**School of Economics**

**Academic Year 2024-25**
**Term 1**

**COURSE CODE & COURSE TITLE: ECON747 Spatial Econometric Models and Methods**


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## 1. Course Description

In many social and economic activities, **interactions** often occur among geographical units, economic agents, or social actors, which generate **spatial/social effects** among these units or agents or actors, e.g., *neighbourhood effects*, *peer effects*, *spillovers*, *network effects*, *social norms*, *externalities*, *conformity*, *imitation*, *contagion*, *bandwagons*, *herd behaviour*.

Spatial econometrics consist of a set of econometric models and methods, proven to be very effective in dealing with these issues. Applications are seen not only in specialized fields of regional science, urban economics, real-estate and economic geography, but also in more traditional fields of economics, finance, and social sciences in general.

Spatial econometric models extend the classical linear or panel data regression models by incorporating **spatial lag**, **spatial error**, and/or **spatial Durbin** terms to capture spatial or social effects through weight or adjacency matrices. This course introduces basic spatial econometric models including spatial linear regression models, spatial panel data models, and dynamic spatial panel data models, and the associated methods of estimation and inference such as (quasi) maximum likelihood, M-estimation, and GMM. Common tests for spatial and/or dynamic effects, e.g., LM tests, standardized LM tests, and bootstrap LM tests are introduced. **Empirical illustrations** of the methods are presented using **Matlab**, **Python** or **Stata**.

## 2. Learning Objectives

The main learning objective of the course is to equip students with a set of state-of-the-art spatial econometric tools important in solving applied research problems where interaction among spatial units matters. Upon completion of the course, students should be able to

(i) identify and formally test the possible existence of spatial/social effects in the empirical studies they face,

(ii) apply suitable spatial econometric models and methods learnt from the class to address issues related to spatial effects, social interactions, social networks, etc.,

(iii) write their own programs in Matlab or Python in cases where the existing packages do not suit the models and methods they adopted.

As spatial econometrics is a fast-growing field with many problems remaining open, this course also serves as a channel for students to find research topics for their PhD study.

## 3. Pre-requisite/Co-requisite/Mutually Exclusive Course(s)

ECON611 Econometrics I and ECON726 Panel Data Econometrics I (or equivalent) are essential. Knowledge of Matlab and Python programming and Stata is useful but not required.

## 4. Assessment Methods

| Assessment Categories | Weightage (%) |
|---|---|
| Assignments | 30 |
| Take-Home Test | 20 |
| Research Paper | 50 |
| **Total** | **100** |

## 5. Course Assessment Details

- **Class participation:** Students are strongly encouraged to attend the class, be attentive during the class, and actively engage in class discussions. The course comprises twelve 3-hour sessions. Each session will include a lecture and an empirical illustration using Matlab or Python or Stata. Necessary computing codes will be provided.
- **Assignments:** There will be bi-weekly assignments, through which students will have much deeper understandings of the course materials and will gain basic skills for empirically implementing the spatial methods. The answer of the assignment should be typewritten, and be submitted in a single pdf file through eLearn –> Assignments.
- **Take-home test:** The test will take place between Sessions 9 and 10 and last 15 hours, intended to check how well the fundaments delivered in classes are taken.
- **Research paper:** The main purpose is to train students to write academic papers. It can be *empirical* on the applications of spatial econometric methods or *theoretical* on the further developments of the spatial econometric methods. The key components in assessing the research paper are: academic writing, knowledge level and oral presentation.

## 6. Recommended Text and Readings

The lecture notes are the main readings of the course, where each "Lecture" draws from a few papers listed below. Lecture 1, recommended textbooks, and Papers 1 and 2 provide fundamentals on spatial econometrics and are ideal for initial readings. The state-of-the-art spatial econometric methods are covered in the subsequent Lectures and papers.

**Recommended Textbooks**

- Anselin, Luc (1988). **Spatial Econometrics: Methods and Models**, *Dordrecht: Kluwer*.
- Lee, Lung-Fei (2024). **Spatial Econometrics: Spatial Autoregressive Models**, *World Scientific*.

## 7. University Policies

**Academic Integrity**

All acts of academic dishonesty (including, but not limited to, plagiarism, cheating, fabrication, facilitation of acts of academic dishonesty by others, unauthorized possession of exam questions, or tampering with the academic work of other students) are serious offences.

All work (whether oral or written) submitted for purposes of assessment must be the student's own work. Penalties for violation of the policy range from zero marks for the component assessment to expulsion, depending on the nature of the offense.

When in doubt, students should consult the instructors of the course. Details on the SMU Code of Academic Integrity may be accessed at

https://smu.sharepoint.com/sites/oasis/SitePages/DOSWKLSWC/UCSC.aspx.

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**Accessibility**

SMU strives to make learning experiences accessible for all. If students anticipate or experience physical or academic barriers due to disability, please let the instructor know immediately. Students are also welcome to contact the university's disability services team if they have questions or concerns about academic provisions: DSS@smu.edu.sg. Please be aware that the accessible tables in the seminar room should remain available for students who require them.

**Digital Readiness for Teaching and Learning (DRTL)**

As part of emergency preparedness, instructors may conduct lessons online via the Zoom platform during the term, to prepare students for online learning. During an actual emergency, students will be notified to access the Zoom platform for their online lessons. The class schedule will mirror the current face-to-face class timetable unless otherwise stated.

## 8. Weekly Lesson Plan

| Week | | Topic | Readings |
|---|---|---|---|
| 1 | 19 Aug 24 | **Introduction:**<br>Common spatial econometric models; spatial weight matrices; quasi maximum likelihood (QML) estimation; M-estimation; generalized method of moments; Basics on matrix algebra; Introduction to Matlab, Python, Stata | Lecture1.pdf<br>Papers 1 & 2 |
| 2 | 26 Aug 24 | **Spatial linear regression models I:**<br>QML estimation and inference; GMM estimation and inference; Empirical illustration. | Lecture2.pdf<br>Papers 3 & 4 |
| 3 | 2 Sep 24 | **Spatial linear regression models II:**<br>Tests of hypotheses: LM tests, standardized LM tests, empirical applications. | Lecture3.pdf<br>Papers 5 & 6 |
| 4 | 9 Sep 24 | **Spatial linear regression models III:**<br>Heteroskedasticity-robust estimation and inference; Empirical illustration. | Lecture4.pdf<br>Paper 7 |
| 5 | 16 Sep 24 | **Spatial linear regression models IV*:**<br>Bias-corrected estimation: general method; For SLR models with SL, SE and SLE; Refined inferences. | Lecture5.pdf<br>Papers 8 & 9 |
| 6 | 23 Sep 24 | **Spatial linear regression models V*:**<br>LM tests for spatial dependence based on bootstrapped critical values; Empirical illustration. | Lecture6.pdf<br>Paper 10 |
| 7 | 30 Sep 24 | **Spatial panel data models I:** | Lecture7.pdf |

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|---|---|---|---|
| | | Random effects model, Fixed effects model; QML estimation and inference; Empirical illustration. | Papers 11 & 12 |
| 8 | 7 Oct 24 | Recess Week | |
| 9 | 14 Oct 24 | **Spatial panel data models II:** Hypothesis tests: LM tests, standardized LM tests; Empirical illustration. | Lecture8.pdf Papers 5 & 6 |
| 10 | 21 Oct 24 | **Spatial panel data models III:** Heteroskedasticity-robust estimation and inference for SPD models with fixed effects; Empirical illustration. | Lecture9.pdf Paper 13 |
| 11 | 28 Oct 24 | **Spatial dynamic panel data models I**: QMLE based on large panels; M-estimation and inference based on short panels; Empirical illustration. | Lecture10.pdf Papers 14 & 15 |
| 12 | 4 Nov 24 | **Spatial dynamic panel data models II**: Tests for dynamic and spatial effects in SDPD models with fixed effects; Empirical illustrations. | Lecture11.pdf Papers 16 |
| 13 | 11 Nov 24 | **Spatial dynamic panel data models III**: Heteroskedasticity-robust estimation and inference for SDPD models with fixed effects; Empirical illustration. | Lecture12.pdf Paper 17 |
| 14 | 18 Nov 24 | Oral Presentation of Research Paper | |
| 15 | 25 Nov 24 | Submission of Final Version of Research Paper: 11:00PM, 25 Nov 24 | |
| 16 | 2 Dec 24 | | |

**Key Papers involved in Lecture Notes:**


1. Anselin, L. and Bera, A. K. (1998). Spatial dependence in linear regression models with an introduction to spatial econometrics. In: *Handbook of Applied Economic Statistics*, edited by Aman Ullah and David E. A. Giles}. New York: Marcel Dekker
2. Anselin, L. (2001). Spatial Econometrics. In: *A Companion to Theoretical Econometrics*, edited by Badi H. Baltagi. Blackwell Publishing.
3. Lee, L. F. (2004). Asymptotic distributions of quasi-maximum likelihood estimators for spatial autoregressive models. ***Econometrica* 72**, 1899-1925.
4. Liu, S. F. and Yang, Z. L. (2015a). Asymptotic distribution and finite-sample bias correction of QML estimators for spatial error dependence Model. ***Econometrics* 3**, 376-411.
5. Baltagi, B. H. and Yang, Z. L. (2013a). Standardized LM tests for spatial error dependence in linear or panel regressions. ***Econometrics Journal* 16**, 103-134.
6. Baltagi, B. H. and Yang Z. L. (2013b). Heteroskedasticity and non-normality robust LM tests of spatial dependence. ***Regional Science and Urban Economics* 43,** 725-739.
7. Liu, S. F. and Yang, Z. L. (2015). Modified QML estimation of spatial autoregressive models with unknown heteroskedasticity and normality. ***Regional Science and Urban Economics*, 52,** 50-70.
8. Yang, Z. L. (2015a). A general method for third-order bias and variance correction on a nonlinear estimator. ***Journal of Econometrics*, 186**, 178-200.

9. Liu, S. F., Yang, Z. L. (2015b). Improved Inferences for Spatial Regression Models. ***Regional Science and Urban*** **Economics 55**, 55-67***.***

10. Yang, Z. L. (2015b). LM tests of spatial dependence based on bootstrap critical values. ***Journal of Econometrics*** **185**, 33-39*.*

11. Lee, L. F. and Yu, J. (2010). Estimation of spatial autoregressive panel data models with fixed effects. ***Journal of Econometrics*** **154**, 165-185.

12. Yang, Z. L., Yu, J. H, and Liu, S. F. (2016). Bias correction and refined inferences for fixed effects spatial panel data models. ***Regional Science and Urban Economics*** **61**, 52-72***.***

13. Liu, S. F. and Yang, Z. L. (2020). Robust estimation and inference of spatial panel data models with fixed effects. ***Japanese Journal of Statistics and Data Science*** **3**, 257–311.

14. Yu, J., de Jong, R. and Lee, L. F. (2008). Quasi-maximum likelihood estimators for spatial dynamic panel data with fixed effects when both *n* and *T* are large. ***Journal of Econometrics*** **146**, 118-134.

15. Yang, Z. L. (2018). Unified M-estimation of fixed-effects spatial dynamic panel data models with short panels. ***Journal of Econometrics*** **205**, 423-447.

16. Yang, Z. L. (2021). Joint tests for dynamic and spatial effects in short dynamic panel data models with fixed effects and heteroskedasticity. ***Empirical Economics*** **60**, 51-92.

17. Li, L. Y. and Yang, Z. L. (2020). Estimation of Fixed Effects Spatial Dynamic Panel Data Models with Small *T* and Unknown Heteroskedasticity. ***Regional Science and Urban Economics*** **81**, 103520.