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Estimating the effects of procrastination on performance: A small sample study

Kazuki Onji*

Abstract

Previous studies have found student procrastination to compromise learning outcomes using initial test scores to control for the influence of unobserved ability. The validity of such analysis rests on the assumption that students do not react to initial test scores. Utilizing daily information on student behavior, this paper shows that feedback effects were negligible in a student sample from a university second-language course. The paper then objectively quantifies the degree of procrastination, and finds evidence for detrimental effects of procrastination on test scores, corroborating previous studies. The result lends confidence to the value-added specification of the education production function.

Keywords: *Education production function, Self-control problems, Test performance*

JEL Classification: D30, I20, J24, C20

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1. Introduction

Recent economics studies examine whether student procrastination affects test performances using observational data (Wong, 2008; Donovan, Figlio & Rush, 2006).¹ Procrastination, meaning acts or habits of putting things off, has drawn attention of economists out of interests on the self-control problems of decision makers. Thaler & Sunstein (2003) among others advocate paternalistic interventions in wide aspects of the economy to redress suboptimal outcomes arising from time-inconsistent preference. While Wong (2008) and Donovan, Figlio & Rush (2006) have found detrimental effects of procrastination in classes, a question on causality remains: Do their non-experimental results suffer from an endogeneity bias arising from correlations between the degree of procrastination and unobserved ability?

A common solution to remove potential biases arising from any correlation between ability and study patterns is to adopt the value-added specification of an education production function that includes test scores at the beginning of sample period (hereafter “pretest”) as a proxy for unobserved ability. In using pretest to control unobserved ability, however, researchers make an implicit assumption regarding the effects of a student’s pretest performance on his/her subsequent study behavior. If a student performs better on the pre-test than he should have done (e.g. he guesses more correct answers than would be expected by chance on questions that he does not know the correct answer to), he may become overconfident and choose to slack on the homework. Similarly, students whose performance is lower than their true ability may attempt to compensate by expending more effort throughout the remainder of the course to make up for their lower-than-expected baseline ability. This dynamic will induce a positive correlation between effort and test score improvement even if effort has no effect on learning. A number of empirical studies document the existence of ‘feedback effects’ (Azmat & Iriberry, 2010; Bandiera, Larcinese, Rasul, 2008; Paola & Scoppa, 2010). In settings where we suspect feedback effects exist, the value-

¹ Donovan, Figlio & Rush (2006) estimate a value-added specification on a sample of US college students. Wong (2008) estimates a contemporaneous specification on a sample from a Singaporean University.

added specification of an education production function may produce biased estimates.

This paper has two aims: First is to outline the conditions under which the effects of procrastination are identified in a non-experimental study. As will be analytically shown, an endogenous input in an education production function is correlated with error term if feedback effects exist. The second aim is to examine any potential bias arising from feedback effects utilizing a very small but highly detailed dataset on student behavior.

My observational data is drawn from a setting where students' activities on assignments are recorded through online software. This allows me to quantify the degree of procrastination based on objectively collected data. Further, I obtained rich information on concurrent study inputs and background characteristics through survey. A drawback to this rich individual-level data is the sample size, which is nonetheless comparable to those from small-scale clinical trials. Estimates of an education production function show a negative and significant correlation between procrastination on performance. An auxiliary examination estimates a two-way fixed effects model to gauge the effects of weekly quizzes on study time, and found feedback effects to be negligible. Thus, procrastination does seem to reduce performance in my sample of students.

The contributions of this paper are twofold. First is additional non-experimental evidence on procrastination and performance, lending confidence to results from Wong (2008) and Donovan, Figlio & Rush (2006). Unlike these previous studies, current paper outlines explicitly the identifying assumptions, and conducts an auxiliary test to validate the assumption on no feedback effects. Second, more broadly, is evidence on the reliability of a value-added specification of education production functions. As clearly articulated by Todd & Wolpin (2003), a number of assumptions are required in consistently estimating education production functions. Applied analyses often implicitly take them as given. This study presents a case in which the concern about the feedback effects is not significant for a semester-length course.

In the reminder, Section 2 discusses the model. Section 3 presents results. Section 4 examines feedback effects. Section 5 concludes.

2. Education production function

Todd & Wolpin (2003) consider an education production function in the context of a child's entire life; their conceptual framework incorporates the initial endowment of ability as well as the current and past inputs provided by parents and schools. The settings for procrastination studies are semester-length classes where relevant inputs are student efforts and other sources of learning. A body of related studies investigates the effects of, for example, lecture attendance (Romer, 1993). My model extends Todd & Wolpin (2003) by explicitly writing out structural equations to obtain a recursive system (Krohn & O'Conner, 2005).

$$(1.1) \quad T_i^0 = X_i' \beta^0 + \mu_i^0 + \varepsilon_i^0$$

$$(1.2) \quad E_i = X_i' \beta^1 + T_i^0 \delta + \mu_i^1 + u_i + \varepsilon_i^1$$

$$(1.3) \quad T_i^2 = X_i' \beta^2 + E_i \theta + \mu_i^2 + \varepsilon_i^2$$

T_i^0 and T_i^2 are test scores from pretest and posttest respectively. E_i is a variable summarizing at the semester level learning activities conducted by student i (hereafter "effort"). Test scores, as well as effort levels, depends on common factors, X_i , a vector of exogenous individual characteristics. μ_i^j is an unobservable ability. Superscripts on β^j and μ_i^j indicate that effects vary across equations. μ_i^j are correlated across equations. u_i is an unobservable motivation possibly correlated with ability. This specification assumes motivation affects learning indirectly through efforts. ε_i^j are stochastic disturbance uncorrelated with one another and with the exogenous regressors.

A least square regression on the posttest equation (1.3) is biased if the unobservable ability affects outcomes. The direction of the bias is upward if able students exert greater efforts. Subtracting γT_i^0 from T_i^2 yields a general specification of a value-added specification.

$$(2) \quad T_i^2 = X_i' (\beta^2 - \gamma \beta^0) + E_i \theta + \gamma T_i^0 + (\mu_i^2 - \gamma \mu_i^0) + (\varepsilon_i^2 - \gamma \varepsilon_i^0)$$

Consider a special case where $\mu_i^0 = \phi_0 \mu_i$ and $\mu_i^2 = \phi_2 \mu_i$ (Dolton, Marcenaro & Navarro, 2003), where μ_i is a time-invariant ability. Since $\gamma = \phi_2/\phi_0$, the direct effects of unobserved abilities are removed from (2); T_i^0 thus serves as a proxy for the ability in this special case.

Although the inclusion of pretest score removes unobserved ability in this special case, the estimate of θ can still be biased from the feedback effects: if a negative shock at the pretest led to more (or less) efforts, E_i is correlated with the component of a disturbance term, ε^0 . Notice, however, that a disturbance term captures a deviation of test scores from his/her “true” potential. For example a student might have had a bad test day due to stomach ache. If a student is aware that he/she have had a bad test day, he/she may correctly infer that his/her poorer than expected performance was simply unlucky and would not react to the experience by exerting more effort that he/she would have done without the stomach ache. Any feedback effects, even if they exist, should be sufficiently small to induce a large bias in this case.

Should we then expect the assumption $\delta = 0$ to hold *a priori*? In a context where a student know his/her potential in absolute term but not in relative term, $\delta = 0$ is a strong assumption since pretest scores would provide students with information on their relative standing in a group and thus induce students to react. Indeed, Azmat & Iriberry (2010) document information on relative standing affects behavior. Assessment grades are often “curved” so that relative standing is of importance to students. Thus, an assumption, $\delta = 0$, is also necessary even in this special case.

T^0 is in addition mechanically correlated with the residual (ε^0) but the consensus in the dynamic panel regression literature is that coefficients on lagged dependent variables are biased more severely than coefficients on covariates (Judson & Owen, 1999); indeed this source of bias seems negligible in my application. In summary, the key assumptions required to obtain consistent estimates are: (1) $\mu_i^j = \phi_j \mu_i$ for $j=0, 2$ and (2) $\delta = 0$.

3. The effects of procrastination in a language course

In the class sample drawn from a university in Japan, an instructor required students to complete 60 drills on English-listening activities in software called ALCNA by a deadline set at the 17th week from the beginning of the semester. This assignment weighs 30 percent of the course grade. The software records the amount of time students spent on different parts within a drill that would take an average student about 10 to 15 minutes to complete. This course aimed to develop student's listening English skills and tested students with exams, conducted before and after the course, using a test format similar to a standardized language qualification exam. A survey was conducted to obtain background characteristics and attitudinal measure on the interests English and motivation for learning the language. The instructor has provided me with the record of attendance (a part of assessment) and the results of weekly quizzes. The sample used in analysis consists of 62 students

The empirical analysis aims to obtain a consistent estimate of the effects of procrastination on test performance. The following model is estimated using OLS.

$$(3) \quad T_i^2 = X_i' \varphi + E_i' \theta + \gamma T_i^0 + v_i$$

X_i is a vector of covariates, including gender, senior students, private high school attendance, class preference, experience living abroad, home prefecture, membership of a university sport clubs, part-time works, and 6 survey items intended to measure the motivations for learning English, such as the strength of interests on a study abroad programs, and attitude towards computer-assisted learning. E_i includes five measures of study inputs. First is the degree of procrastination measured with the Herfindahl–Hirschman Index (HHI) of weekly study time². The key advantage of HHI over alternative measures, such as the fraction of the ALCNA exercise completed during the last two weeks, is that HHI is a summary of the entire distribution of weekly study time. HHI can thus capture the variation created by, for example, the third week from the last. In

² To construct HHI, I first summed study time in each week and divided it by total study time over semester to compute shares of study conducted during each week. I then took square of the shares and summed them to obtain HHI.

application, the samples with high HHI visibly have high concentration of study time near the deadline, so that the choice of measurements should not be crucial. Second is the total length of time spent on ALCNA. Third is the class attendance. Fourth is the extent of student's exposure to English use through part-time jobs/social clubs. Last is the attendance to private English schools. v_i is a heteroskedastic error term assumed uncorrelated across students.

Table 1 summarizes the results. All coefficients on inputs have expected signs for all specifications. The coefficients on HHI and out-of-class English usage are significant at the conventional levels in the full specification. The conservative estimate on HHI implies that score increase on average by 1.4 points by studying an extra week.³ The insignificance of class attendance might be due to an insufficient variation arising from the mandatory attendance. The length of study time is not significant, and is correlated with HHI; no symptom of multicollinearity was found. Interestingly the qualitative results are robust to the inclusion of pretest perhaps due to the relative homogeneity of the student sample. The value-added specification yields smaller coefficient on HHI, suggesting that able students tend not to procrastinate. Overall, the results suggest that consistent study improves test performance.

4. Procrastination and pretest

The above estimates are biased if pretest affects efforts. Since OLS regression on (1.2) is clearly not appropriate, I consider intra-semester data to see whether study patterns are affected by previous performances. 10 quizzes were administered over the semester; this long time dimension enables a sensible application of the fixed-effects framework to control for unobserved ability.

$$(4) \quad Y_{it} = \sum_{k=0}^3 \alpha_k Q_{i,t-k} + \pi_i + \lambda_t + \omega_{it}$$

³ To put the magnitude of the estimate into perspective, consider a student who spent three weeks completing the assignment and that he/she spent the equal amount of time each week. The HHI is 0.33, which close to the sample mean of 0.35. If he/she had spent four weeks studying an equal length of time instead, the HHI would be 0.25, a reduction of 25 percent. Assuming that the other practices are increased correspondingly, this implies that the score would become higher by 1.4 points in a 100-points exam, using the most conservative estimate of -4.8.

Y_{it} , is the amount of weekly ALCNA study time in minutes. Classes (and hence quizzes) are administered on Monday and the study time is the sum of time spent on ALCNA activities on the week following the class (during weekends, students have no access to ALCNA). The students learnt quiz outcomes immediately since the instructor gave answers in class. $Q_{i,t-k}$ is a k th lag of a standardized quiz performance. The sample is restricted to weeks when quizzes were conducted; where no quizzes were conducted in prior week the relevant lag terms takes the value of 0. Quizzes were conducted from week 2 to 13 except week 3 and 11. No quiz was conducted on week 1 and 14-17. Since some missed quizzes, the panel is unbalanced. π_i captures the effects of unobserved ability and of individual background, and λ_t is a time-specific intercept. ω_{it} is an error term assumed to be correlated within students.

Column 1 of Table 2 presents the main estimates. A current quiz has a negative and significant coefficient; on average students who performed better relative to their peers invested less time after classes during the week. The effects are modest: A standard deviation reduction in performance increases a study time by only 2.6 minutes. The lag terms are not statistically significant either individually or jointly; the quiz effects seem immediate and do not spill over across weeks. Column 2 excludes week 13 when the instructor intervened by verbally prompting lagging students to do assignments. The current quiz turns insignificant, suggesting that the results of quizzes by themselves have little effects on effort. Column 3 and 4 shows OLS estimates. The estimates with controls are similar to (1), suggesting that the covariates provide reasonable control for unobserved ability. The positive and significant coefficient on pretest score is likely to be due to the correlation through the ability. Overall, the results show a negligible relationship between the amounts of study and quizzes outcomes. The feedback effects seem negligible for our semester-length study.

5. Conclusion

This paper outlined the identifying assumptions necessary to estimate the effects of procrastination on performance using non-experimental data. The condition on

no feedback effects was verified using intra-semester study pattern in a sample from a semester-length language course at a Japanese university. This lends support to previous studies that interpret correlations between test scores and procrastination on assignments as being causal—an interpretation that seems reasonable in light of the education literature that generally finds the effectiveness of self-directed learning among older students, and also with a casual empiricism of language teachers: the second language acquisition requires patient practice. Clearly, the current study is limited by the size and scope of the sample. The aim of my exercise in this paper is to add to a body of empirical analyses on procrastination, but is not to provide a final conclusion. Further empirical examinations that build on the body of works should be of value to the discipline of economics.

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Table 1: Parameter estimates of the education production function

Dependent variable: raw score (posttest)	(1)	(2)	(3)	(4)
Natural log of total hours spent on ALCNA	1.18 (1.049)	1.60 (1.445)	1.07 (0.907)	1.61 (1.171)
Natural log of HHI	-5.82* (2.365)	-6.58* (3.016)	-4.88* (2.277)	-5.69* (2.508)
Class attendance measure [0. none - 1. all]	24.72+ (14.697)	17.73 (13.043)	22.66+ (12.139)	18.07 (11.734)
Opportunity to use English during club/PT job [1. none - 5. often]	3.01+ (1.538)	2.84+ (1.532)	2.76* (1.291)	2.62+ (1.371)
Attending private language school [1. yes; 0. no]	6.55* (2.550)	5.48 (6.792)	5.51** (2.023)	7.37 (5.009)
Pretest			0.42** (0.108)	0.32** (0.116)
Constant	14.86 (15.269)	9.38 (20.796)	-1.46 (14.002)	-4.88 (18.107)
CONTROL VARIABLES	NO	YES	NO	YES
Observations	62	60	62	60
Adjusted R-squared	0.268	0.480	0.419	0.568

Note: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%.

Table 2: The effects of test performances on weekly study time

VARIABLES	(1) FE	(2) FE	(3) OLS	(4) OLS
Quiz (current)	-2.45+ (1.420)	-1.78 (1.406)	-0.54 (1.559)	-2.42 (1.547)
Quiz (first lag)	-0.60 (1.454)	0.93 (1.345)	1.85 (1.563)	-0.27 (1.423)
Quiz (second lag)	-0.46 (1.252)	0.78 (1.452)	2.63 (1.735)	-0.00 (1.388)
Quiz (third lag)	-0.40 (2.591)	0.90 (2.942)	1.47 (2.543)	-0.38 (2.531)
Pretest score			0.22 (0.259)	0.71** (0.241)
Constant	5.98+ (3.073)	5.83* (2.864)	-5.70 (13.279)	-24.83 (21.855)
CONTROL VARIABLES	NO	NO	NO	YES
FIXED EFFECTS	YES	YES	NO	NO
WEEK DUMMIES	YES	YES	YES	YES
Observations	576	522	576	558
Number of pid	62	62		
Adjusted R-squared	0.075	0.012	0.063	0.184

Note: The dependent variable is weekly study in minutes. Clustered standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Column 2 drops Week 13 observations.

Appendix

Summary statistics for the cross-section analysis

Variable description	Variable	Mean	Std. Dev.	N
Posttest	t2tot	61.87	11.95	63
Pretest	t1tot	49.78	10.72	63
Natural log of total hours spent on ALCNA	lnalctime	9.86	1.26	62
Natural log of HHI	lnhhi	-1.28	0.65	62
Class attendance measure [0. none - 1. all]	attend	0.92	0.10	63
Opportunity to use English during club/PT job [1. none - 5. often]	surq10	1.78	1.05	63
Attending private language school [1. yes; 0. no]	langscho	0.05	0.21	63
Choice 2 [1. second choice; 0. others]	choice2	0.10	0.30	63
Choice 3 [1. assigned; 0. others]	choice3	0.08	0.27	63
Class [1. larger class; 0. smaller class]	classA	0.62	0.49	63
Sex [1. female; 0. male]	sex	0.41	0.50	63
Senior [1. 3rd and above; 0. 2nd year]	senior	0.06	0.25	63
Private high school [1. yes; 0. no]	private	0.22	0.42	63
Experience abroad including a short travel [1. yes; 0. no]	exp_abroad	0.32	0.47	63
Experience with LL or CALL lab. [1. yes; 0. no]	exp_lab	0.41	0.50	63
Experience attending language school [1. yes; 0. no]	exp_lscho	0.25	0.44	63
Kyoto	region2	0.17	0.38	63
Osaka	region3	0.10	0.30	63
Gifu	region4	0.08	0.27	63
Other regions	region5	0.48	0.50	63
A member of sport club [1. yes; 0. no]	sport	0.53	0.50	62
Part time job per week [1. none - 4. every day]	surq11	2.51	0.88	63
TOEIC qualification useful in job hunting [1 - 5]	jobhunt	4.35	0.81	63
Interested in developing communication skills [1 - 5]	int_commu	4.40	0.91	63
Interested in studying abroad [1 - 5]	int_abroad	3.63	1.27	63
Interested in working for a foreign capital [1 - 5]	int_forcap	2.97	1.27	62
Interested in TOEIC [1 - 5]	int_toeic	4.27	0.77	63
ALCNA was simple to use [1 - 5]	alceasy	3.73	0.83	63
English skill develops better with CALL than traditional [1-5]	tradclass	4.06	0.86	63

Note: This summary statistics is based on observations with (1) non-missing pretest and posttest and (2) non-missing observation on int_forcap or sport. The regression without control variables uses a subsample with non-missing study-time variables. The regression with control variables uses a subsample complete survey responses.

Full results not shown in Table 1

Dependent variable: raw score of the posttest	(1)	(2)	(3)	(4)	(5)	(6)
Natural log of total hours spent on ALCNA	1.18 (1.049)	1.96 (1.397)	1.60 (1.445)	1.07 (0.907)	1.60 (1.108)	1.61 (1.171)
Natural log of HHI	-5.82* (2.365)	-6.32* (2.744)	-6.58* (3.016)	-4.88* (2.277)	-5.38* (2.456)	-5.69* (2.508)
Class attendance measure [0. none - 1. all]	24.72+ (14.697)	24.44 (15.739)	17.73 (13.043)	22.66+ (12.139)	23.14 (14.016)	18.07 (11.734)
Opportunity to use English during club/PT job [1. none - 3.01+]	3.01+ (1.538)	3.49* (1.418)	2.84+ (1.532)	2.76* (1.291)	3.45** (1.227)	2.62+ (1.371)
Attending private language school [1. yes; 0. no]	6.55* (2.550)	11.65* (5.510)	5.48 (6.792)	5.51** (2.023)	10.87* (4.757)	7.37 (5.009)
Choice 2 [1. second choice; 0. others]		3.74 (5.914)	-3.96 (4.473)		2.02 (4.317)	-4.01 (3.864)
Choice 3 [1. assigned; 0. others]		2.17 (8.079)	1.58 (8.258)		-0.89 (6.611)	-1.51 (8.312)
Class [1. larger class; 0. smaller class]		4.24 (6.114)	-1.40 (5.175)		1.16 (4.990)	-2.98 (5.174)
Sex [1. female; 0. male]		-5.73 (3.475)	-7.14* (3.209)		-5.04 (3.020)	-6.18+ (3.119)
Senior [1. 3rd and above; 0. 2nd year]		0.69 (8.229)	-2.70 (7.012)		-2.15 (4.794)	-3.15 (5.997)
Private high school [1. yes; 0. no]		-4.55 (4.008)	-2.48 (3.146)		-4.68 (3.264)	-3.33 (2.859)
Experience abroad including a short travel [1. yes; 0. no]		4.24 (2.745)	5.69* (2.506)		1.26 (2.534)	3.85 (2.360)
Experience with LL or CALL lab. [1. yes; 0. no]		0.86 (2.871)	-0.53 (2.937)		0.44 (2.553)	-1.23 (2.513)
Experience attending language school [1. yes; 0. no]		-1.28 (4.903)	-3.40 (4.201)		-5.09 (4.182)	-5.58 (4.289)
Kyoto			8.22 (5.318)			8.67+ (5.034)
Osaka			5.57 (5.627)			7.14 (5.300)
Gihu			7.02 (5.458)			8.44+ (4.957)
Other regions			-2.01 (3.684)			-0.13 (3.312)

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A member of sport club [1. yes; 0, no]			4.58+			3.70
			(2.546)			(2.400)
Part time job per week [1. none - 4. every day]			-0.19			1.02
			(1.412)			(1.391)
TOIEC qualification useful in job hunting [1 - 5]			-0.54			0.55
			(2.577)			(2.135)
Interested in developing communication skills [1 - 5]			-2.50			-2.99+
			(2.285)			(1.703)
Interested in studying abroad [1 - 5]			2.20			2.01
			(1.509)			(1.282)
Interested in working for a foreign capital [1 - 5]			-0.44			-1.37
			(1.377)			(1.249)
Interested in TOEIC [1 - 5]			-2.73			-1.89
			(2.432)			(2.333)
ALCNA was simple to use [1 - 5]			4.47*			3.95*
			(1.693)			(1.689)
English skill develops better with CALL than traditional [1-5]			2.41+			1.68
			(1.194)			(1.088)
Pretest				0.42**	0.47**	0.32**
				(0.108)	(0.113)	(0.116)
Constant	14.86	4.46	9.38	-1.46	-8.36	-4.88
	(15.269)	(23.816)	(20.796)	(14.002)	(19.985)	(18.107)
Observations	62	62	60	62	62	60
Adjusted R-squared	0.268	0.267	0.480	0.419	0.452	0.568

Note: Robust standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%. Variables, Choice k , are dummy variable constructed from the way in which students were assigned to the class. The base sample is those who pick the class as their first choice. Those students who chose the class as their second choice have Choice 2 = 1. Those students who did not make any choice over classes and were assigned to the class by administration have Choice 3 = 1.

Summary statistics for the panel regression analysis

Week	Raw quiz performance		Minutes Studied		N
	Mean	Std. Dev.	Mean	Std. Dev.	
2	0.62	0.19	5	21	65
4	0.70	0.13	15	23	62
5	0.63	0.15	15	23	62
6	0.63	0.15	15	23	63
7	0.63	0.14	12	19	62
8	0.70	0.09	14	32	53
9	0.61	0.13	15	34	64
10	0.80	0.12	13	29	63
12	0.75	0.17	21	40	52
13	0.74	0.17	41	62	57
Total	0.68	0.16	16.47	33.25	603

- ▶ Do procrastination reduces test score?
- ▶ The condition of no feedback effects is important in estimation.
- ▶ This study verifies that condition using detailed intra-semester study data
- ▶ Evidence shows detrimental effects of procrastination on test scores

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