & Charles M. Kahn),

- II Regional Conference on Payments and Financial Market Infrastructures, Banco de la República de Colombia & CEMLA, Bogota, Colombia, September 21, 2023.
- Payments Canada & Bank of Canada Research Symposium, Ottawa, Ontario, October 2017.
- 51st Annual Meetings of the Canadian Economics Association, St. Francis Xavier University, Antigonish, Nova Scotia, June 3, 2017.

"Testing for the Synchronization of International Business Cycles" (with Jean-Marie Dufour)

- Joint Statistical Meetings, American Statistical Association, Toronto, Ontario, August 10, 2023.

Professional Service

Referee
International Statistical Review
Journal of Financial Market Infrastructures

Discussant
CEMLA - II Conference on Payments and FMIs (2023)
58th Annual Meetings of the Canadian Economics Association (2024)

Computational Skills

R, Python, MATLAB, Dynare, C++, Linux, GAUSS, STATA

Software

MSTest - R package, creator & maintainer, available on CRAN
MaxMC - R package, maintainer, available on CRAN
mbreaks (v2) - R package, creator & maintainer, available on GitHub
bootBtest - R package, creator & maintainer, available on GitHub

Languages

English (native), French (fluent), Spanish (fluent)

Citizenship

Canada, Peru

References

Prof. Jean-Marie Dufour, McGill Uiversity, jean-marie.dufour@mcgill.ca, +1 (514) 398 6071
Prof. Zhongjun Qu, Boston University, qu@bu.edu, +1 (617) 358 5921
Prof. John Galbraith, McGill Uiversity, john.galbraith@mcgill.ca, +1 (514) 398 5167
Prof. Hafedh Bouakez, HEC Montreal, hafedh.bouakez@hec.ca, +1 (514) 340 7003

Paper Abstracts

"Monte Carlo Likelihood Ratio Tests for Markov Switching Models", with Jean-Marie Dufour, Discussion Paper, McGill University, 41 pages. Revised October 2024. (**Job Market Paper**)

Markov switching models have wide applications in economics, finance, and other fields. Most studies focusing on testing the number of regimes often focus on the null hypothesis of a single regime (i.e., a linear model with no switching) versus two regimes. Even in such simple cases, this type of problem raises issues of nonstandard asymptotic distributions, identification failure, and nuisance parameters. This paper proposes Monte Carlo likelihood ratio tests for Markov switching models, which address these issues and are applicable to more general settings where a null hypothesis with M_0 regimes can be tested against an alternative with $M_0 + m$ regimes where both $M_0 \geq 1$ and $m \geq 1$. This allows one to compare a broad class of Markov switching and Hidden Markov Models. Applied to likelihood ratio statistics, our approach overcomes the limitations of conventional tests, allowing for broader applicability to non-stationary processes, non-Gaussian errors, and multivariate settings, which have seen little attention in the literature. An important contribution is the Maximized Monte Carlo Likelihood Ratio Test (MMC-LRT), an identification-robust procedure valid in finite samples and asymptotically. Simulation results show that the proposed tests effectively control the level of the test and can provide good power across different settings. An empirical application to U.S. GNP and GDP growth data suggests a three-regime model, confirm evidence of the Great Moderation and identifying a return to the low volatility regime post-Great Recession and post-COVID-19. In a second multivariate application, we use our test procedures with Markov switching VAR models to test business cycle synchronization. Preliminary evidence suggests that adding COVID data weakens the synchronization between the U.S. and Canada.

"Underlying Core Inflation with Multiple Regimes", Discussion Paper, McGill University, 30 pages. Revised November 2024.

This paper introduces a new approach for estimating core inflation indicators based on common factors across a broad range of price indices. Specifically, by utilizing procedures for detecting multiple regimes in high-dimensional factor models, we propose two types of core inflation indicators: one incorporating multiple structural breaks and another based on Markov switching. The structural breaks approach can eliminate revisions for past regimes, though it functions as an offline indicator, as real-time detection of breaks is not feasible with this method. On the other hand, the Markov switching approach can reduce revisions while being useful in real time, making it a simple and robust core inflation indicator suitable for real-time monitoring and as a short-term guide for monetary policy. Additionally, this approach allows us to estimate the probability of being in different inflationary regimes. To demonstrate

the effectiveness of these indicators, we apply them to Canadian price data. To compare the real-time performance of the Markov switching approach to the benchmark model without regime-switching, we assess their abilities to forecast headline inflation and minimize revisions. We find that the Markov switching model delivers superior predictive accuracy and significantly reduces revisions during periods of substantial inflation changes. Hence, our findings suggest that accounting for time-varying factors and parameters enhances inflation signal accuracy and reduces data requirements, especially following sudden economic shifts.

"Estimation and Inference for Higher-order Stochastic Volatility Models with Leverage", with Jean-Marie Dufour & Md. Nazmul Ahsan, Discussion Paper, McGill University, 70 pages. Revised November 2024. Submitted to *Journal of Time Series Analysis* (revision requested).

Statistical inference – estimation and testing – for stochastic volatility models is challenging and computationally expensive. This problem is compounded when leverage effects are allowed. We propose efficient simple estimators for higher-order stochastic volatility models with leverage [SVL(p)], based on a small number of moment equations derived from ARMA representations associated with SVL models, along with the possibility of using "winsorization" to improve stability and efficiency (W-ARMA estimators). The asymptotic distributional theory of the estimators is derived. The computationally simple estimators proposed allow one to easily perform simulation-based (possibly exact) tests, such as Monte Carlo tests (MCT) or bootstrap procedures. In simulation experiments, we show that: (1) the proposed W-ARMA estimators dominate alternative estimators (including Bayesian estimators) in terms of bias, root-mean-square error, and computation time; (2) local and maximized Monte Carlo tests based on W-ARMA estimators yield good control of the size and power of LR-type tests; (3) taking into account leverage improves volatility forecasting. The methods developed are applied to daily returns for three major stock indices (S&P 500, Dow Jones, Nasdaq), confirming the superiority of SVL(p) models over competing conditional volatility models in terms of forecast accuracy.

"Volatility Forecasting with Higher-order Stochastic Volatility Models", with Jean-Marie Dufour & Md. Nazmul Ahsan, Discussion Paper, McGill University, 35 pages. Revised August 2024.

We study the performance of higher-order stochastic volatility [SV(p)] models in forecasting volatility. This class of models provides more flexibility to represent volatility persistence and heavy tails and are natural extensions of the first-order model. The estimation of SV(p) models constitutes challenging problems due to the inherent difficulty of evaluating the likelihood function. Most of the proposed ones are inflexible, inefficient, and computationally expensive. We employ OLS-based winsorized ARMA estimator of Ahsan and Dufour (2021) [which is computationally inexpensive and remarkably accurate], and present empirical applications relating to SV(p) models. Using different volatility proxies (the squared return of S&P 500 index and the realized volatility of S&P 500, FTSE100, NASDAQ100, N225, SSMI20 indices), we conduct two out-of-sample forecast experiments: (1) we forecast a moderately volatile period after the late-2000s financial crisis; (2) we forecast a highly volatile period, *i.e.*, the core financial crisis. We compare the accuracy of volatility forecasts among SV(p) models, GARCH models, and Heterogenous Autoregressive model of Realized Volatility (HAR-RV) models. The results suggest that SV(p) models perform better than other models in most cases. This finding holds even if a high volatility period (such as financial crisis) is included in the estimation sample or the forecasted sample. Formal prediction tests, *i.e.*, model confidence set procedure, also support these inferences. Our findings highlight the usefulness of higher-order SV models for volatility forecasting.

"Joint Determination of Counterparty and Liquidity Risk in Payment Systems", with Jorge Cruz Lopez & Charles M. Kahn, 52 pages. Revised September 2024.

We investigate how banks jointly manage their funding liquidity and counterparty risk in the context of an interbank payments system. Our model evaluates features of the financial system that are

usually analyzed in isolation, such as the issuance of secured and unsecured credit obligations and the use of collateral and capital requirements. Throughout the day, banks issue payment orders, which represent claims on central bank balances that must be settled at the end of the day. A central counterparty (CCP) processes all orders and to remain risk neutral, it collects collateral from the issuer or the recipient using a defaulter-pay or survivor-pay arrangement. These arrangements closely resemble collateral and capital requirements in the wider banking system. Using intra-day data from the Canadian Large Value Transfer System (LVTS), we show that banks coordinate the issuance of payment orders to jointly manage their liquidity and counterparty risk. Coordination leads to netting of credit exposures and unencumbering of collateral assets, which increases liquidity. Banks tend to prefer issuing unsecured payments and do not see secured and unsecured payments as substitutes, although they always coordinate their issuance. For unsecured payments, banks rely on bilateral and multilateral coordination, whereas for secured payments, they rely almost exclusively on multilateral coordination. Differences in coordination arise because unsecured payments depend on the performance of a given counterparty, whereas secured payments only depend on the performance of the collateral supporting them. Thus, to the extend that collateral is homogenous, secured payments are fungible. Coordination incentives increase with risk exposures and the cost of funding. We conclude that coordination disruptions may increase risk exposures that lead to funding constraints and systemic risk. Therefore, coordination should be considered in policies aimed at enhancing financial stability.

"MSTest: An R-package for Testing Markov-Switching Models", with Jean-Marie Dufour, Discussion Paper, McGill University, 37 pages. Revised November 2024. Submitted to *Journal of Statistical Software*.

We present the R package MSTest, which implements hypothesis testing procedures to identify the number of regimes in Markov switching models. These models have wide-ranging applications in economics, finance, and numerous other fields. The MSTest package includes the Monte Carlo likelihood ratio test procedures proposed by Rodriguez-Rondon and Dufour (2024), the moment-based tests of Dufour and Luger (2017), the parameter stability tests of Carrasco, Hu, and Ploberger (2014), and the likelihood ratio test of Hansen (1992). Additionally, the package enables users to simulate and estimate univariate and multivariate Markov switching and hidden Markov processes, using the expectation-maximization (EM) algorithm or maximum likelihood estimation (MLE). We demonstrate the functionality of the MSTest package through both simulation experiments and an application to U.S. GNP growth data.

"mbreaks: R Package for Estimating and Testing Multiple Structural Changes in Linear Regression Models", with Linh Nguyen, Pierre Perron, & Yohei Yamamoto, 28 pages. Revised January 2023.

This article provides a hands-on guide for an R package to implement a comprehensive analysis of issues related to multiple structural changes in the coefficients and variance of linear regression models proposed by Bai and Perron (1998, 2003) and Perron, Yohei Yamamoto and Jing Zhou (2020). The original theoretical framework and computational algorithms are valid for models with non-trending and regime-wise stationary regressors, although some results remain useful when the regressors have deterministic or stochastic time trends, and even endogenous regressors, provided appropriate modifications are made. The package provides methods of constructing the confidence intervals of the break dates, testing for the presence of structural changes and selecting the number of structural changes. It can also plot the conditional mean functions with and without structural changes. Two empirical examples illustrate how the results are presented and how they can be used in subsequent analyses.