

DEPARTMENT OF POLITICAL SCIENCE  
UNIVERSITY OF TORONTO

# **POL 2519 H1F**

## **QUANTITATIVE METHODS AND DATA ANALYSIS**

### **COURSE OUTLINE**

WINTER 2023

**CLASS TIME: WEDNESDAYS, 10AM–12PM**

**CLASS LOCATION: RW 109 (RAMSEY WRIGHT COMPUTER LAB 109)**

**INSTRUCTOR:** Ludovic Rheault  
**OFFICE HOURS:** See Quercus page.

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**OFFICE LOCATION:** Sidney Smith 3005

### **Course Description**

This course provides graduate students with an advanced training in quantitative methods focusing on the two families of models most commonly used in political science: 1) models for categorical dependent variables, and 2) models for panel data analysis. The course builds upon the materials covered in the sequence POL 2504 and POL 2507, and represents a natural continuation for PhD students looking to develop their methodological skills and use statistical methods in their own research. POL 2519 may also be suitable for MA students who received a strong training in quantitative methods at the undergraduate level and are interested in an advanced course going beyond linear regression. The course comprises lectures presenting the theory behind each statistical model, discussions of concrete examples based on published articles, as well as interactive sessions using R.

### **Course Format**

The course takes place in person in the Ramsey Wright computer lab RW 109 (the building next to Sidney Smith). Students can use the computers available in the lab or bring their own laptop. A typical class combines an advanced lecture on statistical theory introducing new concepts during the first half of the class, followed by interactive exercises using the R language and real-world datasets in the second half.

While the course requires prior knowledge in statistics (see requirements below), the pedagogical approach is tailored to students who may not have had an extended training in mathematics as undergraduate students, as is often the case in the social sciences.

### **Requirements**

Normally, PhD students will register for POL 2519 after having taken the quantitative methods sequence POL 2504 and POL 2507. However, MA and PhD students who already have an equivalent background may also register for the course. To maximize the benefits of taking this course, students should have a good understanding of basic statistics and the linear regression model.

## Software

In line with POL 2504 and POL 2507, the previous courses in the quantitative methods sequence, POL 2519 relies on the R programming language for teaching and illustrations. R is an [open-source language available on all operating systems](#) (that is, it is free to use). Students are invited to download [RStudio](#), a free text editor to use the R language, which I will use for in-class examples. The required software is available in the computer lab RW 109.

## Marking Scheme

Written Assignment #1	30%	Due: February 8, 2023
Written Assignment #2	30%	Due: March 15, 2023
Term Paper	30%	Due: April 11, 2023
Participation	10%	

## Readings

Students will be provided with lecture notes covering the course materials. At least one required reading that supplements these lecture notes is associated to each week of the class.

### • Reference Textbooks

The readings are chapters taken from the following textbooks:

- J. Scott Long. 1997. *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks: Sage Publications.
- D.W. Hosmer, S. Lemeshow, R.X. Sturdivant. 2013. *Applied Logistic Regression*. Hoboken: John Wiley & Sons.
- John Fox. 2016. *Applied Regression Analysis and Generalized Linear Models*. 3rd Edition. Thousand Oaks: Sage Publications.
- Edward W. Frees. 2004. *Longitudinal and Panel Data: Analysis and Applications for the Social Sciences*. Cambridge: Cambridge University Press.

### • Other useful References

Other textbooks that can be useful for students looking to explore the topics further.

- P. McCullagh and J. A. Nelder. 1983. *Generalized Linear Models*. Chapman and Hall.
  - \* A classic textbook covering the models under study during the first module of this course.
- Janet M. Box-Steffensmeier, John R. Freeman, Matthew P. Hitt and Jon C. W. Pevehouse. 2014. *Time Series Analysis for the Social Sciences*. Cambridge: Cambridge University Press.
  - \* A useful text for students interested in time series analysis, at a good level for political scientists.
- Jeffrey M. Wooldridge. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge: MIT Press, Chapters 10, 12–20.
  - \* A general textbook covering most of the materials studied in this course.
- William H. Greene. 2011. *Econometric Analysis*. 7th Edition. Upper Saddle River: Pearson Education, Chapters 11–12, 14, 17–20.
  - \* A comprehensive textbook in statistics covering the theoretical aspects of the models studied in this course, and more.

- Peter Kennedy. 2008. *A Guide to Econometrics*. 6th Edition. Wiley-Blackwell.
  - \* For those who prefer English explanations to mathematics, Kennedy's book could be a useful acquisition. There is a good chapter on panel data and some chapters on regression models for limited dependent variables.
- John Fox and Sanford Weisberg. 2011. *An R Companion to Applied Regression*. 2nd Edition. Thousand Oaks: Sage.
  - \* A useful handbook with many examples of fitting models using R.

## Evaluations

### Written Assignments

The two written assignments are problem sets designed to evaluate students' ability to put the methods learned into practice. They may involve running models using a statistical package and answering short factual questions about these models and the results. There is no better way to improve one's skills than practice. Therefore, these assignments are not only useful as evaluations, they serve as a valuable exercise helping students to gain hands-on expertise with the subject-matter. These assignments are done individually and handed in on Quercus at the due date.

### Term Paper

The term paper takes the form of the empirical section of a research paper on a topic of the graduate student's choosing, and involving any of the models discussed during the course. The term paper has a maximum of about 5,000 words.

Students may opt to work on a dissertation chapter or use this opportunity to write a stand-alone paper intended for publication. Students can decide to work as a team for the term paper.

The term paper should include a brief introduction stating the research question, an outline of the theory and some testable propositions (hypotheses). This section is not part of the evaluation per se, but the theory and hypotheses should be clearly stated and logically consistent, as this will inevitably affect the empirical analysis.

The main part of the term paper consists of introducing the research design and performing all the stages of an empirical analysis, using one (or more) of the models studied in the course. Students should make sure to provide replication materials for their study.

## Class Schedule: Summary

Date	Topic	Assignments
January 11	Maximum Likelihood Estimation	
January 18	Maximum Likelihood Estimation (continued)	
January 25	Models for Binary Dependent Variables I	
February 1	Models for Binary Dependent Variables II	
February 8	Models for Ordered Dependent Variables	Assignment 1 Due
February 15	Models for Multinomial Dependent Variables	
February 22	<b>Reading Week</b>	
March 1	Models for Count Dependent Variables	
March 8	Concepts in Time-Series and Panel Data	
March 15	Panel Data I: Random, Between and Fixed Effects	Assignment 2 Due
March 22	Panel Data II	
March 29	Panel Data and Multi-Level/Hierarchical Models	
April 5	Dynamic Panel Data	
April 11	<b>No Class/End of Semester</b>	Term Paper Due

**Note:** Topics and dates mentioned on this syllabus may be adjusted slightly due to unforeseen circumstances, students' interests in specific models, or the total number of registered students.

## **Class Schedule: Detailed**

# **1 Models for Categorical Dependent Variables**

## **1.1 January 11–18: Maximum Likelihood Estimation**

### **Structure of the Class:**

1. Refresher on notation and least squares estimation.
2. Principles of optimization.
3. Maximum likelihood estimation (MLE).
4. Numerical implementation of MLE.

### **Reading:**

- Long, Chapter 2.

## **1.2 January 25: Models for Binary Dependent Variables I**

### **Structure of the Class:**

1. Logit and probit models.
2. Interpretation.
3. Maximum likelihood estimation and inference in R.

### **Reading:**

- Long, Chapter 3; Hosmer et al., Chapters 2–3.

## **1.3 February 1: Models for Binary Dependent Variables II**

### **Structure of the Class:**

1. Classification and goodness-of-fit statistics.
2. Predicted probabilities and marginal effects.
3. Separation and other limitations of logit and probit models.
4. Other models for binary dependent variables.

### **Recommended Readings:**

- Long, Chapter 4; Hosmer et al., Chapter 5.

## **1.4 February 8: Models for Ordered Dependent Variables**

### **Structure of the Class:**

1. Ordered logit and probit models.
2. Estimation and interpretation.
3. Post-estimation techniques.

### **Readings:**

- Long, Chapter 5; Hosmer et al., Chapter 8.

## **1.5 February 15: Models for Multinomial Dependent Variables I**

### **Structure of the Class:**

1. Multinomial logit model (softmax).
2. Alternative-specific variables (conditional logit).
3. Interpretation and post-estimation analysis.
4. Independence of irrelevant alternatives (IIA) assumption.

### **Readings:**

- Long, Chapter 6; Hosmer et al., Chapter 8.

## **February 22: Reading Week**

## **1.6 March 1: Models for Count Dependent Variables**

### **Structure of the Class:**

1. Poisson and negative binomial models.
2. Overdispersion.
3. Estimation and interpretation.
4. The Generalized Linear Model.

### **Readings:**

- Long, Chapter 8.

## **2 Panel Data Analysis**

## **2.1 March 8: Concepts in Time-Series and Panel Data**

### **Structure of the Class:**

1. Time-series v. cross-sectional regressions.
2. Autocorrelation and spurious regression.
3. Dynamic regression.
4. The problem of panel heterogeneity.

### **Readings:**

- Fox, Chapter 16.

## **2.2 March 15-22: Random, Between and Fixed Effects**

### **Structure of the Class:**

1. Introduction to panel data analysis.
2. Fixed effects estimator.
3. Between effects estimator.
4. Random effects estimator.
5. Estimation in R.

**Readings:**

- Frees, Chapters 2–3.

**2.3 March 29: Panel Data and Multi-Level/Hierarchical Models****Structure of the Class:**

1. Random effects estimator (continued).
2. Correspondence with multi-level/hierarchical models.
3. White/HAC and “panel-corrected” standard errors.

**Readings:**

- Frees, Chapters 5–6.

**2.4 April 5: Dynamic Panel Data Estimators****Structure of the Class:**

1. Autoregressive distributed lag (ADL) model.
2. Arellano-Bond estimator [if time permits].
3. Models for panel data with discrete dependent variables.

**Readings:**

- Frees, Chapter 8–9.

## References and Examples

This section contains a list of applications in the literature, and additional references on the methods. We will also look at datasets from published papers during the course.

### Models for Binary Dependent Variables

- Carrubba, Cliff, Barry Friedman, Andrew D. Martin and Georg Vanberg. 2012. "Who Controls the Content of Supreme Court Opinions?" *American Journal of Political Science* 56(2): 400–412.
- Dion, Michelle L., Jane Lawrence Sumner and Sara McLaughlin Mitchell. 2016. "Gendered Citation Patterns across Political Science and Social Science Methodology Fields." *Political Analysis* 26(3): 312–327.
- O'Brien, Diana Z. and Rickne, Johanna. 2016. "Gender Quotas and Women's Political Leadership." *American Political Science Review* 110(1): 112–126.
- Rubenzler, Trevor. 2011. "Campaign Contributions and U.S. Foreign Policy Outcomes: An Analysis of Cuban American Interests." *American Journal of Political Science* 55(1): 105–116.
- Zorn, Christopher. 2002. "U.S. Government Litigation Strategies in the Federal Appellate Courts." *Political Research Quarterly* 55(1): 145–66.
- Zorn, Christopher. 2005. "A Solution to Separation in Binary Response Models." *Political Analysis* 13(2): 157–170.

### Goodness-of-Fit and Predicted Probabilities

- Hagle, Timothy M. and Glenn E. Mitchell II. 1992. "Goodness-of-Fit Measures for Probit and Logit." *American Journal of Political Science* 36(3): 762–784.
- Hanmer, Michael J. and Kerem Ozan Kalkan. 2013. "Behind the Curve: Clarifying the Best Approach to Calculating Predicted Probabilities and Marginal Effects from Limited Dependent Variable Models." *American Journal of Political Science* 57(1): 263–277.
- King, Gary, Michael Tomz, and Jason Wittenberg. 2000. "Making the Most of Statistical Analyses: Improving Interpretation and Prediction." *American Journal of Political Science* 44: 347–361.
- Herron, Michael C. 1999. "Postestimation Uncertainty in Limited Dependent Variable Models." *Political Analysis* 8(1): 8398.

### Heteroskedastic Probit

- Alvarez, R. Michael, and John Brehm. 1995. "American Ambivalence Towards Abortion Policy: Development of a Heteroskedastic Probit Model of Competing Values." *American Journal of Political Science* 39(): 1055–1082.



### **Rare Events Logit**

King, Gary, and Langsche Zeng. 2001. "Logistic Regression in Rare Events Data." *Political Analysis* 9(2): 137–163.

### **Interaction Effects**

Berry, William D., Jacqueline H.R. DeMeritt, and Justin Esarey. 2010. "Testing for Interaction Effects in Binary Logit and Probit Models: Is the Product Term Essential?" *American Journal of Political Science* 54(1): 248–266.

Berry, William D., Matt Golder, and Daniel Milton. 2012. "Improving Tests of Theories Positing Interaction." *Journal of Politics* 74(August): 653–671.

Brambor, Thomas, William Clark and Matt Golder. 2006. "Understanding Interaction Models: Improving Empirical Analyses." *Political Analysis* 14: 63–82.

### **Models for Ordered Dependent Variables**

Alvarez, R. Michael, and John Brehm. 1998. "Speaking in Two Voices: American Equivocation about the Internal Revenue Service." *American Journal of Political Science* 42(2):418–52.

Franklin, Charles H. and Liane C. Kosaki. 1989. "Republican Schoolmaster: The Supreme Court, Public Opinion and Abortion." *American Political Science Review* 83(3): 751–771.

Gelpi, Christopher. 1997. "Crime and Punishment: The Role of Norms in Crisis Bargaining." *American Political Science Review* 91(2):339–60.

Sanders, Mitchell S. 2001. "Uncertainty and Turnout." *Political Analysis* 9(1): 45–57.

### **Multi-Class Goodness-of-Fit**

Hand, David J. and Robert J. Till. 2001. "A Simple Generalisation of the Area Under the ROC Curve for Multiple Class Classification Problems." *Machine Learning* 54(2): 171–86.

Sokolova, Marina and Guy Lapalme. 2009. "A Systematic Analysis of Performance Measures for Classification Tasks." *Information Processing and Management* 45: 427–37.

### **Models for Nominal (Unordered) Dependent Variables**

Brownstone, David and Kenneth Train. 1999. "Forecasting New Product Penetration with Flexible Substitution Patterns." *Journal of Econometrics* 89: 109–129.

Gidengil, Elisabeth, Neil Nevitte, André Blais, Joanna Everitt and Patrick Fournier. 2012. *Dominance and Decline: Making Sense of Recent Canadian Elections*. Toronto: University of Toronto Press.

Glasgow, Garrett. 2001. "Mixed Logit Models for Multiparty Elections." *Political Analysis* 9(2):116–36.

Iyengar, Shanto and Kyu S. Hahn. 2009. "Red Media, Blue Media: Evidence of Ideological Selectivity in Media Use." *Journal of Communication* 59: 19–39.

- Maltzman, Forrest, and Paul J. Wahlbeck. 1996. "May it Please the Chief? Opinion Assignments in the Rehnquist Court." *American Journal of Political Science* 40(2): 421–43.
- Quinn, Kevin M., Andrew D. Martin, and Andrew B. Whitford. 1999. "Voter Choice in Multi-Party Democracies: A Test of Competing Theories and Models." *American Journal of Political Science* 43(4): 1231–1247.
- Rudolph, Thomas J. 2003. "Who's Responsible for the Economy? The Formation and Consequences of Responsibility Attributions." *American Journal of Political Science* 47(4): 698–713.
- Swait, Joffre and Jordan Louviere. 1993. "The Role of the Scale Parameter in the Estimation and Comparison of Multinomial Logit Models." *Journal of Marketing Research* 30(3): 305-314.

## **IIA Assumption**

- Alvarez, R. Michael and Jonathan Nagler. 1998. "When Politics and Models Collide: Estimating Models of Multiparty Elections." *American Journal of Political Science* 42(1): 55–96.
- Dow, Jay K. and James W. Endersby. 2004. "Multinomial Probit and Multinomial Logit: A Comparison of Choice Models for Voting Research." *Electoral Studies* 23(1): 107-122.

## **Models for Count Dependent Variables**

- King, Gary. 1988. "Statistical Models for Political Science Event Counts: Bias in Conventional Procedures and Evidence for the Exponential Poisson Regression Model." *American Journal of Political Science* 32(3): 838-863.
- King, Gary. 1989. "Variance Specification in Event Count Models: From Restrictive Assumptions to a Generalized Estimator." *American Journal of Political Science* 33(3): 762–784.
- King, Gary. 1989. "Event Count Models for International Relations: Generalizations and Applications." *International Studies Quarterly* 33: 123–47.
- Gowa, Joanne. 1998. "Politics at the Water's Edge: Parties, Voters and the Use of Force Abroad." *International Organization* 52(2): 307-24.
- Proksch, Sven-Oliver and Jonathan B. Slapin. 2012. "Institutional Foundations of Legislative Speech." *American Journal of Political Science* 56(3): 520–537.

## **Models for Time Series Analysis**

### **Methodological Literature**

- Beck, Nathaniel. 1993. "The Methodology of Cointegration." *Political Analysis* 4(1): 237-248.
- Box-Steffensmeier, Janet M., John R. Freeman, Matthew P. Hitt, and Jon C.W. Pevehouse. 2014. *Time Series Analysis for the Social Science*. Cambridge University Press.
- Cowpertwait, Paul S. P. and Andrew V. Metcalfe. 2009. *Introductory Time Series with R*. Berlin: Springer-Verlag.
- De Boef, Suzanna and Luke Keele. 2008. "Taking Time Seriously." *American Journal of Political Science* 52(1): 184-200.

- Engle, Robert F. and Clive W. J. Granger. 1987. "Cointegration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55(2): 251-276.
- Granger, Clive W. J. and Paul Newbold. 1974. "Spurious Regressions in Econometrics." *Journal of Econometrics* 2: 111-120.
- Keele, Luke and Nathan Kelly. 2006. "Dynamic Models for Dynamic Theories: The Ins and Outs of Lagged Dependent Variables." *Political Analysis* 14:186-205.
- Pesaran, M. Hashem and Yongcheol Shin. 1999. "An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis." In Steinar Strom, Ed., *Econometrics and Economic Theory in the 20th Century*. Cambridge: Cambridge University Press, pp. 371-413.

### **Applications in Political Science**

- Box-Steffensmeier, Janet M, Suzanna de Boef, and Tse-Min Lin. 2004. "The Dynamics of the Partisan Gender Gap." *American Political Science Review* 98(3): 515-528.
- Brandt, Patrick T. and John R. Freeman. 2009. "Modeling Macro-Political Dynamics." *Political Analysis* 17(2): 113-142.
- Carter, David B. and Curtis S. Signorino. 2010. "Back to the Future: Modeling Time Dependence in Binary Data." *Political Analysis* 18(3): 271-292.
- MacKuen, Michael B., Robert S. Erikson, and James A. Stimson. 1989. "Macropartisanship." *American Political Science Review* 83(4): 1125-1142.

### **Models for Panel Data Analysis**

#### **Methodological Literature**

- Arellano, Manuel and Stephen Bond. 1991. "Some Tests of Specification for Panel Data : Monte Carlo Evidence and an Application to Employment Equations." *Review of Economic Studies* 58: 277-297.
- Arellano, Manuel. 1987. "Computing Robust Standard Errors for Within-Groups Estimators." *Oxford Bulletin of Economics and Statistics* 49(4): 431-434.
- Beck, Nathaniel and Jonathan N. Katz. 1995. "What to Do (and Not to Do) with Times-Series-Cross-Section Data." *American Political Science Review* 89(3): 634-647.
- Beck, Nathaniel and Jonathan N. Katz and Richard Tucker. 1998. "Taking Time Seriously: Time-Series-Cross-Section Analysis with a Binary Dependent Variable." *American Journal of Political Science* 42(4): 1260-1288.
- Beck, Nathaniel and Jonathan N. Katz. 2007. "Random Coefficient Models for Time-Series-Cross-Section Data." *Political Analysis* 15(2): 182-195.
- Beck, Nathaniel and Jonathan M. Katz. 2011. "Modeling Dynamics in Time-Series-Cross-Section Political Economy Data." *Annual Review of Political Science* 14: 331-352.
- Blundell Richard, Bond Stephen. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics*, 87: 115-143.

- Gelman, Andrew and Jennifer Hill. 2007. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge: Cambridge University Press.
- Hausman Jerry and William Taylor. 1981. "Panel Data and Unobservable Individual Effects." *Econometrica* 49: 1377–1398.
- Hood III, M.V., Quentin Kidd and Irwin L. Morris. 2008. "Two sides of the same coin? Employing granger causality tests in a time series cross-section framework." *Political Analysis* 16 (3): 324-344.
- Mundlak, Yair. 1978. "On the Pooling of Time Series and Cross Section Data." *Econometrica* 46(1): 69–85.
- White, Halbert. 1980. *Asymtotic Theory for Econometricians*. Orlando: Academic Press.
- White, Halbert. 1984. "A Heteroskedasticity–Consistent Covariance Matrix and a Direct Test for Heteroskedasticity." *Econometrica* 48: 817–838.
- Applications in Political Science**
- Ban, Pamela, Alexander Fourinaies, Andrew B Hall and James M Snyder. 2018. "How Newspapers Reveal Political Power." *Political Science Research and Methods* 7(4): 661–678.
- Boix, Charles. 2011. "Democracy, Development, and the International System." *American Political Science Review* 105(4): 809-828.
- Pickering, Jeffrey and Emizet F. Kisangani. 2010. "Diversionary Despots? Comparing Autocracies' Propensities to Use and to Benefit from Military Force." *American Journal of Political Science* 54(2): 477-493.
- Stimson, James. 1985. "Regression in Space and Time: A Statistical Essay." *American Journal of Political Science* 29: 914-947.
- Zahariadis, Nikolaos. 1997. "Why State Subsidies? Evidence from European Community Countries 1981-1986." *International Studies Quarterly* 41(2): 341-354.
- Zorn, Christopher J.W. 2001. "Estimating Between-and Within-Cluster Covariate Effects, with an Application to Models of International Disputes." *International Interactions* 27(4): 433-445.