

Traditional versus Online Courses, Efforts, and Learning Performance

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ABSTRACT

The issue of endogeneity on learning efforts has not been addressed in previous researches disentangling on the relationship between learning modes and outcomes. By conducting a two stage least squares procedure to control for this endogeneity bias, we find that online environment is crucial for facilitating better student learning performance. In addition, students who spend more studying hours in Economics significantly outperform their peers making fewer efforts.

Keywords: Learning Mode, Learning Performance, Learning Efforts, Endogeneity

INTRODUCTION

Owing to the distinct advantage of flexibility of distance learning, online courses have been quickly spread among education institutions over the past ten years. This stimulates the development of studies around the effect of learning modes on learning performance. In addition, efforts are found to be an important determinant of learning performance. However, study effort is generally treated as an exogenous variable, which violates the reality and the education production theory. This ignorance of endogenous bias of efforts will lead the classical ordinary least squares estimators to be inconsistent and subsequently the misleading inference in educational evaluation. Accordingly, this paper extends to reconcile the endogeneity of efforts into the relationship between learning modes and learning outcomes.

There are advantages inherent in the online environment (Kim et al., 2005) over the traditional ones. They comprise the convenience of learning location choices and learning schedule arrangement, flexibility and mass delivery as well as the feasibility of repeated learning. Due to these advantages, there are more universities involved in offering online courses. Consequently, it is important and necessary for educational institutions to understand and concern about the effectiveness of those online courses, as compared with the traditional courses.

To respond to this concern, many studies have been carried out to examine the impact of learning modes on learning performance. However, existing empirical findings are largely in controversial and yet reach to a consensus. Some papers assert that little difference in learning performance was found between online format and traditional manner; see, e.g., Abraham (2002) and Kekkonen-Moneta (2002) for instance. Some recent studies, for example, Anstine and Skidmore (2005), Sauers and Walker (2004) and Kan and Cheung (2007), seem to support that students of traditional classes have better performance than those of the online classes. Nonetheless, there are also papers showing that online mode is superior to traditional manner, see, e.g., Scay and Milman (1994) and Raynauld (2006), among many others.

It is surprising that, to the best of our knowledge, none of the existing research ever addressed the potential endogeneity of learning efforts in disentangling learning performance. It is known that Krohn

and Catherine (2005) extend the standard education production function and student time allocation analysis to focus on the interactions between student efforts and performance over the semester. The time students spent is not exogenous but an equilibrium decision in the optimal process. Based on Krohn and Catherine (2005), the optimal time spent on the course can be written as an implicit function of the student's initial ability and parameters of the model. This suggests that the endogeneity of learning efforts should be considered before formally examining the relationship between learning modes and performance.

This paper hence is the first one appropriately addresses the issue of endogenous learning effort by identifying proper instruments and employed subsequently in a two stage least squares analysis. Our approach suggests treating the choice of learning efforts as endogenous and uses the properly constructed instrument to reexamine how learning modes affect performance. We found learning performance in the online environment are superior to that in the traditional mode. Moreover, after controlling the endogeneity bias of learning efforts, the increase in weekly hours a student spent tends to improve learning performance. These results undoubtedly demonstrate a brand new picture toward on-line learning that is different from the previous results obtained in the literature.

We specify our empirical models in section 2. Section 3 introduces the data collection and definitions of employed variables. Section 4 explains the obtained empirical results and Section 5 concludes.

EMPIRICAL MODELS

We conduct two empirical models to investigate the relationship between learning formats and learning outcomes. As a benchmark for comparison and following the typical setup in previous literature in which learning effort is assumed to be an exogenous variable, we estimate the first model using ordinary least squares. In order to take the endogenous problem of learning efforts into consideration, we use the two stage least squares (TSLS) approach in the second part in evaluating the learning performance. Results from both empirical models are subsequently compared.

A Typical Model of Learning Performance via OLS

We utilize ordinary least squares first to evaluate learning performance while controlling for other determinants of learning performance as follows.

$$S_i = \alpha_1 + \varphi_1 D_i + \phi_1 H_i + \theta_1 X_i + \varepsilon_{1i}, \quad i=1 \dots N \quad (1)$$

where S_i represents the exam scores for the individual student i among N students in the data set. For each student, D_i captures the learning mode; $D_i = 1$ denotes the online environment while $D_i = 0$ reveals the traditional manner. H_i reports the learning efforts measured by the time spent on Economics learning. α_1 , ψ_1 , and φ_1 are parameters to be estimated. θ_1 is a row vector of parameters measuring the effects of a column vector X_i of controlled variables on S_i . The unobserved random component of learning outcomes is captured by ε_{1i} . The estimators from ordinary least squares will be unbiased and consistent if the error term is independent of explanatory variables such as $\text{Cov}(H_i, \varepsilon_{1i}) = 0$. As will be shown subsequently, a model that overlooks any endogeneity arisen in the employed variables suffers substantial estimation bias and therefore will mislead the statistical inference.

An Endogeneity-Corrected Model via TSLS

Existing papers on the issue of learning modes and outcomes ignore the potential problem of endogeneity of efforts since they generally treat efforts as an exogenous variable for learning performance. However, Krohn and Catherine (2005) build up an education production model where each student optimally chooses his efforts input. As such, learning efforts is hence endogeneously determined by ability, grading standards, and learning experience. It is nature to expect the problem of measurement error would arise due to the endogeneity of efforts. Once $\text{Cov}(H_i, \varepsilon_{1i}) \neq 0$, estimators from ordinary least squares will in generally be inconsistent. To solve this problem, instrumental variables that are highly correlated with efforts but uncorrelated with performance should be identified and employed.

To analyze the determinants of efforts, we examined some proxy variables following the three dimensions (ability, grading standards, and learning experience) suggested from Krohn and Catherine (2005). On ability, we use variables such as family background factors and entrance exam performance; however, they are not crucial for efforts. As the grading scheme for Economics is on the teacher-level which is identical for all students, it is unlikely that a fixed grading standard will explain much the difference in efforts among students. At last, based on results from a correlation analysis, learning experience captured by reported studying hours one period ahead turned out found to be high and can be served as a suitable instrumental variable for efforts. Moreover, a student's major also provides a good instrument for efforts.

To properly deal with the endogeneity problem disclosed in the recent literature, we adopt a two stage least squares approach. The first stage is to characterize the endogeneity of efforts in the following equation (2).

$$H_i = \alpha_2 + \varphi_2 M_i + \phi_2 H'_i + \theta_2 X'_i + \varepsilon_{2i}, \quad i=1 \dots N \quad (2)$$

where H_i is the reported weekly studying hours capturing efforts for the individual student i among N students. M_i denotes student's major; $M_i = 1$ if the student majors in Financial and Economic Law and otherwise $M_i = 0$. H'_i reports the time spent on Economics learning one period ahead. α_2 , ψ_2 , and φ_2 are parameters to be estimated. θ_2 is a row vector of parameters measuring the effects of the column vector X'_i of all determinants on H_i mentioned in equation (1). The unobserved error term of learning efforts is captured by ε_{2i} .

After the fitted value of efforts is estimated from the first stage, the second stage is similar to equation (1) except for using the fitted efforts to substitute the original efforts.

DATA COLLECTION AND VARIABLE DEFINITION

Different from the extant literature, we collect weekly data in two learning modes from the same group of students. During the autumn semester in 2009, Economics courses are offered in the traditional in-class format before the midterm exam, whereas they are offered completely online after that. This design avoids the potential bias due to sample selection when different students take different learning manners. There are about 150 students enrolled in Economics from two departments. Although the students' major are different, the contents of Economics, including teaching topics, assignment questions, and examination paper, are fully the same. Economics is a three credit course taught over the full 16 weeks of the semester. An identical professor teaches in both traditional and online environment as well as across various classes. This hence enables to eliminate the potential bias that is likely to be introduced when different instructors teach different classes.

Learning performance is evaluated by standardized exam scores termed as S. Course contents focus on the consumer theory before the midterm and they are concentrated on the firm theory after the midterm. In other words, students learn the consumer theory in the traditional environment while they learn the firm theory in the online mode. To control for the effect of course contents on learning performance, standardized scores are employed instead of the original exam scores.

We compare the standardized exam scores for the traditional and online courses holding other things being equal. An indicator for learning modes is represented by D where $D = 1$ reveals the student in the online mode and $D = 0$ exhibits the student in the traditional manner. We examine the relation between learning formats and performance by testing the significance of the coefficient of the mode dummy.

Anstine and Skidmore (2005) conclude that efforts positively impact performance. Learning efforts, denoted by H, are measured by reported weekly hours devoted to Economics. Moreover, based on the optimal studying time allocation derived from the education production theory, we also collect variables that are expected to affect a student's decision of learning efforts. Following the normal process in TSLS dealing with the endogeneity problem, at least one instrumental variable is needed to be identified for efforts in the first stage in addition to determinants of learning performance in the second stage. A student's major as well as his reported weekly hours one period ahead are found to affect learning efforts but not influence learning performance. Accordingly, these variables become appropriate instruments for efforts. We denote separately these two instruments by M and H' where $M = 1$ if the student majors in Financial and Economic Law but otherwise $M = 0$.

Existing literature find a positive correlation between the exam score in period t and that in period t-1 for an individual student. Dellana et al. (2000) conclude that students' previous academic achievements are positively associated with their performance afterward in many studies. Accordingly we gather each student's exam scores one period ahead denoted by S'.

Gender variable is generally considered in the literature and hence we set $G = 1$ for the male while $G = 0$ for the female. Female students were generally found to do better in certain academic subjects, such as language. Male students perform better in other subjects, for example, mathematics and science.

Another kind of factors required to be controlled is academic background which was found to be a strong determinant affecting learning performance. Pretest exam scores (PT) and entrance exam scores (ES) are controlled as the factors of relevant academic background. A pretest is administered at the beginning of the class to evaluate the prior knowledge of Economics. Students are asked to take this pretest seriously.

According to a theoretical model of education production function proposed by Dolton, et al. (2003), student characteristics, such as ability that are potentially different among students, are crucial for learning performance. To capture these characteristics, we collect a student's family background information including father's education level (DAD), together with mother's education level (MOM). There are five education levels, 1-5, separately representing the level of elementary school, junior high school, senior high school, university, as well as graduate school and above. Summary statistics and explanation for all the determinants necessary for the empirical analysis are tabulated in Table 1.

Table 1: Variable Definition and Summary Statistics

Variables	Definition	Mean	St. Dev
S	Standardized exam scores	0.00	1.00
D	Learning mode, $D = 1$ for online while $D = 0$ for traditional	0.57	0.50
H	Efforts, reported weekly hours devoted to Economics	2.45	2.89

G	Gender, G = 1 for the male while G = 0 for the female	0.51	0.50
S'	Exam scores one period ahead	55.12	19.62
PT	Pretest scores	39.60	14.31
ES	Entrance exam scores	50.05	4.34
DAD	Father's education level, 1-5	3.23	0.95
MOM	Mother's education level, 1-5	2.96	0.84
M	Major, M =1 for Financial and Economic Law while M =0 otherwise	0.46	0.50
H'	Reported weekly hours one period ahead	1.36	2.17

EMPIRICAL RESULTS

Table 2 summarizes our empirical results. The second column shows the results from the typical model overlooking the learning effort endogeneity estimated via OLS. As efforts are assumed to be exogenous, reported weekly hours devoted to Economics are directly used to capture efforts. The third and the fourth columns demonstrate the estimation results from a TSLS approach. Due to the endogeneity of efforts, instrumental variables are needed in the first-stage efforts equation. As a consequence, the second-stage regression equation on learning performance is specified as a function of the fitted efforts.

Table 2: OLS and TSLS Coefficients for Standardized Exam Scores

	OLS	TSLS Second stage	TSLS First stage
D	0.0117 (0.08)	0.484** (1.98)	-3.539*** (-9.55)
H	0.0237 (0.96)		
H – fitted		0.169*** (2.66)	
G	-0.332*** (-2.71)	-0.405*** (-2.88)	0.477 (1.32)
S'	0.0272*** (7.25)	0.0262*** (5.88)	0.0130 (1.11)
PT	-0.00255 (-0.52)	-0.00338 (-0.59)	0.0124 (0.79)
ES	0.0362** (2.33)	0.0152 (0.80)	0.0618 (1.32)
DAD	-0.0668 (-0.84)	-0.00497 (-0.05)	-0.221 (-0.95)
MOM	0.114 (1.21)	0.0590 (0.55)	0.200 (0.72)
Constant	-3.091*** (-3.95)	-2.661*** (-2.94)	-0.836 (-0.36)
M			1.197*** (2.89)
H'			0.381*** (5.19)
Number of observations	151	144	144
Adjusted R^2	0.339	0.399	0.455

Note: Standard deviations are in parentheses. ** denotes for significance at the two-tail size of 0.05 and *** denotes for statistically significance at the two-tail size of 0.01.

OLS with Exogenous Efforts

Results from the ordinary least squares estimating the determinants of a typical learning performance model are presented on the first column in Table 2. The results suggest that, on average, boys' exam scores are inferior to those from girls. Exam scores are positively associated with their scores one period ahead. Entrance exam grades positively affect learning performance in Economics. Neither father's education level nor mother's education level significantly affects learning performance. This arises due to the highly positive correlation between these two determinants. After eliminating the multi-collinearity problem by dropping father's education level, a significantly positive influence of mother's education level on performance is apparent. Learning modes show no significant effect on performance as efforts are treated as an exogenous variable. It is interesting that Efforts are not significant determinants of performance as well.

It is noted that, however, Schmidt (1983) has pointed out that learning efforts can be expressed as an implicit function of ability or other factors which suggests that efforts are endogenous variables. This reminds us that the ignorance of the endogeneity of efforts may lead to the potentially biased insignificance of efforts and learning modes on performance. A better econometric recipe that can accommodate this issue is called for.

TOLS with Endogenous Efforts

Our investigation verified the presence of endogeneity of learning efforts in our data. The covariance of two error terms, ε_{1i} and ε_{2i} , separately in the performance and efforts function is -0.197 and significantly different from zero. In addition, the coefficients of the two instrumental variables, reported hours one period ahead and undergraduate majors, are also different from zero at a 1% significant level. These results suggest that TOLS is useful in correcting for the endogeneity-induced inconsistency under the typical OLS approach.

Given that the choice to learning efforts may be related to learning performance, we employ a two stage least squares model. A two stage least squares analysis yields findings different from previous studies using ordinary least squares estimation. When other variables are well-controlled, a two stage least squares analysis reveals that learning performance in the online environment are superior to that in the traditional mode. After controlling the endogeneity bias of efforts, the increase in weekly hours a student spent tends to improve learning performance; however, this relationship cannot be shown when OLS is used.

CONCLUSIONS

As distance-learning courses have dramatically prevailed among conventional education institutions over the past ten years, a great number of papers have focused on the impact of online versus traditional learning mode on learning performance. In these papers, student effort is generally considered as an exogenous variable. Nonetheless, this assumption obviously violates the reality as well as the educational production theories. This paper hence integrates the endogeneity of efforts into the relationship between learning formats and learning outcomes. A simple OLS regression shows that holding other determinants constant, learning modes do not significantly determine learning performance. After correcting for the endogeneity bias, however, TOLS reveals the effect of learning modes. While Economics is generally viewed as a highly quantitative course that students typically find challenging in

most learning environments, this paper suggests that learning performance of a quantitative course can be successfully enhanced in an online environment.

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Acknowledgement

Shan-Ying Chu sincerely thanks NSC for the financial support (NSC 98-2410-H-033 -015).