Academic, Demographic and Spatial Factors in the Classroom Affecting Student Performance in Principles of Agricultural Economics Courses

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A number of studies have examined factors affecting students' performance in principles of economics classes (Clauretie and Johnson 1975; Lumsden and Scott 1987; Anderson, Benjamin, and Fuss 1994; Ballard and Johnson 2004; Benedict and Hoag 2004; Caviglia-Harris 2006; Gossard, Jessup, and Casavant 2006). Previous factors of interest have included academic factors: performance on exams, performance on homework, attendance, use of outside assistance, class status, major, special accomodations, GPA, SAT/ACT test scores, instructor, and transfer credits; demographic factors: ethnicity, age, gender, financial status, being a veteran, and permanent place of residence; and spatial factors: proximity to the front of the classroom, who you sit by, and performance of students around you. Despite the popularity of this topic, results are still inconclusive in regards to the significance and effect of academic, demographic, and spatial factors in the classroom as well as controlling for the same instructor and teaching methods.

This study specifically contributes to previous literature through the incorporation of anisotropic spatial effects. To the authors' knowledge, despite interest in seating location, proximity to the front of the classroom, and who you sit by, no studies have specifically looked at the different impact each student neighbor may have on academic performance. Even outside the academic literature, most spatial models assume that spatial effects are isotropic, or direction does not matter, whereas anisotropic models allow for directionality to be captured (Arbia 2014). In stadium style seating, it is possible that a student might be able to see exams or other coursework of classmates sitting near them; specifically, a student may be able to see over the shoulders of students sitting diagonally to their front left or right as well as directly to their left or right and each of these neighbors may have a different impact on their scores (e.g. the students studied together).

The overall purpose of the current study is to add to the previous literature by examining academic, demographic and anisotropic spatial factors in the classroom affecting student performance in principles of agricultural economics courses at a major Land Grant institution in the midwest. Objectives include: (i) identify factors impacting performance on each of four exams (three regular exams and a comprehensive final exam); (ii) identify factors impacting overall performance in the classroom; and (iii) explore anisotropic spatial relationships in the classroom to identify if peer effects or spatial arrangment impacts student performance.

Previous Literature

Introductory or principles of economics courses have intrigued researchers for decades. Clauretie and Johnson (1975) analyzed the performance of students across five sections of a principles of economics course to identify whether the course should be presented the same way to economic majors versus non majors. They considered five factors expected to affect grades in the course: number of credit hours the student had successfully completed (interpreted in the current study as class status); student's major; grade point average (GPA); instructor; and gender. The results of their study found that a student's GPA was the most significant variable to predict the final grade.

Researchers have also examined attendance and related policies on academic performance in economics courses. Caviglia-Harris (2006) looked at the impact of mandatory attendance policies on grades as well as the impact of absentee rates on exam scores across four principles of microeconomics courses. Additional variables of interest were class size, major, gender, cumulative hours completed, taking a prior economics course, number of courses withdrawn from, transfer student status, SAT scores, GPA, exam scores throughout the semester, class average, and absences before each exam. Exam scores, GPA, and SAT scores were significant predictors of performance while attendance and absentee rates did not impact grades.

In addition to the more general academic and demographic variables of interest, a new wave of research has focused on the spatial aspects of the classroom or where students are sitting. Benedict and Hoag (2004) found that students who indicate a preference for sitting in the front of the class room have a higher probability of receiving As and those who have a preference for sitting in the back of the classroom have a higher probability of receiving Ds and Fs, regardless of whether they actually sat in the back of the room or not. Gossard, Jessup, and Casavant (2006) examined the relationship between seating location within the classroom (front, middle, or back), class preparedness (reviews text before test, reviews notes before class, reviews text before class, and math level), outside assistance, gender, and class standing for an introductory agricultural economics course. They found that students who sat in the front or middle of the room performed better, as did females, students who reviewed the text before tests and those students who had completed higher level math courses. Surprisingly, their results indicated that students who sought outside assistance performed worse; however, this may be due to these students struggling with the material and recognizing early on they needed extra assistance.

Marshall and Losonczy-Marshall (2010) considered grades and attendance across five different seating configurations: row, column, front of the room versus back of the room, center of the room versus the perimeter of the room, and middle of the room versus sides of the room. Their findings indicated that students who sat in the middle or central part of the room had better grades and attendance and that female students generally had better attendance although females did not necessarily perform better academically. Marshall and Losonczy-Marshall (2010) acknowledge that future research to identify why students choose specific seats or locations in the classroom would be useful.

Tagliacollo, Volpato, and Pereira, Jr. (2010) take a different approach in that their focus is on Brazilian public elementary schools. Despite a different sample of students, the research results support what is often observed in college classrooms across the U.S. The researchers found that students sitting in the front of the room performed better academically and had fewer absences. The students were questioned regarding their reason to choose a seat in a particular location and motivation for learning was identified as the primary reason to choose a seat in the front of the room. Friendship was the primary reason students chose to sit in the middle of the classroom, and social isolation was identified as the primary reason students chose to sit in the back of the classroom.

While many studies have examined factors on performance in principles of economics classes, combining academic, demographic, and spatial factors into one study that also controls for teaching methods has not been extensively explored to the authors' knowledge. This research identifies factors impacting performance on exams, identifies factors impacting overall performance in the course, and explores anisotropic spatial relationships in the classroom to identify if students' peers and seating choice affect their performance. Secondary classroom data from a course in which the material has been taught in a similar fashion for the past few years is used, helping to control for differences in teaching methods.

Data

This study utilizes secondary data regarding gender, grades, level of math completed, GPA, class status, major, course load and seating arrangement obtained from a principles of agricultural economics and agribusiness course taught by the same professor from a major Land Grant university in the midwest during the Fall 2009 and 2010 semesters. The data were collected from course performance (grades) and seating charts (seating arrangement); and was supplemented from the university's student information system to control for other factors (gender, level of math completed, GPA, class status, major, and course load). Each semester included in the sample had at least 160 students enrolled in the course. In addition, the professor that taught the course has over 30 years of teaching experience and is recognized as a distinguished teaching scholar by the university, as well as other national organizations.

Summary statistics are reported in Table 1. In 2009, data were available for 161 students and in 2010, data were available for 186 students. The percentage of female students was slightly higher in 2009 compared to 2010, 47.83% and 42.47%, respectively. The number of students who were recorded as an agricultural economics major was greater in 2010 as was the number of students not in the College of Agriculture. The course was comprised of a higher percentage of freshman in 2010 compared to 2009.

Over the course of each semester, the students took three in-class exams (exams 1-3) and a comprehensive final examination (exam 4). Course grades were also comprised of homework assignments and quizzes before each exam and attendance. For this study, the quiz and homework grades were combined in the analysis. The authors have no reason to believe this will impact the results. All quiz and homework grades were graded on a 10 point scale. The attendance score is intuitively interesting in general; however, this portion of the dataset had a number of inconsistencies and was not readily usable.

Class was held in a traditional, lecture style classroom with individual desks. The room seats approximately 200 students and is equipped with a computer for the instructor, projector, document camera, and whiteboard. Students were able to choose their seat at the beginning of the semester and were asked to sit in that seat for the remainder of the semester. Consistency in seating assignment was maintained by attendance grades that were based on the seating chart. There were a total of 15 rows of seating with up to 14 seats per row. The class room has a slight incline from the front to the back of the classroom. Each row of seating from the front to the back of the classroom is slightly higher than the row before it (i.e. stadium style seating). In addition, seats are in perfect columns within the rows, lining up from the front to the back of the classroom. That is, the seats are not offset from each other from row to row.

Table 1: Summary Statistics for Principles of Agricultural Economics

Demographics	2009	2010
Female	47.83%	42.47%
	(50.11%)	(49.56%)
Hours (course load)	13.73	13.48
	(2.08)	(1.98)
Current GPA	2.73	2.79
	(0.89)	(0.82)
Algebra	34.16%	37.63%
	(47.57%)	(48.58%)
Ag Econ Major	32.30%	19.89%
	(46.91%)	(40.03%)
Non Ag Major	10.56%	5.91%
	(30.83%)	(23.65%)
Freshman	45.96%	51.08%
	(49.99%)	(50.12%)
Sophomore	32.30%	29.57%
	(46.91%)	(45.76%)
Junior	15.53%	12.90%
	(36.33%)	(33.61%)
Senior	6.21%	6.45%
	(24.21%)	(24.63%)
Homework 1	81.57	76.60
	(16.72)	(15.55)
Exam 1	71.50	70.98
	(14.59)	(12.09)
Homework 2	70.90	77.02
	(18.25)	(13.67)
Exam 2	69.75	66.53
	(17.15)	(15.24)
Homework 3	76.47	68.27
	(18.6)	(17.77)
Exam 3	75.24	72.71
	(16.94)	(16.32)
Homework 4	82.70	82.10
	(24.17)	(18.57)
Comprehensive Final Exam (Exam 4)	78.93	74.12
	(14.57)	(12.26)
Overall Homework Grade	77.91	76.00
	(15.58)	(11.79)
Final Course Grade	78.11	76.05
	(13.28)	(11.79)

Note: the reported statistics represent the sample mean and standard deviation (in parentheses).

Methods

This section of the paper presents the methods used to assess the factors impacting performance on exam grades and overall class performance. We present a model of student performance that is designed to capture student specific, performance, and spatial factors.

Performance Model: A student's performance, as demonstrated in the literature review, is dependent on a number of explanatory factors. These include student specific factors ($\boldsymbol{X}_i$, e.g. gender, course load, preparedness, student rank, college and major); class performance factors ($\boldsymbol{Z}_i$, e.g. homework and GPA); and spatial factors ($\boldsymbol{R}_i$, e.g. seat row). Let a student *i*'s performance on a specific exam or final course grade be given by G_i. Then, assume that G_i is related to these explanatory factors via the following functional relationship:

$$G_i = \alpha + \boldsymbol{\beta}'\boldsymbol{X}_i + \boldsymbol{\gamma}'\boldsymbol{Z}_i + \boldsymbol{\theta}'\boldsymbol{R}_i + u_i, \quad (1)$$

where $(\alpha, \boldsymbol{\beta}, \boldsymbol{\gamma}, \boldsymbol{\theta})$ are parameters to be estimated and u_i is a mean zero IID error term capturing the unmodeled portion of a student's performance on an exam or class. A factor of particular interest in this paper, is the seat row. There are 15 rows of seating in the classroom. Given the limited degrees of freedom and the number of explanatory factors, the classroom was broken into three sections: front (rows 1 to 5), middle (rows 6 to 10), and back (rows 11 to 15). Binary variables are included in the regression given by equation (1) for the middle and back sets of rows in $\boldsymbol{R}_i$ to model "row" effects. The sign on these variables is expected to be negative and greater the further back a student sits in the classroom (Gossard, Jessup, and Casavant 2006; Marshall and M. Losonczy-Marshall 2010; Tagliacolloab, Volpatoac, and Pereira Jr. 2010). While the "row" effect is of interest, unique to this study is the effect of who a student sits by.

Incorporating Anisotropic Spatial Effects: Most spatial models assume that spatial effects are isotropic, meaning that direction does not matter (Arbia 2014). While this may be true in certain situations, it is the hypothesis here that who a student sits by matters. If spatial effects are significant, this implies that not only where a student sits, but who sits around that student will impact their performance. For example, a student who sits by friends or colleagues (to the left or right of them) may improve their performance, given that these individuals may study and do homework together, having a positive spillover effect for the i^{th} student. That is, the better performance of neighboring students and their understanding of the material, may provide better performance and understanding for the i^{th} student; therefore, this model is capturing unobserved social networks. Given the stadium style seating in the classroom (i.e. upward incline from the front to back of the classroom), it may be the case that student performance may improve due to academic dishonesty, as well. A student in the classroom, if positioned correctly, could see an exam by a student in the row below them (or beside them) diagonally to their left or right. Given the seats in the rows are aligned in perfect columns, seeing the exam of the person in front of you is much more difficult and assumed to not be possible for the purposes of this study. Thus, the i^{th} student may perform well on an exam by copying another student's exam in the row below or next to them. Thus, the nearest neighbors for the i^{th} student can impact their performance and each neighbor may have a different impact. That is to say, the spatial effects of neighbors are anisotropic.

To model the anisotropic spatial effects of the i^{th} student's neighbors, it is assumed that only the immediate neighbors in the seats to the i^{th} student's right (R) and left (L), as well as the seats in the row below to the (diagonally) right (DR) and (diagonally) left (DL) of the person sitting in front of them impact their performance. To model these effects spatially, four separate directional weight matrices are developed following Arbia (2014) that indicate the neighbors for a given seat in the classroom. These include weight matrices for seats to i^{th} student's right ($\mathbf{W}_{\text{R}}$), left ($\mathbf{W}_{\text{L}}$), diagonally right and in front of ($\mathbf{W}_{\text{DR}}$), and diagonally left and in front of ($\mathbf{W}_{\text{DL}}$). All weight matrices are row standardized as is convention in the spatial econometrics literature for interpretation purposes (Arbia 2014).

To incorporate the spatial effects into the performance model, spatial lags for the four spatial directions being modeled are included in equation 1, giving:

$$G_i = \alpha + \boldsymbol{\beta}'\boldsymbol{X}_i + \boldsymbol{\gamma}'\boldsymbol{Z}_i + \boldsymbol{\theta}'\boldsymbol{R}_i + \rho_R \mathbf{W}_{\text{R}} G_i + \rho_L \mathbf{W}_{\text{L}} G_i + \rho_{DR} \mathbf{W}_{\text{DR}} G_i + \rho_{DL} \mathbf{W}_{\text{DL}} G_i + u_i, \qquad (2)$$

where ρ_j for $j = \text{R}, \text{L}, \text{DR}, \text{DL}$ are the spatial dependence parameters representing the spatial dependence among students in different directions (Arbia 2014).

Estimation: Estimation of the model is completed using a two stage estimation process to account for the endogeneity of both the GPA of the students and spatial lags in the model. GPA represents the current semester GPA for a student taking the course that semester and will be dependent on the performance in that class. It is utilized to account for a student's performance in their other classes that semester. Thus, GPA is an endogenous variable. In addition, the spatially lagged variables ($\mathbf{W}_{\text{R}} G_i, \mathbf{W}_{\text{L}} G_i, \mathbf{W}_{\text{DR}} G_i, \mathbf{W}_{\text{DL}} G_i$) will be endogenous, as well. Following Arbia (2014), the independent variables and the spatial lags of the independent variables (e.g. $\mathbf{W}_{\text{R}}\boldsymbol{X}_i, \mathbf{W}_{\text{L}}\boldsymbol{X}_i, \mathbf{W}_{\text{DR}}\boldsymbol{X}_i, \mathbf{W}_{\text{DL}}\boldsymbol{X}_i. \mathbf{W}_{\text{R}}\boldsymbol{Z}_i, \mathbf{W}_{\text{L}}\boldsymbol{Z}_i, \mathbf{W}_{\text{DR}}\boldsymbol{Z}_i, \mathbf{W}_{\text{DL}}\boldsymbol{Z}_i$) are used as instruments to deal with the endogeneity. In the first stage, GPA and the spatially lagged dependent variables are regressed on the set of instruments using ordinary least squares. Using the resulting estimated parameters from the regression, instrumented regressors of the endogenous variables are then calculated to include in the second stage that models equation (2).

The second stage estimates the regression given by equation (2). Given that the dependent variable is constrained to be between 0 and 1 (0% and 100%) with grades for individual students potentially accumulating at both endpoints, the regression given by equation (2) is estimated as a censored or tobit regression model following Greene (2012) with the endogenous variables replaced with their instrumented regressors. In addition, it is assumed that the intercept (α) is a random parameter, allowed to randomly vary across students. This assumption allows for student preferences concerning teaching styles and environment, as well as differences in learning abilities to vary across students. Furthermore, it is assumed that this variation is random and the variation is unobserved by the modelers. Failure to capture this variation could result in biased and inconsistent estimates. The random parameter tobit model following equation (2) is estimated in LIMDEP 9.0 using a simulated maximum likelihood estimation procedure following Greene (2012) using 1000 Halton draws and the BFGS Quasi-Newton algorithm with an increased tolerance for the norm of the gradient of 1e-8.

Results

Results indicate that being female, currently enrolled hours for that semester, haven taken algebra, being an agricultural economics major, class status, seating location, GPA, and homework scores all affected student academic performance at some point in time throughout the semester for both 2009 and 2010. Table 2 presents the random parameter tobit coefficients for 2009 and 2010, respectively, for each of the four exams (3 regular exams and 1 comprehensive final exam) and the overall course grade. The results for 2009 are discussed first. The coefficient on female was negative but not significant for all four exams as well as the overall grade. Previous studies have found mixed results for gender. While Gossard, Jessup, and Casavant (2006) found being female to be a significant predictor of higher GPAs, Anderson, Benjamin, and Fuss (1994) found male students performed significantly better than female students in introductory economics courses and Lumsden and Scott (1987) found female students generally perform better on essay exams but male students performed better on multiple choice questions.

In 2009, the greater the number of hours a student was taking on average, the better they performed on exams and overall. This may be explained by the fact that students who are motivated to enroll in additional hours or to work during the semester have better time management skills and are generally higher achieving students. The coefficient on having taken an algebra course or higher was negative and significant for exam 1 and exam 3. This result was surprising; however, almost 50% of the students enrolled were freshman, so it is likely that they were either transferring in a math course from high school or had tested out of algebra. This may be an indication that they actually were not prepared mathematically with the previous quantitative courses taken for the rigor of this course. Success or mastery in math was found to be an indicator of higher performance in economics courses by Ballard and Johnson (2004). It is possible that a student may pass algebra with a C or D grade yet not have the skills necessary for this course. Being an agricultural economics major had a positive and significant effect on the exam 3 score. This may be the result of students being more motivated to take courses directly related to their major.

Class status (sophomore, junior, or senior) had mixed effects on exam scores and the overall grade. The authors do not have a strong sense of why this was the case. It is possible that some of the upper classmen were non-majors as this course is generally taken by freshman majors, some students may have been retaking the course, or previously taking other courses such as macroeconomics made it more difficult for them to understand a microeconomics based course.

As expected, where a student sits in the classroom matters. Students who sat in the back of the classroom performed worse on each exam and overall in the course. In 2009, the coefficient was significant in all instances except for exam 3. This is consistent with previous studies; however, like the previous research, we cannot say whether it is because of sitting in the back students performed worse or if students who are less motivated choose to sit in the back to begin with. It should be a relief to most instructors that the results indicate who a student sits by or behind was generally not significant. There was a positive and significant coefficient for who sat to a student’s right side on the overall grade, indicating that if the person to the student’s right performed better, the student also performed better. This may be the result of studying together

Table 2. Tobit Model Estimation Results

	2009					2010				
	Exam 1	Exam 2	Exam 3	Final Exam	Overall Grade	Exam 1	Exam 2	Exam 3	Final Exam	Overall Grade
Female	-0.0127	-0.0324	-0.0387	-0.0159	-0.0187	-0.0257	-0.0623*	-0.0094	-0.0310	-0.0128
	(0.0100)	(0.0218)	(0.0274)	(0.0268)	(0.0144)	(0.0250)	(0.0347)	(0.0435)	(0.0239)	(0.0167)
Hours	0.0047*	0.0133***	0.0070*	0.0146***	0.0058**	-0.0052	-0.0016	0.0055	0.0056	0.0015
	(0.0024)	(0.0042)	(0.0043)	(0.0040)	(0.0025)	(0.0072)	(0.0118)	(0.0109)	(0.0091)	(0.0037)
Algebra	-0.0460***	-0.0249	-0.0620***	-0.0047	-0.0222	0.0041	0.0312	0.0252	0.0123	0.0177
	(0.0105)	(0.0213)	(0.0234)	(0.0270)	(0.0140)	(0.0187)	(0.0230)	(0.0273)	(0.0185)	(0.0131)
Ag Econ Major	-0.0070	0.0383	0.0599**	0.0350	0.0182	0.0135	0.0050	0.0366	0.0270	0.0138
	(0.0119)	(0.0245)	(0.0276)	(0.0310)	(0.0144)	(0.0214)	(0.0276)	(0.0349)	(0.0253)	(0.0145)
Non Ag Major	-0.0107	0.0452	0.0453	0.0515	0.0243	0.0572	0.0336	0.0527	0.0119	0.0294
	(0.0163)	(0.0301)	(0.0464)	(0.0370)	(0.0197)	(0.0458)	(0.0573)	(0.0700)	(0.0531)	(0.0356)
Sophomore	0.0269**	0.0293	-0.0351*	-0.0064	0.0008	0.0379**	-0.0055	0.0359	0.0325	0.0190*
	(0.0110)	(0.0221)	(0.0207)	(0.0269)	(0.0136)	(0.0192)	(0.0260)	(0.0266)	(0.0220)	(0.0112)
Junior	-0.0344**	0.0096	-0.0006	-0.0101	-0.0068	0.0819***	-0.0076	0.0616*	0.0163	0.0215
	(0.0141)	(0.0301)	(0.0337)	(0.0433)	(0.0198)	(0.0272)	(0.0385)	(0.0376)	(0.0309)	(0.0161)
Senior	0.0367*	-0.0025	0.0115	-0.0092	-0.0026	0.0112	0.0199	0.0384	0.0452	0.0368
	(0.0228)	(0.0534)	(0.0569)	(0.0501)	(0.0345)	(0.0347)	(0.0670)	(0.0711)	(0.0528)	(0.0319)
Middle	-0.0194*	-0.0193	-0.0106	0.0101	0.0071	-0.0365	-0.0346	-0.0090	-0.0043	-0.0105
	(0.0121)	(0.0253)	(0.0287)	(0.0303)	(0.0167)	(0.0230)	(0.0297)	(0.0280)	(0.0231)	(0.0134)
Back	-0.0344***	-0.0634***	-0.0408	-0.0566**	-0.0266*	-0.0395*	-0.0564**	-0.0129	-0.0077	-0.0152
	(0.0123)	(0.0249)	(0.0273)	(0.0275)	(0.0156)	(0.0232)	(0.0273)	(0.0285)	(0.0213)	(0.0135)
Instrumented GPA	0.0685***	0.0605	0.0248	0.0820*	0.0410	0.1166*	0.0996	0.0709	0.0962	0.0363
	(0.0199)	(0.0543)	(0.0549)	(0.0447)	(0.0294)	(0.0672)	(0.1048)	(0.0991)	(0.0729)	(0.0522)
Homework 1	0.2265***					-0.0272				
	(0.0585)					(0.1859)				
Homework 2		0.2552*					0.2186			
		(0.1467)					(0.3259)			
Homework 3			0.5091***					0.2731		
			(0.1552)					(0.2672)		
Homework 4				0.1163*					0.0673	
				(0.0686)					(0.1435)	
Overall Homework Score					0.5241***					0.5851***
					(0.1036)					(0.2283)

Anisotropic Spatial Effects										
Right Side	-0.0134	0.0357	0.0461	0.0238	0.0280*	-0.0357	-0.0639	0.0122	-0.0816*	-0.0368*
	(0.0161)	(0.0315)	(0.0352)	(0.0329)	(0.0170)	(0.0376)	(0.0513)	(0.0486)	(0.0439)	(0.0228)
Diagonal Right	-.0280*	-0.0155	-0.0236	0.0032	-0.0162	-0.0272	-0.0348	-0.0577	0.0371	-0.0069
	(0.0143)	(0.0309)	(0.0303)	(0.0303)	(0.0189)	(0.0347)	(0.0442)	(0.0474)	(0.0355)	(0.0213)
Diagonal Left	-0.0223	-0.0416	0.0307	-0.0365	-0.0049	0.0785**	0.0253	-0.0187	-0.0357	0.0143
	(0.0154)	(0.0302)	(0.0291)	(0.0370)	(0.0169)	(0.0363)	(0.0377)	(0.0473)	(0.0400)	(0.0195)
Left Side	-0.0184	-0.0305	0.0009	0.0083	-0.0019	-0.0482	-0.0011	0.0585	0.0315	-0.0121
	(0.0153)	(0.0318)	(0.0303)	(0.0348)	(0.0178)	(0.0353)	(0.0470)	(0.0481)	(0.0432)	(0.0206)
Random Intercept										
Mean	0.3609***	0.2198***	0.2114***	0.2818***	0.1936***	0.5046***	0.3313***	0.2435***	0.3657***	0.2160***
	(0.0423)	(0.0780)	(0.0752)	(0.0849)	(0.0481)	(0.0814)	(0.1251)	(0.0937)	(0.0771)	(0.0715)
Standard Deviation	0.1037***	0.0902***	0.0327***	0.0066	0.0204***	0.0041	0.0037	0.0242**	0.0073	0.0023
	(0.0048)	(0.0079)	(0.0089)	(0.0093)	(0.0052)	(0.0073)	(0.0092)	(0.0095)	(0.0073)	(0.0044)
σ_μ	0.0568***	0.1088***	0.1150***	0.1179***	0.0667***	0.0990***	0.1251***	0.1283***	0.0998***	0.0604***
	(0.0032)	(0.0058)	(0.0055)	(0.0068)	(0.0036)	(0.0057)	(0.0064)	(0.0071)	(0.0048)	(0.0032)

Note: ***, **, * indicate significance at 1%, 5%, 10% level, respectively. Standard errors are reported in parentheses.

such that a student sits next to a friend, but it could also be the results of academic dishonesty. Future research with greater controls will need to be conducted to disentangle these effects. There was a negative and significant coefficient for diagonal right indicating that if that individual did better you did worse. This might potentially be the effect of "bad" cheating. The instructor did use multiple versions of exams; however, the authors do not know which version each student was given.

The instrumented GPA, a measure of preparedness and overall academic success, was positive and significant for exam 1 and the final exam in 2009. This result is as expected that students who perform better overall would also perform better on individual components of this course. The homework scores were positive and significant for each exam. This is intuitive that students who were able to comprehend the material and complete the homework assignments adequately would also test better on the material. The mean of the random parameter intercept was significant across all models. This indicates the fact that student preferences and abilities do vary and needed to be captured by the model.

In 2010, similar to 2009, the coefficient for female was negative indicating that on average, females performed worse than their male peers. However, this result was only statistically significant for exam 2. Higher class status had a positive impact more frequently in 2010 compared to 2009. Sophomores performed better than freshmen on exam 1 and overall and juniors performed better than freshman on exam 1 and exam 3. Sitting in the middle or back of the classroom had a negative effect on exam and overall class performance. And, who a student sat by mattered, but not in the way one might think. The performance of the individual on your right had a negative and significant effect for the final exam and the overall course grade. One explanation for this might be that studying with this individual actual brought the student's score down because they were confused by the material or questions the other student was having, both students had bad study habits, or both students are friends and social occasions (e.g. partying) interfered with class performance. It could also be attributed to "bad" cheating. The score of the individual to the left diagonal had a positive and significant effect on the exam 1 grade. This could be cause for concern, if the positive relationship can be attributed to academic dishonesty. Again, more research is needed to disentangle these spatial effects. The coefficient for instrumented GPA was positive and statistically significant for exam 1. The overall homework score had a positive and significant effect on the overall course grade and the mean of the random parameter intercept was significant across all models.

Summary

Overall, the results of this study were consistent with previous findings indicating that males generally perform better than female students in economics courses and specifically on multiple choice exams. Additionally, where students sit matters although who they sat by may have less of an impact than previously thought. Students who sat in the middle or back of the classroom in general performed worse on each of the four exams and the final. This is consistent with previous studies; however, this study does not attempt to identify whether students chose to sit in the back because they were disinterested in the subject matter, were generally less motived students, prefer not to be called on/feel more at ease in the back, or simply were late getting to the classroom when seats were chosen and were left with the backs rows. It should be a relief to instructors who have been concerned about student dishonesty or academic cheating from the statistically insignificant results in regards to students sitting to the left, right, left diagonal, or right diagonal for many of the spatial effects. The coefficients for the spatial variables were significant in a few instances; however, they generally do not support the general fear of students' cheating.

Future research could include a survey of students asking why they chose specific seat locations and their relationship to the students sitting near them. Additionally, the survey could include questions regarding studying habits, transfer credits, housing situation, interest in taking this course, attempts to seek outside assistance, employment during the semester, and whether the student was left or right-handed. This information would help to disentangle the spatial effects and provide much more explanatory power for this type of analysis.

The primary contribution of this research was incorporating anisotropic spatial factors of the i^{th} student's neighbors, assuming that only the immediate neighbors in the seats to the i^{th} student's right (R) and left (L), as well as the seats in the row below to the diagonal right (DR) and diagonal left (DL) of the person sitting in front of them impacted their performance. The neighbors were allowed to impact the student's performance and the impact could vary across neighbors. To the authors' knowledge this is a novel contribution especially combined with the academic and demographic factors. It was initially expected that the anisotropic spatial effects would have a larger impact on grades; however, the relative lack of statistical significance is reassuring to those who may fear students are engaging more regularly in acts of academic dishonesty.

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