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Placement Directors

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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 Specialization

Primary: Econometrics, Macroeconomics and Monetary Economics
Secondary: Finance, Machine Learning

Dissertation

Monte Carlo Tests 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. Hamed Bouakez (HEC Montreal)

Job Market Paper

“Monte Carlo Likelihood Ratio Tests for Markov Switching Models” (with Jean-Marie Dufour), 33 pages. Revised in 2024.

Markov switching models have wide applications in economics, finance, and other fields. Most studies focusing on identifying the number of regimes in a Markov switching model have been limited to testing the null hypothesis of only one regime (i.e., a linear model with no switching) against an alternative hypothesis with two regimes. Even in such simple cases, this type of problem raises issues of nonstandard asymptotic distributions, identification failure, and nuisance parameters. In this paper, we propose Monte Carlo tests methods which deal transparently with these distributional issues, even allowing for finite-sample inference. The procedure is applied to likelihood ratio statistics. The tests circumvent the issues plaguing conventional hypothesis testing. This also allows one to deal with non-stationary processes, models with non-Gaussian errors and multivariate settings, which have received little attention in the literature. An important contribution of this paper is the Maximized Monte Carlo Likelihood Ratio Test (MMC-LRT), which is an identifications-robust valid test procedure both in finite samples and asymptotically. Further, the methods proposed are applicable to more general settings where a null

hypothesis with M_0 regimes is tested against an alternative with $M_0 + m$ regimes where both $M_0 \geq 1$ and $m \geq 1$. Simulation results are provided and suggest the proposed tests are able to control the level of the test and have good power. Finally, a univariate empirical application to U.S. GNP growth data and a multivariate empirical application for testing the synchronization of business cycles are presented.

“Underlying Core Inflation with Multiple Regimes” 31 pages. Revised in 2024.

This paper proposes a new method for estimating core inflation indicators that are based on the common factor among a large number of price indices. Specifically, using procedures for detecting multiple regimes in high dimensional factor models, we propose an underlying core inflation indicator with structural breaks and an underlying core inflation indicator with Markov switching. To illustrate the value of these indicators, we consider two empirical applications: one using Canadian price data and another using U.S. PCE data. Results suggest that considering time-varying factors and parameters lead to smaller revisions and more timely estimates of underlying inflation when using the Markov switching approach which is also useful as a real-time indicator and hence as a short-term guide for monetary policy. On the other hand, the structural breaks approach is able to eliminate revisions in some cases but this comes at the cost of being an off-line method. In both cases, the proposed methods are able to detect an increase in inflation in Canada much sooner than the current core inflation indicator, CPI-Common, produced by the Bank of Canada.

Other Research work

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

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

“MSTest: An R-package for Testing Markov-Switching Models” (with Jean-Marie Dufour), 38 pages. Revised in 2024. Discussion Paper, McGill University (Department of Economics)

“Volatility Forecasting with Higher-order Stochastic Volatility Models” (with Jean-Marie Dufour & Md. Nazmul Ahsan), 35 pages. Revised 2024. Discussion Paper, McGill University (Department of Economics)

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

“MNbreaks: An R Package for Estimating and Testing Multiple Structural Changes in Multivariate Linear Regression Models” (with Pierre Perron and Zhongjun Qu), work in progress.

“Monte Carlo Test for Factor Models with Markov switching”, work in progress.

“Identification Through Heteroskedasticity Using Multiple Structural Change Tests” (with Pierre Perron), work in progress.

Proceedings, Policy Notes, & Technical Notes

“Measuring Underlying Inflation Post-COVID” (with Mikael Khan & Luis Uzeda), 2024, *Canadian Economic Analysis Inquiry*, Bank of Canada, 10 pages, Ottawa, ON.

“Simulation-Based Inference for the Synchronization of Business Cycles” (with Jean-Marie Dufour), 2023 *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, 12 pages, Toronto, ON.

“Simulation-Based Inference for Markov Switching Models” (with Jean-Marie Dufour), 2022 *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, 275-289, Washington, D.C..

“The Government of Canada Debt Securities Dataset” (with Jeffrey Gao & Francisco Rivadeneyra), 2017 *Bank of Canada Technical Report*, 17 pages, Ottawa, ON.

Teaching Experience

Instructor, Econometrics II (PhD), 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)	2021 - 2024
Graduate Excellence Award	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
Dufour Graduate Award	2020 - 2022
Carleton Academic Scholarship	2012 - 2013

Papers Presented In Conference and Seminars

(* Scheduled)

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

- * 39th Annual Meeting of the Canadian Econometrics Study Group (CESG), Toronto, Ontario, October 25, 2024.
- * 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)

- 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, 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 University, 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 University, john.galbraith@mcgill.ca, +1 (514) 398 5167

Prof. Hamed Bouakez, HEC Montreal, hamed.bouakez@hec.ca, +1 (514) 340 7003

Other Paper Abstracts

“Estimation and Inference for Higher-order Stochastic Volatility Models with Leverage” (with Jean-Marie Dufour & Md. Nazmul Ahsan), 70 pages. Revised in 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.

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

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 extent 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.

“Volatility Forecasting with Higher-order Stochastic Volatility Models” (with Jean-Marie Dufour & Md. Nazmul Ahsan), 35 pages. Revised 2024. Discussion Paper, McGill University (Department of Economics)

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.

“MSTest: An R-package for Testing Markov Switching Models” (with Jean-Marie Dufour), 38 pages. Revised in 2024. Discussion Paper, McGill University (Department of Economics)

We describe the R package MSTest, which implements hypothesis testing procedures that can be used to identify the number of regimes in Markov switching model. Markov switching models have wide applications in economics, finance, and many other fields. The package MSTest makes available hypothesis testing procedures that are valid (including exact Monte Carlo test procedures) and can be used to compare Markov switching models with different numbers of regimes. The package also allows users to simulate Markov regime switching processes, estimate Markov switching autoregressive and vector autoregressive models as well as hidden Markov models using the expectation maximization (EM) algorithm or maximum likelihood estimation (MLE). We illustrate the functionality of the MSTest package using both simulation experiments and data for U.S. GNP growth.