# McGill University
# Department of Economics
# Econ 706
# Special topics in econometrics / Sujets spéciaux d'économétrie
# Winter / Hiver 2008
# Course outline / Syllabus

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This course has two main objectives The first one is to review parts elements of statistical theory which are especially relevant to the development of tests and confidence sets in econometrics. The second objective is to study and apply in different contexts various methods allowing one to obtain finite-sample inference procedures as well more reliable large-sample methods. Among the topics that will receive special attention, we may note: test methods based on simulation (Monte Carlo tests, bootstrapping), projection techniques for the construction of tests and confidence sets, weak instrument problems in structural modelling, finite-sample nonparametric methods.

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Ce cours comporte deux objectifs principaux. Le premier consiste à étudier certains éléments de théorie statistique qui sont importants pour le développement de tests et régions de confiance en économétrie. Le second sera d'étudier et appliquer dans différents contextes diverses méthodes qui permettent d'obtenir des procédures d'inférence valides dans les échantillons finis ou encore des procédures asymptotiques plus fiables. Parmi les sujets qui recevront une attention particulière, on notera: les techniques de test fondées sur le recours à des simulations (tests de Monte Carlo, bootstrap), l'emploi de techniques de projection pour la construction de tests et régions de confiance, les problèmes d'instruments faibles en économétrie structurelle, ainsi que diverses techniques non-paramétriques exactes.

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The evaluation will be based on 2 elements:

1. a mid-term exam: 40% of the grade;
2. a final exam: 60% of the grade.

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L'évaluation sera basée sur deux éléments:

1. un examen intra-semestriel: 40% de la note;
2. examen final: 60% de la note.

L'examen intra-semestriel aura lieu en dehors des heures normales de cours.

## Recommended texts / Manuels recommandés /

(GM) Gouriéroux, C. et A. Monfort (1989), Statistique et modèles économétriques, Volumes 1 et 2. Economica, Paris.

(GM) Gouriéroux, C. et A. Monfort (1995), Statistics and Econometric Models, Volumes 1 and 2. Cambridge University Press, Cambridge, U.K.. English translation of previous book.

(U) Ullah, A. (2004), Finite Sample Econometrics, Advanced texts in Econometrics, Cambridge University Press, Cambridge, U.K.

## Other books used / Autres livres utilisés

(Am) Amemiya, T. (1985), Advanced Econometrics, Harvard University Press, Cambridge, Massachusetts.

(An) Anderson, T. W. (1984), An Introduction to Multivariate Statistical Analysis, Second Edition, Wiley, New York.

(DM) Davidson, R. et J. G. MacKinnon (1993), Estimation and Inference in Econometrics, Oxford University Press, Oxford.

(GA) Gallant, A. R. (1987), Nonlinear Statistical Models, Wiley, New York.

(GW) Gallant, A. R. et H. White (1988), A Unified Theory of Estimation and Inference for Nonlinear Statistical Models, Basil Blackwell, New York.

(LE) Lehmann, E. L. (1983), Theory of Point Estimation, Wiley, New York.

(LT) Lehmann, E. L. (1986), Testing Statistical Hypotheses, Second Edition, Wiley, New York.

(R) Rao, C. R. (1973), Linear Statistical Inference and its Applications, Second Edition, Wiley, New York.

(W) White, H. (1984), Asymptotic Theory for Econometricians, Academic Press, Orlando, Florida.

**Topics**

# 1. Philosophy of science and statistics

1. Objectives of scientific knowledge
2. Criteria for evaluating theories and models

# 2. Inference techniques

1. Statistical models
   (a) Notion of statistical model
   (b) Important econometric models
2. Statistical problems
   (a) Statistical problems as decision problems
   (b) Review of important statistical problems
      i. Estimation
      ii. Tests
      iii. Confidence regions
      iv. Multiple tests and simultaneous inference
      v. Prediction
      vi. Model selection
3. Information and identification
   (a) Sufficient and ancillary statistics
   (b) Information
   (c) Identification
4. Estimation
   (a) Criteria for evaluating estimators
   (b) Unbiased estimation
   (c) Some general estimation methods
      i. Maximum likelihood
      ii. M-estimators

iii. Instrumental variables
iv. Methods of moments
v. Minimum distance

5. Testing

    (a) Basic concepts: level, size, power, conservative test, liberal test
    (b) Optimal tests and Neyman-Pearson theorem
    (c) Important classes of tests
        i. Similar tests
        ii. Unbiased tests
        iii. Invariant tests
    (d) Some general methods for building tests
        i. Likelihood ratio
        ii. Wald tests
        iii. Score-based procedures [Rao, Lagrange multiplier, Neyman's $C(\alpha)$]
        iv. Union-intersection methods

6. Confidence regions

    (a) Basic concepts
    (b) Pivotal functions
    (c) Duality between tests and confidence regions

7. Multiple tests and simultaneous inference

8. Prediction and residuals

9. Model selection

10. Bayesian approach

## 3. Distributional problems and finite-sample analysis

1. Asymptotic theory and its limitations

    (a) Review of basic asymptotic notions and results
    (b) Asymptotic expansions
    (c) Limitations of asymptotic theory

2. Invariance problems in nonlinear models

3. Techniques for building finite-sample inference procedures

    (a) Analytical derivation of distributions

        i. Exact distributions of quadratic forms in Gaussian variables
        ii. Imhof's algorithm

    (b) Elimination of nuisance parameters

        i. Conditioning
        ii. Transformations

    (c) Bounds
    (d) Projection
    (e) Randomization

4. Theory of Monte Carlo tests

5. Bootstrap

## 4. Static and dynamic regressions

1. Nonregular problems in classical linear regressions

    (a) Linear models with non-normal disturbances
    (b) Confidence intervals for ratios of coefficients, Fieller's method
    (c) Linear models with exact collinearity
    (d) Tests of nonlinear hypotheses
    (e) Nonlinear restrictions
    (f) Tests of multiple hypotheses

2. Specification tests and analysis of residuals

    (a) Normality of errors
    (b) Heteroskedasticity
    (c) Autocorrelation
    (d) Outliers

3. Linear regressions with autocorrelated errors

4. Multiple equation regression models

    (a) Multivariate linear regressions (MLR)

   (b) Seemingly unrelated regressions (SURE)

5. Regressions with heteroskedastic errors
6. Inference problems in dynamic models
   (a) Review of technical difficulties
   (b) Exact inference in dynamic models
7. Structural change analysis
8. Nonlinear regressions

## 5. Identification and structural models

1. Simultaneous equations and identification
2. Inference problems associated with identification.
   (a) Impossibility theorems
   (b) Weak instruments
3. Exact inference in structural models
4. Methods adapted to weak instruments
5. Nonlinear structural models
6. Generalized method of moments

## 6. Causality and multivariate time series models

1. Multivariate time series models
2. General notions on causality in econometrics
3. Causality in multivariate time series models

# 7. Nonparametric methods

1. Signs, ranks and permutations
2. Location tests
3. Tests against serial dependence
4. Conditional independence tests
5. Goodness-of-fit tests

## 8. Philosophie des sciences et statistique

1. Objectifs de la connaissance scientifique
2. Critères servant à évaluer les théories et les modèles

## 9. Techniques d'inférence

1. Modèles statistiques
   (a) La notion de modèles statistique
   (b) Quelques modèles économétriques importants
2. Problèmes statistiques
   (a) Les problèmes statistiques comme problèmes de décision
   (b) Revue des principaux problèmes statistiques
      i. Estimation
      ii. Tests
      iii. Régions de confiance
      iv. Tests multiples et inférence simultanée
      v. Prévision
      vi. Choix de modèles
3. Information et identification
   (a) Notions de statistique exhaustive et de statistique libre
   (b) Information
   (c) Identification
4. Estimation
   (a) Critères pour les estimateurs
   (b) Estimation sans biais
   (c) Quelques méthodes générales d'estimation
      i. Maximum de vraisemblance
      ii. M-estimateurs

iii. Variables instrumentales
iv. Méthodes de moments
v. Distance minimale

5. Tests

   (a) Concepts de base: niveau, taille, puissance, tests conservateurs, tests libéraux
   (b) Tests optimaux et théorème de Neyman-Pearson
   (c) Classes importantes de tests
      i. Tests $\alpha$-semblables
      ii. Tests sans biais
      iii. Tests invariants
   (d) Quelques méthodes générales pour construire des tests
      i. Quotient de vraisemblance
      ii. Tests de Wald
      iii. Tests fondés sur la vraisemblance [Rao, multiplicateur de Lagrange, $C(\alpha)$ de Neyman]
      iv. Méthodes d'union-intersection

6. Régions de confiance

   (a) Concepts de base
   (b) Notion de fonction pivotale
   (c) Dualité entre tests et régions de confiance

7. Tests multiples et inférence simultanée

8. Prévision et résidus

9. Choix de modèles

10. Approche bayésienne

## 10. Problèmes distributionnels et analyse à distance finie

1. La théorie asymptotique et ses limitations

   (a) Rappels de théorie asymptotique
   (b) Expansions asymptotiques
   (c) Limitations de la théorie asymptotique

2. Problèmes d'invariance de tests dans les modèles non linéaires
3. Techniques pour la mise au point de procédures d'inférence à distance finie
   (a) Dérivation de distributions analytiques exactes
      i. Distributions exactes de formes quadratiques dans le cas gaussien
      ii. Algorithme d'Imhof
   (b) Élimination des paramètres du nuisance
      i. Conditionnement
      ii. Transformations
   (c) Bornes
   (d) Projection
   (e) Randomisation
4. Théorie des tests de Monte Carlo
5. Bootstrap

## 11. Modèles de régression statiques et dynamiques

1. Problèmes non réguliers dans le modèle linéaire classique
   (a) Modèles linéaires avec erreurs non-normales
   (b) Intervalles de confiance pour des ratios de coefficients, méthode de Fieller
   (c) Modèles linéaires avec collinéarité exacte
   (d) Tests d'hypothèses non linéaires
   (e) Contraintes non-linéaires
   (f) Tests d'hypothèses multiples
2. Tests de spécification et analyse de résidus
   (a) Normalité des erreurs
   (b) Hétéroscédasticité
   (c) Autocorrélation
   (d) Observations à l'écart
3. Modèles de régression avec erreurs autocorrélées
4. Modèles de régression à plusieurs équations

   (a) Modèles de régression multivariés (MLR)
   (b) Régressions empilées (SURE)
   (c) Applications à des modèles d'évaluation de prix d'actifs financiers (CAPM)

5. Régressions avec erreurs hétéroscédastiques

6. Problèmes d'inférence dans les modèles dynamiques

   (a) Revue des difficultés techniques
   (b) Inférence exacte dans les modèles dynamiques

7. Problèmes d'analyse du changement structurel

8. Modèles de régression non-linéaires

## 12. Modèles structurels

1. Équations simultanées linéaires et identification

2. Problèmes d'inférence reliés à l'identification.

   (a) Théorèmes d'impossibilité
   (b) Instruments faibles

3. Inférence exacte dans les modèles structurels

4. Méthodes d'inférence adaptées aux instruments faibles

5. Modèles structurels non linéaires

6. Méthode des moments généralisés

## 13. Causalité et modèles de séries chronologiques multivariés

1. Modèles de séries chronologiques multivariés

2. Généralités sur la causalité en économétrie

3. Causalité dans les modèles de séries chronologiques multivariés

## 14. Méthodes non-paramétriques

1. Généralités sur les tests de signes, de rangs et de permutations
2. Tests de localisation
3. Tests contre la dépendance sérielle
4. Tests d'orthogonalité
5. Tests d'ajustement

## Lectures et références principales / Readings and main references

The symbol * represents required readings. Topics for which no reference is provided will covered in class-notes. Photocopied lecture notes also constitute required reading.

Le symbole * représente des lectures obligatoires. Les sujets pour lesquels aucune référence n'apparaît seront couverts au moyen de notes de cours. Les notes de cours photocopiées constituent des lectures obligatoires.

### 1. Philosophy of science and statistics / Philosophie des sciences et statistique

**1 - 2**. Dufour (2000), Dufour (2001).

### 2. Inference techniques / Techniques d'inférence

**2**. * GM, Ch. 1.

**2a**. * GM, Ch. 2.

**3**.* GM, Ch. 3. Basu (1977).

**4**. GM, Ch. 5. 6.

**5**. * GM, Ch. 14, 15, 16.

**6**. * GM, Ch. 20.

**7**. * GM, Ch. 19.

**8**. GM, Ch. 11.

**9**. GM, Ch. 22.

**10**. GM, Ch. 4, 12

### 3. Distributional problems and finite-sample analysis / Problèmes distributionnels et analyse à distance finie

**3a.** *Ullah (2004, Chapters 1 and 2).

**1.** *Dufour (2000), *Dufour (2001), Dufour (2003), *Bahadur and Savage (1956).

**2**. *Dagenais and Dufour (1991), Dufour and Dagenais (1992), Dagenais and Dufour (1992), Dagenais and Dufour (1994).

**3c**. *Dufour (1990).

**3d**. *Abdelkhalek and Dufour (1998).

**4**. *Dufour and Khalaf (2001b), *Dufour (2006).

**4. Static and dynamic regressions / Modèles de régression statiques et dynamiques**

*Ullah (2004, Chapter 5 and 6).

**1b**. *Dufour (1997).

**1c**. *Dufour (1982).

**1d**. *Dufour (1989).

**1f**. *Dufour (1989).

**2a**. Dufour, Farhat, Gardiol, and Khalaf (1998).

**2b**. Dufour, Khalaf, Bernard, and Genest (2004).

**4a**. Dufour and Khalaf (2002b).

**4b**. Dufour and Khalaf (2002a), Dufour and Khalaf (2001a), Dufour and Torrès (1998).

**4c**. *Dufour, Khalaf, and Beaulieu (2003), *Beaulieu, Dufour, and Khalaf (2006), *Beaulieu, Dufour, and Khalaf (2007), .

**5**. Dufour (1991), Dufour and Mahseredjian (1993).

**6**. Dufour (1990), *Dufour and King (1991), *Dufour and Kiviet (1998), Kiviet and Dufour (1997), Dufour and Torrès (1998), Dufour and Torrès (2000).

**5**. **Identification and structural models / Identification et modèles structurels**

**1**. *Ullah (2004, Chapter 7).

**2**. *Dufour (2003), *Stock, Wright, and Yogo (2002), *Dufour (1997).

**3**. *Dufour (1997), *Dufour and Jasiak (2001), *Dufour and Taamouti (2005).

**4**. *Kleibergen (2002), *Moreira (2003).

## **7**. **Causality and multivariate time series models / Causalité te modèles de séries chronologiques multivariés**

2. **?**. Pearl (2000)

3. *Dufour and Renault (1998), Dufour, Pelletier, and Renault (2006), Boudjellaba, Dufour, and Roy (1992).

## **7**. **Nonparametric methods / Méthodes non-paramétriques**

**1**. Dufour, Lepage, and Zeidan (1982).

**2**. Dufour and Hallin (1990).

**3**. Dufour (1981), Dufour and Roy (1985), Dufour and Roy (1986a), Dufour and Roy (1986b), Dufour and Hallin (1987), Dufour, Hallin, and Mizera (1998), Dufour, Farhat, and Hallin (2006).

**4**. Campbell and Dufour (1991), Campbell and Dufour (1995), Campbell and Dufour (1997).

**5**. Dufour and Farhat (2001a), Dufour and Farhat (2001b).

## References

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BEAULIEU, M.-C., J.-M. DUFOUR, AND L. KHALAF (2006): "Multivariate Tests of Mean-Variance Efficiency with Possibly Non-Gaussian Errors: An Exact Simulation-Based Approach," *Journal of Business and Economic Statistics*, forthcoming.

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CAMPBELL, B., AND J.-M. DUFOUR (1991): "Over-rejections in Rational Expectations Models: A Nonparametric Approach to the Mankiw-Shapiro Problem," *Economics Letters*, 35, 285–290.

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——— (1989): "Nonlinear Hypotheses, Inequality Restrictions, and Non-Nested Hypotheses: Exact Simultaneous Tests in Linear Regressions," *Econometrica*, 57, 335–355.

——— (1990): "Exact Tests and Confidence Sets in Linear Regressions with Autocorrelated Errors," *Econometrica*, 58, 475–494.

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——— (2000): "Économétrie, théorie des tests et philosophie des sciences," in *Présentations de l'Académie des lettres et des sciences humaines*, vol. 53, pp. 166–182. Royal Society of Canada/Société royale du Canada, Ottawa.

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——— (2003): "Identification, Weak Instruments and Statistical Inference in Econometrics," *Canadian Journal of Economics*, 36(4), 767–808.

——— (2006): "Monte Carlo Tests with Nuisance Parameters: A General Approach to Finite-Sample Inference and Nonstandard Asymptotics in Econometrics," *Journal of Econometrics*, 133(2), 443–477.

DUFOUR, J.-M., AND M. G. DAGENAIS (1992): "Nonlinear Models, Rescaling and Test Invariance," *Journal of Statistical Planning and Inference*, 32, 111–135.

DUFOUR, J.-M., AND A. FARHAT (2001a): "Exact Nonparametric Two-Sample Homogeneity Tests," in *Proceedings of the 2000 International Workshop on "Goodness-of-fit Tests and Validity of Models"*, ed. by C. Huber-Carol, N. Balakhrishnan, M. Nikulin, and M. Mesbah. Birkhaüser, Boston, Massachusetts, Forthcoming.

——— (2001b): "Exact Nonparametric Two-Sample Homogeneity Tests for Possibly Discrete Distributions," Discussion paper, C.R.D.E., Université de Montréal, 26 pages.

DUFOUR, J.-M., A. FARHAT, L. GARDIOL, AND L. KHALAF (1998): "Simulation-Based Finite Sample Normality Tests in Linear Regressions," *The Econometrics Journal*, 1, 154–173.

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DUFOUR, J.-M., AND M. HALLIN (1987): "Tests non paramétriques optimaux pour le modèle autorégressif d'ordre un," *Annales d'Économie et de Statistique*, 5, 411–434.

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