# How Much Time-Inconsistency Is There and Does It Matter? Evidence on Self-Awareness, Size, and Effects*

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**Abstract**

Using students' predicted and unpredicted delays in midterm preparation as measures of time-inconsistency and self-awareness, this paper shows that time-inconsistent behavior is associated with inferior class performance even after controlling for the actual time spent in preparation. Most students showed some time-inconsistency. Most were at least partially aware of their time-inconsistency. Despite full awareness, the sophisticates still under-performed in class relative to the time-consistent. Furthermore, they might still show over-confidence in their self-evaluation of future class performance. Those naive about future time-inconsistency also under-performed relative to the time-consistent.

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# 1 Introduction

Using the class behaviors and class performances of two different groups of undergraduates, this paper empirically examines three questions. First, are people time-consistent? Most are not; in both samples, only six to seven percent of the students behaved time-consistently in their preparation for midterm examination. Second, to what extent are people aware of their future time-inconsistency? Most are at least partially aware. Many cited reasons such as procrastination and laziness to explain why they predicted deviations from their own optimal plans. Third, does time-inconsistency matter? It does. The time-inconsistent under-performed relative to the time-consistent. Moreover, in the absence of pre-commitment devices, being aware of future time-inconsistency did not prevent under-performance in class. Compared to the time-consistent, being naive about future time-inconsistency may also hurt class performance.

The two samples consist of two semesters of students in my introductory macroeconomics class at the National University of Singapore (NUS). To measure class performance, I use scores in tutorial participation, midterm, final examination, their sum and the final letter grade awarded for overall performance. To identify time-inconsistency and self-awareness, I use survey responses to questions regarding their optimal, predicted, and actual study plans for the midterm examination. As the benchmark, the time-consistent students behave according to plan, and they plan according to what is optimal from the long-run perspective. Thus, they predict and experience no delay in implementing their ideal study plan (i.e., ideal from the prior perspective).

Time-inconsistency, on the other hand, can take three forms. First, the naifs, who are completely unaware of their future time-inconsistency, predict no delay in initiating their study plan but end up deviating from it. Second, the sophisticates, who are fully aware of their future time-inconsistency, incorporate their time-inconsistency into their plan. In the absence of pre-commitment devices, they choose the best plan among those they will actually follow when the moment of action arrives, given their true future time-inconsistency. This plan may not be the best plan from the long-run perspective if they can pre-commit themselves. Thus, the sophisticates predict deviations from their ideal study plan but experience no unpredicted delay in implementing their chosen plan. Finally, the partial naifs, who are aware of their future time-inconsistency but mis-estimate its severity, predict delay from the prior perspective but end up deviating further from their chosen plan. Thus, they show both predicted and unpredicted delays.

In summary, I use the students' predicted delay in initiating their *own* ideal study plan from the prior perspective as a measure of sophistication about future time-inconsistency, and unpredicted delay in implementing their chosen study plan as a measure of naiveté about future time-inconsistency. While I expect predicted delay from optimal plan to be a good measure of sophistication, the interpretation of unpredicted delay needs to be qualified: in a world with external shocks, unpredicted delay is likely to be a noisy signal of naiveté because there may be other shocks that cause the students to deviate from their predicted plans for reasons unrelated to time-inconsistent preferences. However, if the other shocks are exogenous and random, unpredicted delay will still be an unbiased estimator of naiveté.

It turns out that both predicted and unpredicted delays have negative effects on all measures of class performance in both samples. Furthermore, the effect of unpredicted delay is comparable in magnitude across samples. The negative effects of predicted delay are comparable in magnitude to the effects of unpredicted delay in one sample. However, somewhat surprisingly they turn out to be larger in size and more statistically significant in the other sample. A priori, delays may be due to factors unrelated to time-inconsistency, such as an unusually busy schedule. However, it turns out that the negative effects of predicted and unpredicted delays remain even after controlling for the actual days or hours spent in midterm preparation although more hours spent did raise midterm score with diminishing returns. An interpretation of this finding is that the negative effects of delays are mainly due to sub-optimal intertemporal allocation of time rather than less time spent per se.

The failure to anticipate preference reversal also shows up as prediction error in class performance, defined as the difference between the students' actual and predicted grade performance, where the prediction was made by the students themselves before the midterm and after they have had significant exposure to course materials. This prediction error in class performance is always significantly related to unpredicted delay. Furthermore, it is significantly related to predicted delay in one of the two samples. Thus, the evidence suggests that self-awareness of future time-inconsistency, as measured by predicted delay, is sometimes not fully incorporated into the self-evaluation of its consequence.

# 2 Methodology and Results

The Related Literature

Economists generally assume that people have time-consistent preferences: a person's relative preference for well-being at an earlier date over a later date remains unchanged no matter when he is asked. Strotz (1955) shows that the only discount function that gives time-consistent preferences is the exponential discount function, in which the discount rate is constant over time. There is empirical evidence that the discount rates may not be constant over time. For example, Thaler (1981) and Benzion et al. (1989) find that the discount rates on monetary payoffs are not constant but are decreasing with delays in the realization of the tradeoffs. There is also evidence of preference reversal when the payoffs are shifted over time. For example, Ainslie and Haslam (1992) find that some people do not prefer a $100 certified check in 6 years to a $200 certified check in 8 years but they prefer a $100 certified check now over a $200 certified check in two years.[1]

These types of empirical evidence motivated the theoretical literature on present-biased preferences, typically modelled using hyperbolic or quasi-hyperbolic discounting, in which the discount rate declines over time (for example, Loewenstein and Prelec 1992 and Laibson 1997).[2] Thus, when considering tradeoffs between two future moments, stronger relative weight is given to the earlier moment as it gets closer (O'Donoghue and Rabin 1999).[3]

Strotz (1955) and Pollak (1968) lay out two extreme paradigms that can be used to analyze self-awareness of future time-inconsistency: sophistication and naiveté. Being fully aware of their future time-inconsistency, the sophisticates fully anticipate their own propensity to experience preference reversals. In contrast, the naifs are fully unaware of their future time-inconsistency. Thus,

[1]Because the discount rates apply to utilities rather than monetary payoffs, one needs to make some strong assumptions before one can impute the discount rates for utilities based on choices on monetary payoffs over time. See for example Laibson (2003) for details. Andersen et al. (2008) show that eliciting the discount rates independently of risk preferences (as it is typically done) would lead to estimated discount rates that are significantly biased upwards if people are risk averse.

[2]Phelps and Pollak (1968) first use quasi-hyperbolic discounting to model imperfect altruism across generations.

[3]While there can be time-inconsistency due to either present-bias or future-bias, the existing literature typically models time-inconsistency as present-biased preferences. Akerlof (1991) attributes present-bias to saliency of immediate cost and its effect on decision. Ameriks et al. (2007), on the other hand, argue that present-bias is no more prevalent than is future-bias, measured by the tendency to consume less (instead of more) now than would be ideal.

they fail to anticipate preference reversals. O'Donoghue and Rabin (2001) extend the paradigms to include the partial naifs. Being only partially aware of their future time-inconsistency, the partial naifs anticipate preference reversals but mis-predict their extent. O'Donoghue and Rabin (1999, 2003) show that the degree of self-awareness is a crucial determinant of the implications of present-biased preferences and that severe harm can arise if and only if there is some naiveté in self-awareness.

There is evidence that people voluntarily impose self-limiting "commitment devices" that are costly to violate. Such devices represent "smoking guns" that cannot be explained by any time-consistent preferences (for example, Wertenbroch 1998, Ariely and Wertenbroch 2002). It appears that people do use self-imposed constraint and penalty to improve performance, but the constraint is not set optimally for maximum performance enhancement (for example, Trope and Fishbach 2000 and Ariely and Wertenbroch 2002). Thus, the evidence is consistent with people being to some degree aware, but not completely aware, of future time-inconsistency.

However, only people who are at least partially aware of their future time-inconsistency would pre-commit themselves to a smaller choice set. Thus, evidence on the use of pre-commitment devices cannot distinguish the time-consistent from the naifs because both will not choose to pre-commit themselves: the time-consistent cannot benefit from pre-commitment to a smaller choice set, whereas the naifs, believing that they will be well-behaved in the future, do not think they need pre-commitment. Evidence on the use of pre-commitment devices alone also cannot distinguish the partial naifs from the sophisticates because both will choose to pre-commit themselves. This paper attempts to fill this gap by proposing a methodology that separately identifies all four types:

the time-consistent, the naifs, the partial naifs, and the sophisticates.

The methodology is most similar to Ameriks et al. who ask the participants to indicate their ideal and their predicted intertemporal allocation in a hypothetical two-period consumption problem. They measure self-control as the difference between the intertemporal allocation the participants initially viewed as optimal and the allocation they expected to choose.[4] This paper differs from Ameriks et al. in that I consider a task that the participants actually perform. More importantly, because Ameriks et al. measure only ideal and predicted behaviors but not actual behavior, they cannot distinguish between the time-consistent and the naifs because both will predict ideal behavior. They also cannot distinguish between the partial naifs and the sophisticates because both will predict deviations from ideal behavior.

It is worth noting that the empirical evidence on discount rates and preference reversals is subject to different interpretations. Read (2001) shows that subadditive time discounting, with greater discounting over subdivided intervals, can also cause the discount rates to decrease with delays. On the other hand, Rubinstein (2001, 2003) argues that a similarity-based heuristic, in which the decision maker simplifies the choice by canceling out "similar components," is also consistent with the evidence. Similarly, Manzini and Mariotti (2006) propose a vague theory of choice over time as an explanation. They assume that the decision maker perceives choices in the distant future only vaguely, so he simply chooses the alternative that is better in the dimension (outcome or time) that he regards as the most important.

It may well be that these alternative mechanisms may operate together with present-biased

[4]They find that present-bias is no more prevalent than is future-bias. They also find that those with a present-bias are less wealthy than those with a future-bias.

preferences in situations that involve intertemporal choice. However, in the context of this paper, it is difficult to see how the similarity- or vagueness-based heuristics or subadditive discounting would lead to predicted deviations from optimal plan, especially when both optimal and predicted plans were elicited on the same prior date (so both plans would appear equally vague or similar) using the same time unit for measurement, for example days (so both plans would appear to be divided into the same subintervals). Furthermore, these behaviors can only arise if people are at least partially aware of their future time-inconsistency and they regard this future time-inconsistency as suboptimal from the prior perspective.[5] It seems cognitively less intuitive for such awareness to arise from the mechanisms posited by alternative theories (i.e., similarity, vagueness, or subadditive discounting). Moreover, if awareness does arise from these alternative mechanisms, it is unclear why future preference reversals would be considered undesirable or not optimal from the prior perspective. Self-awareness of time-inconsistent preferences appears to be a more intuitive explanation.

The Surveys

This paper considers the task of midterm preparation, a familiar task for the undergraduates. The participants were undergraduates in my introductory macroeconomics class at the National University of Singapore (NUS). I administered similar surveys to two different groups of students from the Fall 2004 semester and the Spring 2006 semester respectively by distributing survey questions in single sheets of paper during lectures. In each semester, I ran two surveys in two different weeks to collect the data used in this paper. Every participant from the same semester

[5]This argument also applies to the voluntary imposition of self-limiting commitment devices that are costly to violate.

answered the same survey questions at the same time.

The time line of the surveys is as follows: each semester consists of 12 weeks of weekly lectures, with a five-day mid-semester break between week 6 and week 7. For the Fall 2004 semester, with the midterm examination held in week 8 (5 October 2004), I ran the first survey in week 6 (14 September 2004). In addition to collecting information on gender, choice of major, current semester of study, nationality and whether they were exchange students, the first survey asked the students for their ideal and predicted dates to start midterm examination preparation and for their predicted final grade in the class. The survey questions read as follows:

> 1. Preparing for midterm involves forgoing some activities you enjoy, such as watching TV, playing basketball, and shopping but it may improve your grade performance. If you take both the costs and benefits into consideration, what is the *optimal or ideal date* for you to start preparing for the Midterm? Write down a specific date and the number of days before the midterm (e.g., 4 October 2004 is one day before the midterm).
>
> Note: The midterm will be held on Tuesday, 5 October 2004
>
> 2. Knowing yourself, what is the *predicted date* you think you would start preparing for the Midterm, whatever the ideal date may be?
>
> Briefly explain your answers to questions 1 and 2:
>
> If you have to make a prediction, what grade do you think you will get in EC2102 (e.g., A, B+, D, etc.)?[6]

I ran the second survey on the day of the midterm examination (before the examination started) with the following question:

> What is the *actual date* you started preparing for the Midterm? Write down a specific date and the number of days before the midterm (e.g., 4 October 2004 is one day before the midterm).

For the Spring 2006 semester, the survey design was similar but with a few differences. First, with the midterm examination held one week earlier in week 7 (1 March 2006), I ran the first survey also one week earlier in week 5 (8 February 2006) so that the gap between the first survey and the

[6]EC2102 is the module code for the class.

midterm examination was roughly the same as before. Second, the question explicitly reminded the students that they might have other midterm examinations during the same period that they needed to take into consideration when deciding on the optimal date.[7] Third, the surveys consisted of three additional questions on average hours spent in preparation following the respective questions on the optimal date, predicted date, and actual date. These questions read as follows:

> Again taking into account both the costs and benefits, on average, what is the optimal number of hours per day you will spend studying for the midterm examination of EC2102 during that period?
>
> Again knowing yourself, how many hours you think you will actually spend preparing for the midterm examination of EC2102 during that period. In other words, on average, what is the predicted number of hours per day you will spend studying for the midterm examination of EC2102 during the period?
>
> On average, what is the actual number of hours per day you spent studying for the midterm examination of EC2102 during the above period?

For the Fall 2004 semester, the first survey contained some other unrelated questions. For the Spring 2006 semester, these questions were the only questions in the two surveys.

Before proceeding, let me acknowledge that the use of survey responses has obvious limitations. One particular worry is that the students may lie about their study plans. However, it is worth emphasizing that all university examinations were graded anonymously. Thus, lying would

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[7] Specifically, the questions read as follows:

> 1. Spending more time to prepare for the midterm examination of EC2102 involves forgoing some activities you enjoy, such as watching TV, playing basketball, etc. It also means that you have less time to prepare for the midterm examination of the other modules. However, it may improve your performance in the class.
>
> If you take both the costs and benefits into consideration, what is the optimal date for you to start preparing for the Midterm examination of EC2102? Convert that into the optimal number of days to start preparation before the midterm examination. For example, if the optimal date is 28 February 2006, that is one day before the midterm examination on 1 March 2006.
>
> 2. Knowing yourself, what is the predicted date you think you will start preparing for the midterm examination of EC2102, whatever the ideal date may be?
>
> Briefly explain your answers:
>
> If you must make a prediction, what is your best forecast of the grade you will get in EC2102? A+, A, A-, B+, B, B-, C+, C, D+, D, F.

not change the instructor's evaluation, especially given the large and inevitably impersonal class setting. Furthermore, to the extent that there was lying, it would be the bad type pretending to be the good type, biasing against finding any negative effects from delays.

The Identification Strategy

Based on these responses, I create two variables to measure a student's time-inconsistency and self-awareness. First, predicted delay is defined as the difference between optimal and predicted days.[8] Predicted delay is similar to Ameriks et al.'s measure of self-control problems, which is defined as the gap between expected consumption and ideal consumption in the first period of a hypothetical two-period consumption problem. Predicted delay measures the degree to which a person is aware of his future time-inconsistency because a person will only predict deviation from his optimal plan when asked in advance if he is aware of his future time-inconsistency. Both the time-consistent and the naifs will predict no delay.[9]

Second, unpredicted delay is defined as the difference between predicted and actual days.[10] In a world with no external shocks, unpredicted delay measures the degree to which a person mis-estimates his true time-inconsistency and plans either too optimistically or too pessimistically. Both the time-consistent and the sophisticates will experience no unpredicted delay. However, with shocks, unpredicted delay may also capture the effect of unexpected shocks that cause a student

[8]For example, if his optimal date is November 10 but his predicted date is November 11, then predicted delay is equal to +1 day.

[9]O'Donoghue and Rabin (1999) show that even for an onerous task, a sophisticate can do it either too early or too late from the long-run perspective. Specifically, a sophisticate can start too early to avoid doing it too late given certain cost structure of completing the onerous task. In other words, even assuming present bias, predicted delay can be negative or positive.

[10]For example, if the predicted date is November 11 but actual date is November 13, then unpredicted delay is equal to +2 days. These definitions do not rule out negative values for predicted and unpredicted delays. For example, if unpredicted delay equals -2, it means that the person actually starts midterm preparation two days before planned.

to deviate from his study plan. Nevertheless, if these shocks are random and exogenous, then unpredicted delay is still an unbiased estimate of the degree of naiveté and an OLS regression of class performance on unpredicted delay still gives an unbiased estimate of the effect of naiveté.

This identification strategy has three advantages. First, the identification strategy is based on theory. Second, it makes no assumption about the nature of the task – whether studying for midterm is considered onerous or enjoyable. Third, since it makes no assumption about the direction of the bias and so it does not rule out future-biased preferences.

Table 1 presents the summary statistics for both samples. The two samples seem largely comparable with two exceptions. First, on average the students in the later semester seem to score lower in the midterm and higher in the final examination. The two effects are similar in magnitude but opposite in sign, so total scores are comparable across semesters. Second, while students from both semesters show over-confidence in their forecasts of their own class performance, the students in the later semester seem to exhibit greater over-confidence; their prediction error, defined as the difference between actual grade and predicted grade (measured in the corresponding grade points), is almost twice as large on average.[11]

The Results

Out of 158 students from Fall 2004, this strategy identifies 11 time-consistent persons (7% of total), 31 naifs (19.6%), 96 partial naifs (60.8%), and 20 sophisticates (12.7%). Similarly, out of 287 students from Spring 2006, this strategy identifies 17 time-consistent persons (5.9% of total), 67 naifs (23.3%), 168 partial naifs (58.5%), and 35 sophisticates (12.2%). Thus the distribution of

[11]The final grade ranges from A+, A, A-, B+, B, B-, C+, C, D+, D, to F. A+ and A correspond to a grade point of 5.0, A- a grade point of 4.5, B+ a grade point of 4.0, etc. Each lower grade is associated with a 0.5 grade point reduction except grade F, which is a failed grade with zero grade point.

types seems quite comparable across different samples with most students exhibiting some time-inconsistency and awareness.

It is natural to ask whether the above findings are robust to small perturbations to the identification strategy. Specifically, could the strategy misclassify a large number of the time-consistent and sophisticates because they either remembered the actual date incorrectly or they experienced random unexpected shocks that forced them to deviate slightly from plan? To check robustness, I relax the criteria for the time-consistent and sophisticates to include also those with +1 or -1 unpredicted delays. Similarly, I change the criteria for the naifs to exclude those with +1 or -1 unpredicted delays.

With these changes, the strategy identifies 20 time-consistent persons (12.7% of total), 22 naifs (13.9%), 68 partial naifs (43%), and 48 sophisticates (30.4%) from Fall 2004. Similarly, there are now 24 time-consistent persons (8.4% of total), 60 naifs (20.9%), 136 partial naifs (47.4%), and 67 sophisticates (23.3%) from Spring 2006. Not surprisingly, more are now classified as the time-consistent and sophisticates. Nevertheless, most students still exhibit some time-inconsistency and awareness. Thus, bad memory and small unexpected shocks cannot account for the finding that time-inconsistency and awareness are prevalent.

To investigate whether time-inconsistency and self-awareness matter, I regress various measures of the students' performance in class (including their numerical scores in tutorials, midterm, and final examination) on predicted delay, unpredicted delay, and a number of control variables for personal characteristics. Tutorials were based on continuous assessment and accounted for 10 points. The students were evaluated based on both tutorial attendance and participation. The midterm examination consisted of only multiple choice questions and accounted for 30 points. The final examination was a written examination that included both analytical and numerical questions.[12] It accounted for the remaining 60 points. Anonymous grading was used for both midterm and final examinations. For tutorials, clear guidelines of evaluation were publicly announced and followed.

By using class performances measured at different time points during the semester, I assume that a person's time-inconsistency and self-awareness are relatively stable and persistent, at least within one semester. Mischel et al. (1992) show that the ability to resist temptation is a very long lasting personality trait with significant cross domain validity. They find that the ability of four-year-old children to delay immediate gratification is significantly and positively related to both their propensity for self-control and their SAT scores when they reach adolescence.

Table 2 reports the OLS estimates. In what follows, the columns that are numbered with an "A" suffix refer to the estimates from the Fall 2004 sample and those with a "B" suffix refer to the estimates from the Spring 2006 sample. Predicted delay was associated with lower class performance for all performance measures. The effects are always statistically significant at the 1% level for the Fall 2004 sample and at least at the 10% level for the Spring 2006 sample, although the effects are generally smaller in magnitude in the latter sample. The sophisticates still under-performed relative to the time-consistent although their delays were perfectly anticipated. This is expected if the sophisticates could not pre-commit to the optimal plan from the long-run perspective. In this case, the sophisticates would do what Pollak refers to as "consistent planning"; they would choose

[12]In Spring 2006, because of the much larger class size, the final examination also included some multiple choice questions, which accounted for half of the points in the final examination.

the best plan among those they would actually follow given their self-control problem.

On the other hand, unpredicted delay also affected class performance negatively. The effects of unpredicted delay are comparable in magnitude across samples. For the Spring 2006 sample, they are always statistically significant at least at the 5% level and also comparable in magnitude to the effects of predicted delay. However, for the Fall 2004 sample, the effects of unpredicted delay are only statistically significant at the 5% level for final examination and at the 10% level for aggregate performance; they are also smaller in magnitude compared to the effects of predicted delay.[13]

The other explanatory variables (gender, current semester, dummy for exchange student and dummy for economics major) have mixed effects: they sometimes change signs across samples and performance measures. Furthermore, they are never statistically significant in both samples.[14] In contrast, the effects of predicted and unpredicted delays are more robust. They always have the same sign across samples and across different performance measures. They are often statistically significant at the conventional levels in at least some performance measures in both samples.

A potential problem with the preceding analysis is the existence of unobservable variables that affect both class performance and delays. Though I cannot reject all such unobservables,

[13]Theoretically, O'Donoghue and Rabin (1999) argue that naiveté is especially costly for a task involving immediate cost because naifs with self-control problem may procrastinate *repeatedly* and do the task at a time when it is especially costly to do (in terms of disutility cost). In contrast, because the sophisticates fully incorporate future tendency to procrastinate into their plan, their decision to procrastinate is a one-shot delay taking into account future costs and benefits. However, for the task this paper considers, even the naifs, who were completely unaware of their future time-inconsistency, could not procrastinate indefinitely because the midterm examination was due in finite horizon.

[14]More specifically, except for the midterm in Fall 2004, male students tend to perform better in class, and the effects are statistically significant at the 5% level for tutorial, midterm, and aggregate performance in Spring 2006. In Fall 2004, students who entered the university earlier tend to perform worse though the effect is never statistically significant at the conventional levels. However, except for tutorials, they tend to perform better in Spring 2006, and the effect is statistically significant at the 5% level only for midterm performance. Exchange students tend to perform significantly worse in Fall 2004, but their performance is mixed in Spring 2006. There were six exchange students in Fall 2004 and two in Spring 2006. Thus the results probably depend greatly on the individuals. Except for tutorial performance in Spring 2006, economics majors tend to perform worse in class, but the effect is statistically significant at the 5% level only for final examination and aggregate performance in Fall 2004.

in what follows I will test for the more obvious ones to verify my results. For example, it is possible that those students who reported longer delays were also those who spent less time in preparation for other reasons unrelated to time-inconsistency. For example, the students might have mis-interpreted the question on the optimal or the ideal date as what they would do in an ideal world with no constraints, despite the question's explicit emphasis of the opportunity costs of studying. If this were true, then students who were especially busy and wished to have been able to start the preparation earlier would report longer predicted delay. Similarly, unpredicted delay may be attributable to unexpected negative shocks that forced the students to spend less time studying than others in general. Thus, the negative correlations between delays and class performance may not be due to time-inconsistency, but simply reflect the omitted variable bias for not controlling for actual time spent in preparation. However, this would imply that once actual study time is controlled for, predicted and unpredicted delays should have no effect on class performance.

To check for this possible omitted variable bias, Table 3 re-estimates the regressions, including actual days of preparation as additional control. To account for possible diminishing returns, the regressions also include a quadratic term. It turns out that once predicted and unpredicted delays are controlled for, actual days spent in preparation have no statistically significant effect on class performances. On the other hand, the estimated effects of both predicted and unpredicted delays are very similar in magnitude as before. Moreover, eleven out of sixteen estimates on predicted and unpredicted delays in Table 3 are still statistically significant at the 5% level.

For the Spring 2006 sample, the survey also asked for the average number of hours spent per day during actual midterm preparation. Thus I can calculate the total hours actually spent in preparation and include this variable in the regressions. Table 4 reports the OLS estimates. There is evidence that more time spent in midterm preparation is generally associated with better performance with diminishing returns. The estimates are statistically significant for midterm score at the 5% level. However, the negative effects of predicted and unpredicted delays are not diminished by the inclusion of actual hours in the regressions. An interpretation of this finding is that sub-optimal intertemporal allocation of time rather than less time input is the main mechanism through which delays affect class performance.

Are the effects of predicted and unpredicted delays economically significant? How do the effects on numerical scores translate into impacts on the final grade that students receive, which is a letter grade based on curve grading of total scores?[15] To investigate this, I re-estimate the regressions using the final grade (an ordinal variable) as the dependent variable. Table 5 and Table 6 report the estimates from ordered logit and ordered probit models respectively. The impacts are indeed economically significant. For example, in the ordered logit regression in column (1A) of Table 5, the marginal effects of predicted and unpredicted delays on final grade are as follows: negative and statistically significant at the five percent level for grades that are B+ or better; positive and statistically significant at the five percent level for grades between B- and C+; and positive and statistically significant at the ten percent level for grade C. Thus, the turning point occurs at grade B, where the marginal effects change sign; the marginal effects turn positive but are statistically insignificant at the conventional levels. These findings mean that predicted and unpredicted delays reduce the likelihood of getting an above average grade (B+ or better) and increase the likelihood of getting a below average grade (B- and below).

[15] As noted earlier, the final grade ranges from A+, A, A-, B+, B, B-, C+, C, D+, D, to F.

According to theory, the sophisticates plan by taking into account their true tendency to be time-inconsistent in the future, in addition to the associated costs and benefits. Therefore, it is interesting to ask whether the sophisticates do have rational expectations about the consequence of their predicted time-inconsistency. If they do, then predicted delay should be fully incorporated into the students' own prediction of their future class performance. I define the prediction error of grade performance as the difference between actual grade and predicted grade (after converting them into the corresponding grade points). I then regress this prediction error on the same set of independent variables. Table 7 and Table 8 report the estimates using ordered logit and ordered probit models respectively.

The results show that predicted delay has no significant effect on prediction error in the Fall 2004 sample, but it is negatively related to prediction error in the Spring 2006 sample. In the later sample, it implies that students with higher predicted delays still made grade predictions that were more optimistic than warranted by actual grade performance. This effect is always statistically significant at the 1% level for the Spring 2006 sample. This finding suggests that while the sophisticates plan by taking into account their future tendency to be time-inconsistent, sometimes they can still under-estimate the consequence of their fully predicted future time-inconsistency.

Male students and exchange students tend to be overconfident too, but the effects are statistically significant at the conventional levels only for the Fall 2004 sample. The finding of male overconfidence is consistent with the behavioral finance literature (see, for example, Barber and Odean 2001). On the other hand, exchange students may be overconfident because they are unfamiliar with the grading system in their host university or because they fail to anticipate their self-control problem while studying abroad.[16] Finally, current semester and the dummy for economics major are not significantly related to prediction error.

# 3 Conclusions

This paper empirically identifies the degree of time-inconsistency and self-awareness in two independent samples of undergraduates and relates them to class performance. Using survey responses on the optimal, predicted, and actual dates of midterm preparation, I create two variables, predicted and unpredicted delays in initiating midterm preparation, and use them as proxy measures of time-inconsistency and self-awareness. The identification strategy is as follows: a time-consistent person plans what is optimal from the long-run perspective and acts according to plan, a naive person plans what is optimal from the prior perspective but fails to act according to plan, a sophisticated person fully anticipates preference reversal and chooses the best plan among those that he will actually follow, then acts according to plan, and a partially naive person chooses the best plan among those he *believes* he will follow, but he fails to act according to plan because his belief about his future behavior is partially wrong.

The existing literature has contributed important and interesting evidence supporting time-inconsistency, particularly the findings that people use pre-commitment devices to constrain their future choices and the findings that people's predicted intertemporal allocation deviates from the allocation they view as optimal. However, this evidence is less successful in distinguishing the time-consistent from the naifs and the partial naifs from the sophisticates. This paper attempts

[16]However, it is worth noting that because there were relatively few exchange students in the sample, the results may depend sensitively on the individuals.

to fill this gap. By exploiting differences in predicted and unpredicted delays among the time-consistent, the naifs, the partial naifs, and the sophisticates, this paper attempts to distinguish all types of time-inconsistency and self-awareness.

To the extent that predicted and unpredicted delays capture time-inconsistency and awareness, the evidence suggests that time-inconsistency is prevalent and that it matters. I find that most students behaved time-inconsistently and they were at least partially aware of their time-inconsistency. This finding remains even if I relax the criteria for the time-consistent and sophisticates to include those with small unpredicted delays. Time-inconsistent behavior is associated with inferior class performances. The effects are generally statistically and economically significant.

Robustness checks show that predicted and unpredicted delays still matter to class performances even after controlling for actual days or hours spent in preparation. An interpretation of this evidence is that the negative effects of delays arise mainly from sub-optimal intertemporal allocation of time (i.e., doing a task when it is more costly) rather than less time spent per se. This also rules out certain unobservables, such as an unusually busy schedule, as explanations for the negative relationship between delays and class performance. Furthermore, predicted delay is sometimes not fully incorporated into the students' self-evaluation of future performance. On the other hand, not surprisingly, unpredicted delay is always associated with overconfidence in self-evaluation. Male students and exchange students also tend to be overconfident, although the effects are not always statistically significant at the conventional levels.

While the identification strategy is based on concepts developed in the literature on present-biased preferences, it is interesting to ask whether time-inconsistent preferences are indeed the underlying cause of delays, especially since there are alternative theories such as subadditive discounting, vagueness- and similarity-based heuristics that can explain preference reversals. It is possible that these mechanisms are at work in some situations. However, they seem less likely and less intuitive as explanations for ex-ante preference reversal from optimal plan (i.e., predicted delay), especially when both the optimal and predicted plans are elicited on the same prior date (so that both optimal and predicted plans should be equally vague or similar) using the same subdivision of time intervals, specifically days, so that there is no subadditive discounting. Moreover, if delays are not related to time preferences, it is unclear how the predicted plan can be different from the optimal plan, making the predicted plan sub-optimal from the prior perspective. In these cases, self-awareness based on time-inconsistent preferences appears to be a more intuitive explanation. Nevertheless, more work is needed to uncover what goes on in the black box: the cognitive processes that lead to preference reversals.

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Table 1: Summary Statistics

| | Fall 04 (N=158) | | Spring 06 (N=287) | |
|---|---|---|---|---|
| Variable | Mean | Std. Dev. | Mean | Std. Dev. |
| Tutorial Scores | 7.3 | 1.4 | 6.8 | 1.3 |
| Midterm Scores | 23.0 | 4.5 | 18.8 | 4.9 |
| Final Exam Scores | 28.2 | 9.3 | 35.1 | 10.0 |
| Total Scores | 58.5 | 13.1 | 60.7 | 14.0 |
| Final Grade (grade points) | 3.5 | 0.9 | 3.4 | 0.9 |
| Prediction Error in Final Grade (grade points) | -0.29 | 0.93 | -0.56 | 0.87 |
| Predicted Delays | 2.7 | 4.2 | 2.3 | 3.8 |
| Unpredicted Delays | 2.1 | 4.2 | 2.5 | 4.4 |
| Dummy for Male Student | 0.38 | 0.49 | 0.38 | 0.49 |
| Current Semester | 3.3 | 1.1 | 2.8 | 1.6 |
| Dummy for Exchange Student | 0.04 | 0.19 | 0.01 | 0.08 |
| Dummy for Economics Student | 0.64 | 0.48 | 0.70 | 0.46 |
| Actual Days for Midterm Preparation | 5.8 | 4.5 | 5.2 | 3.6 |

Table 2: Time-Inconsistency and Class Performance - OLS

| | Dependent Variable: Numerical Score | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fall 04 | | | | Spring 06 | | | |
| | [1A] | [2A] | [3A] | [4A] | [1B] | [2B] | [3B] | [4B] |
| Independent Variable | Tutorial | Midterm | Final Exam | Total* | Tutorial | Midterm | Final Exam | Total* |
| Predicted Delays | -0.1 | -0.29 | -0.66 | -1.05 | -0.06 | -0.14 | -0.41 | -0.61 |
| | [0.03]*** | [0.09]*** | [0.18]*** | [0.24]*** | [0.02]*** | [0.08]* | [0.16]** | [0.22]*** |
| Unpredicted Delays | -0.04 | -0.04 | -0.4 | -0.48 | -0.05 | -0.16 | -0.37 | -0.59 |
| | [0.03] | [0.09] | [0.18]** | [0.24]* | [0.02]*** | [0.07]** | [0.14]*** | [0.19]*** |
| Male | 0.37 | -0.22 | 0.42 | 0.57 | 0.63 | 1.67 | 1.41 | 3.71 |
| | [0.23] | [0.69] | [1.43] | [1.98] | [0.16]*** | [0.59]*** | [1.21] | [1.67]** |
| Current Semester | -0.12 | -0.33 | -0.65 | -1.1 | -0.06 | 0.49 | 0.58 | 1.01 |
| | [0.13] | [0.40] | [0.82] | [1.13] | [0.07] | [0.24]** | [0.50] | [0.68] |
| Exchange Student | -1.48 | -7.44 | -14.12 | -23.04 | 0.46 | -2.14 | 4.48 | 2.8 |
| | [0.69]** | [2.08]*** | [4.29]*** | [5.93]*** | [0.92] | [3.35] | [6.90] | [9.52] |
| Econ Student | -0.02 | -1.36 | -3.65 | -5.02 | 0.12 | -0.59 | -2.37 | -2.84 |
| | [0.28] | [0.84] | [1.74]** | [2.41]** | [0.24] | [0.87] | [1.79] | [2.47] |
| Constant | 7.97 | 26.2 | 35.68 | 69.85 | 6.95 | 17.9 | 36.47 | 61.31 |
| | [0.59]*** | [1.78]*** | [3.66]*** | [5.06]*** | [0.35]*** | [1.29]*** | [2.65]*** | [3.66]*** |
| N | 158 | 158 | 158 | 158 | 287 | 287 | 287 | 287 |
| $R^2$ | 0.11 | 0.16 | 0.17 | 0.2 | 0.11 | 0.12 | 0.09 | 0.12 |

Notes: * Total Numerical Score = Numerical Score in Tutorial + Numerical Score in Midterm + Numerical Score in Final Exam. Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 3: Accounting for Actual Days Spent in Preparation - OLS

| | Dependent Variable: Numerical Score | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fall 04 | | | | Spring 06 | | | |
| | [1A] | [2A] | [3A] | [4A] | [1B] | [2B] | [3B] | [4B] |
| Independent Variable | Tutorial | Midterm | Final Exam | Total* | Tutorial | Midterm | Final Exam | Total* |
| Predicted Delays | -0.09 | -0.28 | -0.65 | -1.01 | -0.06 | -0.11 | -0.38 | -0.55 |
| | [0.03]*** | [0.09]*** | [0.18]*** | [0.25]*** | [0.02]** | [0.08] | [0.17]** | [0.23]** |
| Unpredicted Delays | -0.02 | -0.02 | -0.38 | -0.42 | -0.04 | -0.12 | -0.34 | -0.51 |
| | [0.03] | [0.09] | [0.19]** | [0.26] | [0.02]** | [0.07]* | [0.15]** | [0.21]** |
| Male | 0.35 | -0.24 | 0.48 | 0.58 | 0.65 | 1.8 | 1.54 | 3.99 |
| | [0.23] | [0.70] | [1.44] | [1.99] | [0.16]*** | [0.59]*** | [1.23] | [1.69]** |
| Current Semester | -0.17 | -0.38 | -0.65 | -1.2 | -0.06 | 0.48 | 0.56 | 0.98 |
| | [0.13] | [0.41] | [0.84] | [1.16] | [0.07] | [0.24]** | [0.50] | [0.68] |
| Exchange Student | -1.53 | -7.53 | -14.33 | -23.39 | 0.48 | -1.62 | 5.13 | 3.99 |
| | [0.69]** | [2.10]*** | [4.33]*** | [5.98]*** | [0.92] | [3.37] | [6.94] | [9.58] |
| Econ Student | -0.04 | -1.39 | -3.68 | -5.11 | 0.15 | -0.62 | -2.47 | -2.94 |
| | [0.28] | [0.85] | [1.75]** | [2.42]** | [0.24] | [0.87] | [1.80] | [2.48] |
| Actual Days | -0.007 | 0.037 | 0.25 | 0.28 | -0.05 | 0.28 | 0.49 | 0.71 |
| | [0.064] | [0.195] | [0.40] | [0.56] | [0.06] | [0.21] | [0.44] | [0.60] |
| Actual Days Squared | 0.003 | 0.001 | -0.010 | -0.006 | 0.005 | -0.010 | -0.025 | -0.030 |
| | [0.003] | [0.009] | [0.018] | [0.025] | [0.003] | [0.012] | [0.024] | [0.034] |
| Constant | 8.01 | 26.06 | 34.69 | 68.75 | 6.96 | 16.72 | 34.86 | 58.54 |
| | [0.64]*** | [1.95]*** | [4.02]*** | [5.55]*** | [0.41]*** | [1.50]*** | [3.09]*** | [4.26]*** |
| N | 158 | 158 | 158 | 158 | 287 | 287 | 287 | 287 |
| $R^2$ | 0.13 | 0.16 | 0.17 | 0.21 | 0.12 | 0.13 | 0.1 | 0.13 |

Notes: * Total Numerical Score = Numerical Score in Tutorial + Numerical Score in Midterm + Numerical Score in Final Exam.
Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Accounting for Actual Hours Spent in Preparation - OLS

| | Dependent Variable: Numerical Score | | | |
|---|---|---|---|---|
| | Spring 2006 | | | |
| | [1B] | [2B] | [3B] | [4B] |
| Independent Variable | Tutorial | Midterm | Final Exam | Total* |
| Predicted Delays | -0.06 | -0.14 | -0.43 | -0.63 |
| | [0.02]*** | [0.08]* | [0.16]*** | [0.22]*** |
| Unpredicted Delays | -0.05 | -0.17 | -0.42 | -0.63 |
| | [0.02]** | [0.07]** | [0.15]*** | [0.20]*** |
| Male | 0.65 | 1.97 | 1.61 | 4.23 |
| | [0.16]*** | [0.60]*** | [1.24] | [1.70]** |
| Current Semester | -0.06 | 0.46 | 0.56 | 0.96 |
| | [0.07] | [0.24]* | [0.50] | [0.68] |
| Exchange Student | 0.52 | -1.48 | 4.78 | 3.82 |
| | [0.92] | [3.34] | [6.93] | [9.54] |
| Econ Student | 0.11 | -0.56 | -2.24 | -2.69 |
| | [0.24] | [0.86] | [1.80] | [2.47] |
| Total Actual Hours | 0.006 | 0.094 | 0.068 | 0.176 |
| | [0.011] | [0.039]** | [0.080] | [0.110] |
| Total Actual Hours Squared | 0.00001 | -0.0009 | -0.001 | -0.002 |
| | [0.00009] | [0.0003]*** | [0.0007] | [0.0009]** |
| Constant | 6.85 | 16.77 | 35.91 | 59.53 |
| | [0.38]*** | [1.39]*** | [2.88]*** | [3.97]*** |
| N | 286 | 286 | 286 | 286 |
| $R^2$ | 0.11 | 0.14 | 0.1 | 0.14 |

Notes: * Total Numerical Score = Numerical Score in Tutorial + Numerical Score in Midterm + Numerical Score in Final Exam.
Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Time-Inconsistency and Final Grade – Ordered Logit

| | Dependent Variable: Final Grade* | | | |
|---|---|---|---|---|
| | Fall 04 | | Spring 06 | |
| Independent Variable | [1A] | [2A] | [1B] | [2B] |
| Predicted Delays | -0.15 | -0.15 | -0.08 | -0.07 |
| | [0.04]*** | [0.04]*** | [0.03]*** | [0.03]** |
| Unpredicted Delays | -0.09 | -0.08 | -0.08 | -0.07 |
| | [0.04]** | [0.04]** | [0.03]*** | [0.03]** |
| Male | 0.06 | 0.07 | 0.53 | 0.57 |
| | [0.29] | [0.30] | [0.22]** | [0.22]** |
| Current Semester | -0.21 | -0.23 | 0.07 | 0.06 |
| | [0.18] | [0.19] | [0.09] | [0.09] |
| Exchange Student | -4.15 | -4.23 | 0.42 | 0.61 |
| | [0.98]*** | [0.99]*** | [1.06] | [1.07] |
| Econ Student | -0.86 | -0.88 | -0.61 | -0.63 |
| | [0.36]** | [0.37]** | [0.34]* | [0.34]* |
| Actual Days | | 0.038 | | 0.098 |
| | | [0.083] | | [0.080] |
| Actual Days Squared | | -0.0009 | | -0.003 |
| | | [0.0037] | | [0.005] |
| N | 158 | 158 | 287 | 287 |

Notes: * Final grade is a letter grade based on the student's total numerical score in class. Each letter grade in turn corresponds to a numerical grade point that is used to calculate the cumulative grade point average of a student. Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Time-Inconsistency and Final Grade – Ordered Probit

| | Dependent Variable: Final Grade* | | | |
|---|---|---|---|---|
| | Fall 04 | | Spring 06 | |
| Independent Variable | [1A] | [2A] | [1B] | [2B] |
| Predicted Delays | -0.09 | -0.09 | -0.05 | -0.05 |
| | [0.02]*** | [0.02]*** | [0.02]*** | [0.02]*** |
| Unpredicted Delays | -0.05 | -0.04 | -0.05 | -0.04 |
| | [0.02]** | [0.02]* | [0.01]*** | [0.02]** |
| Male | 0.03 | 0.04 | 0.3 | 0.33 |
| | [0.17] | [0.17] | [0.13]** | [0.13]** |
| Current Semester | -0.09 | -0.09 | 0.07 | 0.07 |
| | [0.10] | [0.10] | [0.05] | [0.05] |
| Exchange Student | -2.29 | -2.32 | 0.32 | 0.42 |
| | [0.54]*** | [0.54]*** | [0.73] | [0.73] |
| Econ Student | -0.47 | -0.47 | -0.21 | -0.22 |
| | [0.21]** | [0.21]** | [0.19] | [0.19] |
| Actual Days | | 0.027 | | 0.054 |
| | | [0.048] | | [0.047] |
| Actual Days Squared | | -0.001 | | -0.002 |
| | | [0.002] | | [0.003] |
| N | 158 | 158 | 287 | 287 |

Notes: * Final grade is a letter grade based on the student's total numerical score in class. Each letter grade in turn corresponds to a numerical grade point that is used to calculate the cumulative grade point average of a student. Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: Self-Awareness and Prediction Error in Grade Performance - Ordered Logit

| | Dependent Variable: Prediction Error in Final Grade* | | | |
|---|---|---|---|---|
| | Fall 04 | | Spring 06 | |
| | [1A] | [2A] | [1B] | [2B] |
| Predicted Delays | -0.02 | -0.01 | -0.1 | -0.1 |
| | [0.04] | [0.04] | [0.03]*** | [0.03]*** |
| Unpredicted Delays | -0.09 | -0.08 | -0.1 | -0.09 |
| | [0.04]** | [0.04]** | [0.03]*** | [0.03]*** |
| Male | -0.7 | -0.69 | -0.15 | -0.13 |
| | [0.30]** | [0.30]** | [0.22] | [0.22] |
| Current Semester | -0.1 | -0.11 | -0.01 | -0.01 |
| | [0.17] | [0.18] | [0.09] | [0.09] |
| Exchange Student | -3.93 | -3.98 | -0.69 | -0.6 |
| | [0.95]*** | [0.96]*** | [1.06] | [1.07] |
| Econ Student | -0.11 | -0.11 | -0.3 | -0.28 |
| | [0.35] | [0.35] | [0.33] | [0.34] |
| Actual Days | | 0.037 | | 0.013 |
| | | [0.078] | | [0.080] |
| Actual Days Squared | | -0.0012 | | 0.0009 |
| | | [0.0033] | | [0.0044] |
| N | 158 | 158 | 286 | 286 |

Notes: * The actual and predicted final grades refer to letter grades. Each letter grade in turn corresponds to a numerical grade point that is used to calculate the cumulative grade point average of a student. I first convert the actual and predicted final grades into grade points that correspond to the respective letter grades. I then calculate the prediction error as the difference between the two grade points: Prediction Error = Actual Grade Point - Predicted Grade Point.
Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: Self-Awareness and Prediction Error in Grade Performance - Ordered Probit

| | Dependent Variable: Prediction Error in Final Grade* | | | |
|---|---|---|---|---|
| | Fall 04 | | Spring 06 | |
| | [1A] | [2A] | [1B] | [2B] |
| Predicted Delays | -0.01 | -0.01 | -0.06 | -0.06 |
| | [0.02] | [0.02] | [0.02]*** | [0.02]*** |
| Unpredicted Delays | -0.04 | -0.04 | -0.06 | -0.06 |
| | [0.02]** | [0.02]* | [0.02]*** | [0.02]*** |
| Male | -0.38 | -0.38 | -0.07 | -0.06 |
| | [0.17]** | [0.17]** | [0.13] | [0.13] |
| Current Semester | -0.09 | -0.09 | -0.004 | -0.004 |
| | [0.10] | [0.10] | [0.05] | [0.05] |
| Exchange Student | -2.18 | -2.2 | -0.41 | -0.39 |
| | [0.54]*** | [0.54]*** | [0.73] | [0.73] |
| Econ Student | -0.11 | -0.11 | -0.16 | -0.15 |
| | [0.21] | [0.21] | [0.19] | [0.19] |
| Actual Days | | 0.021 | | -0.002 |
| | | [0.047] | | [0.046] |
| Actual Days Squared | | -0.0007 | | 0.0008 |
| | | [0.0021] | | [0.0026] |
| N | 158 | 158 | 286 | 286 |

Notes: * The actual and predicted final grades refer to letter grades. Each letter grade in turn corresponds to a numerical grade point that is used to calculate the cumulative grade point average of a student. I first convert the actual and predicted final grades into grade points that correspond to the respective letter grades. I then calculate the prediction error as the difference between the two grade points: Prediction Error = Actual Grade Point - Predicted Grade Point.
Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%