International Education Studies
www.ccsenet.org/ies
Vol. 3, No. 1
February 2010

Econometric Assessment of 'One Minute' Paper as a Pedagogic Tool

Amaresh Das
College of Business
Southern University at New Orleans
New Orleans, LA 70056
E-mail: adas2@cox.net

Abstract

This paper makes an econometric testing of one-minute paper used as a tool to manage and assess instruction in my statistics class. One of our findings is that the one minute paper when I have tested it by using an OLS estimate in a controlled Vs experimental design framework is found to statistically significant and effective in enhancing students' knowledge. It is found to be equally effective when I have tested it by using a seemingly unrelated regression that allows the error terms to be correlated across separate but related regressions. This is irrespective of students' ability levels as is measured by GPA in both cases.

Keywords: Production function, Quasi-concavity, Seemingly unrelated regression

1. Introduction

Learning can take place in a class room setting. It can take place in an on line environment, through a e-mail system (see Ruth (2008) and others) or through a Blackboard. The one - minute paper, a recent innovation in higher education in a class room setting, is gradually becoming popular. According to a simple finding of the Harvard Assessment Report, the one minute paper is a modest, relatively simple and a low-tech innovation that can improve student's learning and active participation in class in a big way (see Light (1990)). There are many, for example, Naeve *et al* (2008) who investigated a modeling approach to learning process. The purpose of this paper is to do the same and statistically assess the impact of this technique on student learning.

This 'low-tech' innovation is designed to obtain regular feedback from students – a scarce commodity in a lecture setting. Again, based on the premise that students who have genuine input and control will be better motivated to learn, the one –minute paper can encourage active engagement in the class process. In the final minute or two of the class, the instructor, asks students to respond to the following two questions:

What is the most important thing you learned to day?

What is the muddiest point still remaining at the conclusion of today's class?

The first question directs students to focus on the big picture, that is, what is being learned, whereas the second seeks to determine how well learning proceeding is. The instructor encouraged students to provide thoughtful, sincere responses to these questions. Unlike standard end-of-term evaluations students were providing guidance for *their own* on- going instruction, not for students coming in future. If, based on a simple analysis of students' responses, the teacher decides that the main points of the previous class are poorly understood, or, that the misunderstandings of the key points – the 'mud' - is particularly deep, the teacher reviews and clarifies these points at the beginning of the subsequent class. Most importantly, through one minute paper, the teacher is able to demonstrate a respect for and interest in, student opinion that by itself can encourage students' 'active' involvement in the learning process.

2. Methodology

I taught two sections of statistics both in Fall 2005 and Spring 2006 at Trinity University in Washington, D.C. In Spring 2006, I used one minute paper only in one of two sections. Here I used a 'controlled vs. experimental' design to test the effectiveness of one minute paper. I taught two sections of the same course again in the Fall of 2005 when I used one minute paper in the both the sections. For Spring 2006 data I use the Ordinary Least Square Estimate (OLS) to estimate the parameters and for Fall 2005 data, I estimate the same parameters by using a technique called Seemingly Unrelated Regression (SUR). I had three major goals to accomplish in both Spring and Fall. These are: to assess the effectiveness of one minute tool and along with it gain classroom experience by way of students' reasoning, problem solving, and creativity

2.1 OLS estimate

In Spring 2006, when I used one minute paper in only one class – the experimental class, I taught identically the same materials and used the same pedagogical style in both sections. The two sections were almost of the same size (30 students in one and 27 in another) in terms of student enrollment. At the conclusion of each class period, I asked students in my experimental class to complete a one-minute paper (card). Using paper and pencil students responded to the one-minute paper questions and dropped their responses in a box located on the front desk as they left. They were given the choice to drop their responses even by e-mail. I asked students to do the same in every class.

I read and analyzed all of their responses in Excel spreadsheet. Then I began each subsequent (experimental) class with a short discussion of the most frequently mentioned ‘muddy’ points from the previous class. This way I could demonstrate to the students that their understanding and feed back were of much importance. I scheduled the controlled class before the experimental class to mediate against the possibility of inadvertently using feedback from the experimental class (concerning what students learnt and how well did they learn it) to promote learning in the control class. As an additional check against inadvertently transferring feedback from the experimental class to the other class, the feedback from a previous experimental class was not analyzed until after the subsequent controlled class had concluded. At the beginning of the semester, I also administered a ‘pretest’ in both the experimental as well as in the controlled classes to measure initial knowledge in the area.

I used a variant of the well-known educational production function approach with all its conventional properties. That is, the production function $\int$ is a continuous function and twice differentiable or, in other words, as in the two variable case, for example, $\int_1 > 0, \int_2 > 0$ and because of twice differentiability of $\int$,

$\int_{12} = \int 21$. The bordered Hessian of the strictly quasi-concave production function satisfies the

inequality

$$\begin{bmatrix} \int_{11} & \int_{12} & \int_1 \\ \int_{21} & \int_{22} & \int_2 \\ \int_1 & \int_2 & 0 \end{bmatrix} > 0$$

$G_S =$ f [pre- test score, A_S, A_0, Gender, One Min, One Min*GPA], where

G_S = the student’s post- test score in the posttest (score will not count toward a student’s final grade

A_S = the student’s aptitude in Statistics to be measured by a Pretest (ETS)

A_0 = the student’s aptitude in all other courses as measured by the GPA, excluding the Statistics grade. Another possible proxy might be the student’s ACT score.

Gender = dummy variable for gender = 1 for male students,

= 0 for female students

One Min = a dummy variable for treatment

= 1 for data with there is a one minute paper

= 0 for data in a class with no one minute paper

One Min*GPA = dummy variable for treatment interaction terms,

One Min*GPA 3.*0*, where One Min* GPA 3.0 = 1 when the student’s GPA ≥ 3.0 and

One Min*GPA 2.*0,* where One Min* GPA 2.0 has value 1 when the student’s GPA < 3.0 but ≥ 2.0.

To allow the slope of the one min variable to differ according to students’ differing ability levels, I introduced a series of interaction terms. To check for multi collinearity again I tried a ridge estimator (not reported here) incorporating the stochastic constraint that β is the zero vector. Note 1

Instead of obtaining two different post- score equations for two classes, I chose a more efficient procedure involving the estimation of only one equation with a dummy variable treatment of One Mi*n.* In this study the one minute paper was not allowed to change the constant (intercept) term in the equation but only the slope (β_4 in eq. (1) below). Note 2.

I estimated the following regression model:

E(Post- test score) =

$$\beta_0 + \beta_1 \text{ Prtest} + \beta_2 \text{ GPA} + \beta_3 \text{ Gender} + \beta_4 \text{ one Min} + \beta_5 \text{ one Min}^* \text{ GPA 3.0} + \beta_6 \text{ one Min}^* \text{GPA 2.0} + \mu \quad (1)$$

where μ = error term and

$$E(\mu) = \begin{bmatrix} E(\mu_1) \\ E(\mu_2) \\ . \\ . \\ .E(\mu_n) \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ . \\ . \\ .0 \end{bmatrix} \quad \text{and}$$

$E(\mu\mu') = \sigma^2 I$ This assumption gives the variance matrix as

$$\begin{bmatrix} \sigma^2 & 0 & 0 \\ 0 & \sigma^2 & 0 \\ 0 & 0 & \sigma^2 \end{bmatrix}$$

This means the μ_{ii} has the same variance and all μ_{ij} are pair-wise are uncorrelated.

2.2 Results of the OLS

The principal hypotheses to be tested were:

The introduction of one-minute paper enhanced student's knowledge.

The one-minute paper enhanced the performance of all students regardless of the initial ability levels of students.

The value and the statistical significance of the coefficient β_4 associated with the One Min variable, if found positive and significant, will suggest that the use of one minute paper enhance students' knowledge. The amount of the gain in knowledge that would depend on students' ability levels was measured by the coefficients of the interaction terms, β_5 and β_6. The hypothesis that $H_0 : \beta_5 = \beta_6 = 0$, which means that the change in post- test score promoted by the interaction of One Min with GPA 3.0 and GPA 2.0 is jointly zero, could not ne be rejected .

(see Table 1)

I tried with other specifications of the GPA dummy variable in my study. The results (not reported here) were not sensitive to other specifications. I employed a pre test score in my estimation but this since this was an extraneous (a priori) information it would create a bias, often called 'pretest' bias in econometrics. I, therefore, used what Kennedy (1992) calls a 'testing down' strategy (not reported) to eliminate this bias. I estimated the coefficients of a more relevant model that supported our finding that the coefficients of the interaction terms, β_5 and β_6 are jointly zero.

Because there is some controversy in the inclusion of pre-test score as a regressor and to demonstrate the robustness of our finding concerning the importance of one minute paper, I employed a final specification of our model in which Post test – Pretest is used as the dependent variable. But R^2 did not drop significantly (the results are not reported here) .More importantly, the One Min coefficient which was significant before is found to be equally significant in the final specification. That is β differs in absolute value by less than some pre assigned positive number. That is,

$$p\lim \beta = k \text{ if } \lim_{n \to \infty} \text{prob}(| \hat{\beta} - k | < \delta = 1$$

3. Seemingly Unrelated Regression (SUR)

3.1 A few words on SUR

In this section I ran two regressions separately for two sections (30 in one section and 29 in another) taught in Fall 2005 at Trinity by using the technique called Seemingly Unrelated Regression (SUR). The SUR is a set of regression equations that seem unrelated but is in reality related. SUR allows the error terms to be correlated across separate but related regressions. The μ s in the four regressions above do not have to be independent of each other in any one time period.

Theorem 1.

If the error terms of the equation are uncorrelated or if all equations in the simultaneous estimation have the san=me right hand side variables, then SUR and OLS will produce identical estimated values for the parameters of the equation. If one equation has more independent variables than the other, but all independent variables in the smaller equation are included in the larger, then SUR and OLS produce identical estimated values for the smaller equation but not the larger one.

Theorem 2.

If the equations of he system have different right hand side variables and the errors are correlated, then SUR and OLS will produce different estimates of the β's as well as different estimated standard errors. If the Gauss-Markov assumptions are satisfied, then the SURE estimates will be consistent and more efficient (i.e., they will have lower standard errors) than the OLS estimates for sufficiently large samples.

[Proofs are given in any graduate econometrics text]

Suppose there are n equations of this form $Y_i = X_i \beta_i + \mu_i$ All are in vectors. *X* is a data matrix.

The subscript *i* refers to the *i* th equation. These equations can be written as

$$\begin{bmatrix} Y_1 \\ Y_2 \\ .. \\ Yn \end{bmatrix} = \begin{bmatrix} X_1 & & \\ & X_2 & \\ .. & & \\ & & X_n \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ .. \\ \beta n \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu e_2 \\ . \\ \mu_n \end{bmatrix}$$

Or,

$$Y^* = X^* \beta^* + \mu^*$$

If we allow correlation between the error terms across equations, so that, for example, the i th error term in the i th equation is correlated with the i th term in the j th equation the variance –covariance matrix of μ^* will not be diagonal. I estimate the following two equations , one for each class separately.

$$E(\text{Post test score})_{\text{WITH ONE MINUTE CLASS}} =$$

$$\beta + \beta_1 \text{ Prtest} + \beta_2 \text{ GPA} + \beta_3 \text{ D} + \beta_4 \text{ one Min} + \beta_5 \text{ one Min}^* \text{ GPA 3.0} + \beta_6 \text{ one Min}^* \text{GPA 2.0} + \mu_1$$

$$E\text{ (Post test score)}_{\text{WITHOUT ONE MINUTE CLASS}} = \quad (2)$$

$$\beta + \beta_1 \text{ Prtest} + \beta_2 \text{ GPA} + \beta_3 \text{ D} + \beta_4 \text{ one Min} + \beta_5 \text{ one Min}^* \text{ GPA 3.0} + \beta_6 \text{ one Min}^* \text{GPA 2.0} + \mu_2 \quad (3)$$

The SUR allows the error terms μ_is to be correlated across separate but related regressions. This way the SUR procedure can use the correlation between error terms to improve the estimates Any correlation between error terms in regressions is valuable information; it is trying to tell us something. It could be telling us that there is some change or event in the class policy or even a text book in that time period that affects more than one class. The change may not be captured by any of the independent variables and that is why it will show up in the error term. The SUR procedure uses this information (Table 2 & Table 3) to improve the coefficient estimates. Note 4.

3.2 Results

4. Conclusion:

Our test provides an empirical assessment of one - minute paper. Our finding is that it is positively and significantly important in student's learning in Statistics. This is irrespective of students' ability as is measured by GPA. One major limitation of our test is the 'power' of the test that can not be determined without being able to randomize the sample selection or control the demography and the behavior of students. The faculty involved in curriculum and assessment reform should view this work as a learning process that will provide a kind of 'library' of examples to other reform practitioners and will thus expand the 'community' of reformers . Our findings will help foster shared value in evaluating students' performance.

References

Chow, G.C. (1983). *Econometrics*, New York, McGraw-Hill

Cross, K.P. and T. A. Angelo. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers,*_San Francisco, Jossey-Bass

Congdon, Peter. (2001). *Bayesian Statistical Modelling*, John Wiley

Kennedy, P. (1992). "How much Bias from Using Pretest as a Regressor", Unpublished paper, Simon Fraser University, Burnaby BC, Canada.

------. (1981). "Estimated with Correctly Interpreted Dummy Variables in Semi logarithmic Equations," *American Economic Review,* 71, pp 802-818

Light, R. J. (1990). Explorations with Students and Faculty about Teaching, Learning and Student Life, the Harvard Assessment Seminars, First Report, Cambridge, Mass., Graduate School of Education and Kennedy School of Government.

Maddala, G. S. (1988). *Introduction to Econometrics*, New York, Mc millan.

Naeve Ambjorn, Louma Perrtti, Kravick Milos and Lytras Miltiadis (2008): A modeling approach to study learning process with a focus on knowledge creation*", International Journal of Technology Enhanced Learning*, 1, pp 1- 34

Ruth, Alison (2008), "Learning in an on line mediated environment," *International Journal of Technology Enhanced Learning,* 1, pp 132-142

Vinod, H. D. and Ullah, A. (1981). *Recent Advances in Regression Methods.* New York, Mercel Dekker.

Notes

Note 1. In a Bayesuan interpretation the extent of the shrinking depends on the confidence with which it is believed that β is the zero vector (see Vinod and Ullah (1981, Congdon (2001)). Chow 91983) and Maddala (1988), however, holds an opposite view.

Note 2. Remember we want to test the joint hypothesis that, the fifth and elements of β, say, are equal to 6.76 and 3.62. That is, we wish *t* test the hypothesis that the sub- vector

$$\begin{bmatrix}\beta_5\\ \beta_6\end{bmatrix}$$

is equal to the vector

$$\begin{bmatrix}3.04\\ 3.56\end{bmatrix}$$

This is a different question from the two separate questions of whether β_5 is equal to 3.04 and

whether β_6 is equal to 3.56.

Note 3. For econometrics of different specifications see Kennedy, P (1992, 1981), Cross and Angelo (1993).

Note 4. I used the student version of Eviews for SUR estimation.

Table 1. Dependent variable post test score

Variable	Coefficient	Standard Error	t-statistic	p-value
Constant	5.3	1.4	3.76	0.12
Pre test	7.45	4.60	5.97	0.10
GPA	7.13	1.94	9.62	0.01
Gender	2.10	3.34	2.11	0.11
One minute	4.22	1.45	5.30	0.01
One Min* GPA 3	3.04	3.02	1.32	0.56
One Min* GPA 2	2.56	1.81	2.87	0.13

Table 1 contd,,,

Observations : 57

$R^2 = 0.84$, Adjusted $R^2 = 0.81$

Residual Sum of Squares= 51.76

$\hat{\sigma} = 7.556$

DW= 1.323 F statistic = 6.56

Table 2. Dependent variable post test score in one minute class

Variable	Coefficient	Standard Error	t-statistic	p-value
Constant	10.3	2.41	1.76	0.52
Pre test	17.4	6.46	3.94	0.40
GPA	16.1	1.93	8.12	0.00
Gender	3.10	3.22	1.16	0.71
One Min	4.22	1.13	4.31	0.00
One Min*GPA3	1.23	4.78	1.11	0.12
One Min*GPA2	1.77	4,43	1.85	0.28

Observations : 30

$R^2 = 0.92$, Adjusted $R^2 = 0.91$

Residual Sum of Squares=31.11

$\hat{\sigma} = 4.554$

DW= 1.32

F statistic = 7.33

Table 3. Dependent variable post test score without a one minute class

Variable	Coefficient	Standard Error	t-statistic	p-value
Constant	3.30	1.31	813	0.10
Pre test	7.34	2.50	3.91	0.30
GPA	8.23	1.91	7.44	0.05
Gender	3.11	4.24	3.10	0.31
One Min	3.26	3.45	2.56	0.48
One Min*GPA3	2.61	3.22	1.98	0.17
One Min*GPA2	1.43	3.29	1.89	0.11

Observations : 29

$R^2 = 0.88$, Adjusted $R^2 = 0.80$

Residual Sum of Squares= 47.11

$\hat{\sigma} = 7.343$

DW= 1.322

F statistic = 5.98