HOW ABOUT TOMORROW? OPTIMAL PROCRASTINATION AND THE IMPLICATIONS FOR DELAY IN SUBMITTING TO CONFERENCES

by

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No. 280

November 2000

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Discussion Paper No 280

ISSN 1033-4661

HOW ABOUT TOMORROW? OPTIMAL PROCRASTINATION AND THE IMPLICATIONS FOR DELAY IN SUBMITTING TO CONFERENCES.

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ABSTRACT. In these times of academic stress in which one's time budget is a binding constraint, procrastination and delay may be an optimal response to deadlines imposed by conference organizers. We formulate a model of optimal procrastination using optimal stopping theory. Whilst the date of the conference is known and the "soft" deadline is also known by the authors of the paper, the "hard" deadline for the publication of the conference proceedings and program is only known by the organizers. Organizers possess a lower and upper bound on the numbers of participants that is determined by the budget by their budget and the capacity of the conference venue. The authors would like to submit papers as late as possible subject to these constraints. The question this paper attempts to address is "What is the optimal period of procrastination for the authors?"

1. INTRODUCTION

This paper makes a contribution to the economics of procrastination. While there is an existing strand of literature on optimal timing in investment theory (for example Ingersoll and Ross [8] and McDonald and Siegel [11]), there have been relatively few papers on a more general theme of procrastination in the literature.

The papers from investment theory rely on discounted time preferences in order to formulate their objective functions. A recent contribution by O'Donoghue and Rabin [12] has questioned the use of discounting in that it

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Key words and phrases. Optimal stopping and Markov decision theory, renewal theory, academic conference attendance, optimal procrastination, the economics of academic skulduggery and the sociology of economics.

JEL Classification: A14, C44, C61

We would like to acknowledge the generosity and patience of the conference organizers for allowing the late submission of the paper to the 2000 Conference of Economists in Australia. Incidentally, this was the second last paper received.

implies a preference for impatience. The paper has suggested that procrastination may in fact be an optimal response for some people when making decisions. Amongst the growing literature on procrastination, contributions by Gottbrath et al [5],[6] question the effectiveness of acting immediately. In this series of papers there is a question of investing in expensive hardware when waiting, or procrastinating, may be an optimal response under technological innovation. Alternative approaches in the theme of procrastination occur in the Computational Sciences literature where *machine learning* looks at procrastination as being optimal in the presence of hierarchial classes of learnable phenomena [1],[4],[9]. In this case procrastination represents an optimal delay that occurs through breaking down information.

In this paper we apply the economics of procrastination to the problem faced by researchers wanting to submit papers to a forthcoming conference. In announcing a call for submissions of papers to a conference the organizers will typically announce the venue at the same time. By this date the availability of this venue and its facilities will almost certainly be secured and in doing so the organizers will incur substantial outlay costs in hiring of the venue before attendance fees have been collected from participants. In addition, plans need to be made for catering, the scheduling of sessions, and the publication of conference materials like schedules and associated proceedings. All of which will add to the costs incurred . The organizers need to ensure that the conference at least breaks even by matching the outlay for the conference venue, the publishing of proceedings and associated anomalous costs with revenues from attendances.

However, when organizers select and hire a venue for a conference and make plans for the scheduling of sessions they typically do not know with precision how many participants there are going to be. They can make a best guess based on the number of participants from conference attendances in previous years as well as the relative change in the size of membership of the professional society from which the conference participants will be drawn. In addition, astute choice of conference venue, "special deals" with respect to travel costs and accommodation and adequate and timely promotion of the conference, its venue and any special features and discounts will contribute to the success of the conference in terms of the numbers of participants.

As the time for the conference gets closer and participants register their interest in attending by submitting papers or abstracts, the organizers will get a better idea of the numbers of likely participants. However at some stage the organizers must make a cut-off on submissions so that they can finalize accommodation, catering, scheduling and printing. At this stage the organizers will have some idea of the upper and lower bounds on attendance whereby either overcrowding of the venue or lack of attendance would cause the conference to fail. Since these preparations for the conference must take place at some fixed unit of time before the actual conference starts, there must also be a "hard" deadline after which the submissions can no longer be accepted. This deadline is usually much closer to the date of the conference

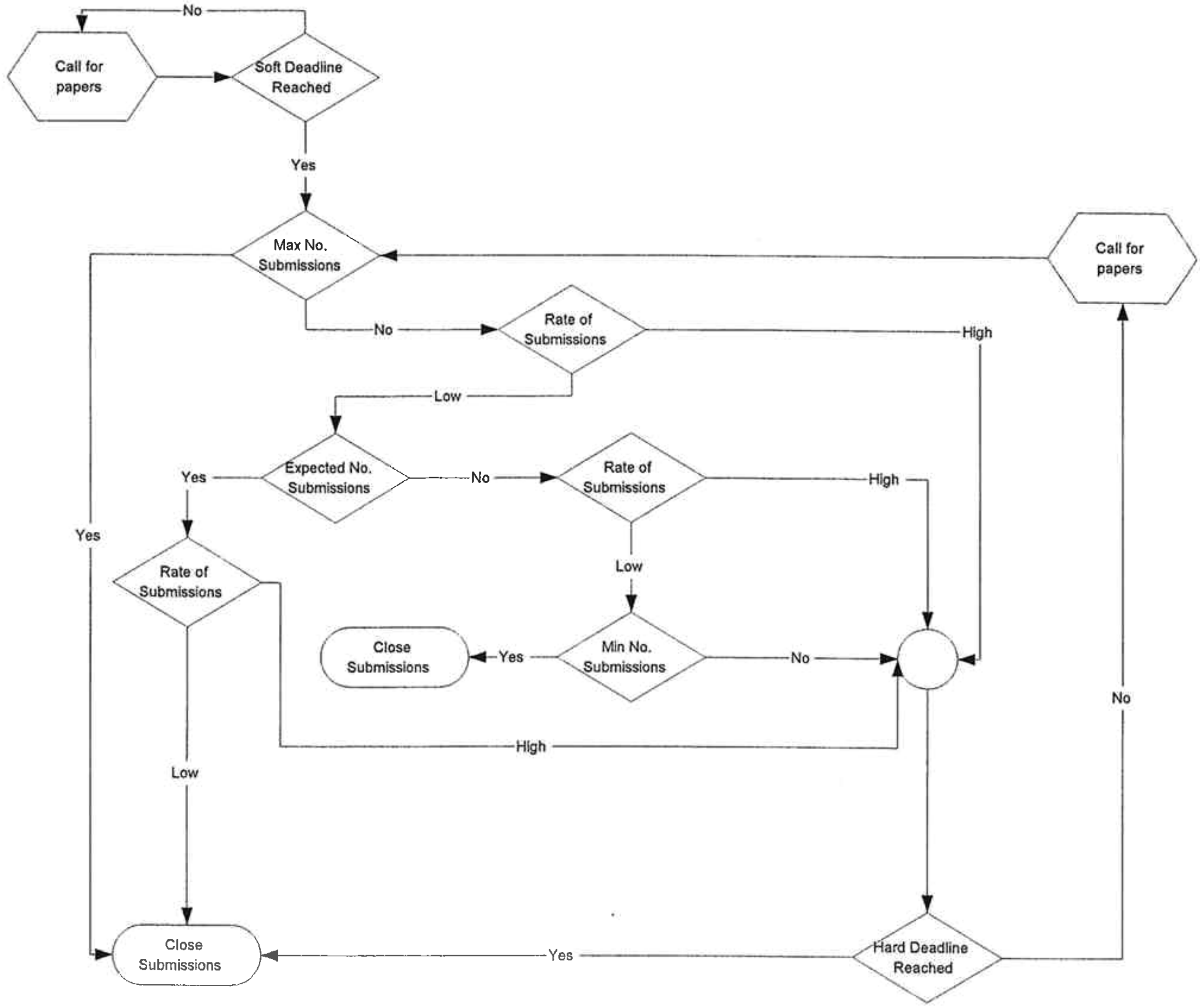

FIGURE 1. Conference organizer's decision process

than the "soft" deadline for submissions that is announced by conference organizer.

In the best possible outcome for the conference organizer, where the number of submissions is larger than the size of the conference venue, the organizer will close the call for submissions at the "soft" deadline, refuse to accept any late offerings and screen the submissions received to determine their suitability. However if the numbers of submissions at the date of the "soft" deadline are below the organizers' upper bound, then the organizer may be prepared to allow late submissions and potential participants more time to register. The final date for late submission in this case will be "hard" deadline. The decision for the conference organizer is best understood by referring to the flowchart shown in Figure 1

For the conference organizer, the variable of interest is not only the number of papers received but the rate at which the papers are submitted. The arrival time between papers gives the organizer an indication of the final number of papers expected and thus how successful the conference will be.

In this model it is assumed that although this deadline is known to the conference organizers, this information will not be shared with conference participants. The only information available for someone submitting late is the numbers of papers submitted at the date of the "soft" deadline. From the view-point of the strategic procrastinator, submitting before or on the "soft" deadline is not an option as they do not have the paper completed. As they would like to attend the conference, they therefore would like to submit after the "soft" deadline. Sinçe they do not know the date of the "hard" deadline, they must therefore judge the optimal time to submit. It will be assumed that although our procrastinator does not have access to the date of the "hard" deadline, information is available with respect to number of attendees and the rate of submission for the conference in previous years. Based on this information the decision to submit at some point in time after the "soft" deadline must therefore be balanced against the expectation of successfully submitting late and the costs in time of continuing to work on the paper.

An explanation of the formulation of this problem will be provided in the in the second section of this paper, whilst the third section provides its solution. Discussion of possible extensions to this line of research will be provided in the conclusion.

2. The problem for the optimal procrastinator

We will assume that the best possible outcome for the conference organizer has not been achieved., i.e. where the number of submissions is larger than the size of the conference venue. At the organizer's discretion, late offerings will be accepted. Recalling that from the view-point of the strategic procrastinator, submitting before or on the "soft" deadline is not an option as they do not have the paper completed, then their decision to submit will be made sometime between the "soft" and "hard" deadlines. The times of successive arrivals of late submissions can therefore be described by

$$0 < T_1 < T_2 < ... < T \tag{2.1}$$

where 0 and T are respectively the dates of the "soft" and "hard" deadlines, while T_n refers to the arrival time of the nth paper.

We will let $N(t) = 0, 1, 2, ...$ define the number of people that have submitted papers by time $t \in [0, T]$. Given that one would expect there to be late withdrawals as well as late arrivals, the population of conference attendees will be modelled as a birth-death process

$$\mathcal{N} = \{N(t); t \geq 0, N(0) = N_0\}, \tag{2.2}$$

with $N(0) = N_0$ as the number of papers received at time of the "soft" deadline. The distribution of $N(t)$ will be given by the *simple birth-death* *process* given by

(2.3)

$$P_{nm}(t) = P(N(t+h) = m|N(t) = n) = \begin{cases} \lambda h + o(h) & \text{if } m = n+1 \\ \mu h + o(h) & \text{if } m = n-1 \\ o(h) & \text{if } |m-n| > 1, \end{cases}$$

where λ and μ are respectively the rates of birth and death. It will be assumed that $\lambda > \mu$ so that there is only positive probability of eventual extinction equal to $\left(\frac{\lambda}{\mu}\right)^{-1}$; if $\lambda \leq \mu$ then eventual extinction is assured (see Grimmet and Stirzaker [7] or Taylor and Karlin [16] for a discussion).

From the point of view of the organizers the arrival of late papers at the conference can be understood to be a *renewal process.* A renewal process refers to the continual periodic occurrence of some non-negative "event" over time. Let X_1 define the period before arrival of the first late paper and let

$$X_n = T_n - T_{n-1}, \quad n = 2, 3, ..., K_u \tag{2.4}$$

define the period between the arrival of the $(n-1)$th and nth paper, then the time of arrival of the nth paper is given by

$$T_n = \sum_{j=1}^{n} X_j, \quad n = 1, 2, ..., K_u. \tag{2.5}$$

While this is the view of the conference organizers, from the perspective of someone submitting these are dispatch times. As a consequence of the number of conference attendees $N(t)$ being Poisson distributed, intervals between the paper arrivals will form a stochastic process $\{X_n\}_{n \in \mathcal{N}}$, which will be independent and identically (iid) exponentially distributed with mean λ.

The conference organizers have defined an upper and lower bound to the number of papers they receive.. These are respectively K_u and K_d. The upper bound K_u represents a capacity constraint for the conference. The lower bound K_d will represent the least number of papers the organizers must receive for the conference to go ahead. Without loss of generality we will set $K_u = k$ and $K_d = 0$, where k is a positive integer. It will be assumed that at any point in time if $N(t) < 0$, the conference will be called off by the organizers due to insufficient interest. In addition it will be assumed that the organizers will freely accept papers while $0 < N(t) < k$. However when $N(t) \geq k$, the conference organizers will choose either to accept or reject late submissions with probability $1/2$. Therefore the instantaneous rate of late arrivals is actually given by

$$\lambda_n = \begin{cases} \lambda, & n = 1, 2, ..., k \\ \lambda/2, & n = k+1, k+2, \ldots . \end{cases} \tag{2.6}$$

We will let P_n denote the probability that the number of papers accepted at time t is $N(t) = n$, then at *steady state* the numbers of conference papers submitted have the following probabilistic behaviour

$$P_n = \begin{cases} 2^n \rho^n P_0 & n = 0, 1, 2, ..., k-1 \\ \rho^{n-k} P_k = 2^k \rho^k \rho^{n-k} P_0, & n = k, k+1, ... \end{cases} \tag{2.7}$$

where $\rho \equiv \lambda / 2\mu < 1$ gives the rate of "acceptance" at any point in time. This would mean that after the upper bound on the number of papers has been reached the organizers will accept half of the subsequent papers submitted. The upper bound in this case is not the maximum number of places available for attendees, rather it serves as a point from which a filtering process takes over. The distribution for P_0 is derived recursively from (2.7) and is given by

$$P_0 = \left(\sum_{n=0}^{k-1} 2^n \rho^n + \frac{2^k \rho^k}{(1-\rho)} \right)^{-1}. \tag{2.8}$$

This then leads to a measure of the average number of papers that will be accepted by the conference organizers

$$L = \sum_{j=0}^{\infty} n P_n = P_0 \left(\sum_{n=0}^{k-1} n 2^n \rho^n + 2^k \rho (1-\rho)^{-2} - 2^k \sum_{n=0}^{k-1} n \rho^n \right)^{-1}. \tag{2.9}$$

3. The optimal time to submit and its implications for organizers

Our procrastinator has to make a decision on whether to submit or not and the time at which it is optimal to make this decision, given the offsetting expected rewards and costs of submitting late. Once the strategic procrastinator has made their decision to submit or not, it will not be reversed. The timing-strategy π for procrastinating can be understood to be a sequence $\{a_n\}_{n=0}^{\infty}$, representing the sequential "send-quit-wait" strategy pre-selected by the procrastinator from their action space A. We propose the following cost structure, if the procrastinator chooses action a when the conference population is in state n, then the procrastinator's cost function is given by $C(X_n, a_n)$ with $c(X_n, a_n)$ incurred up to the time of the next transition. The procrastinator's decision will be modelled as a problem of optimal stopping, where they attempt to select an appropriate *timing-strategy* π for procrastinating subject to an expected pay-off under this policy π

$$V_\pi(n) = E_\pi \left[\sum_{n=0}^{\infty} e^{-\delta(\tau_1 + ... + \tau_{n-1})} \left(C(X_n, a_n) + \int_0^{\tau_n} c(X_n, a_n) e^{-\delta t} \right) | X_0 = n \right], \quad n = 0, 1, 2, ..., \tag{3.1}$$

where E_π represents the conditional expectation given π, $a_n \in A = \{0, 1, 2\}$ where "0" is the decision not to submit at time t, "1" is the decision to submit at time t and "2" is the decision to wait longer and the discount rate $\delta \in (0, 1)$.

This leads to a *semi-Markov decision process.* This is a consequence of the times of the transitions to the next state being defined by a (possibly) non-Markovian distribution $F_{nm}(t|a_m)$. Following Ross [15] we can define the discounted objective function as follows:

$$V_\delta(n) = \inf_{\pi\in\Pi} V_\pi(n), \quad n = 0,1,2,\ldots. \tag{3.2}$$

A policy π^* is said to be optimal if

$$V_{\pi^*}(n) = V_\delta(n), \quad \forall n = 0,1,2,\ldots. \tag{3.3}$$

It can be shown (for example Ross [15, p157–158] or Prabhu [14]) that the procrastinator's discounted objective function is given by

$$\begin{aligned} V_\delta(n) \quad = \quad & \min_{a_n\in\{0,1,2\}} \{\bar{C}_\alpha(X_n, a_n) + \\ & \left.\sum_{m=1}^{\infty} P_{nm}(a_m) \int_0^\infty e^{-\delta t} V_\alpha(m)\, dF_{nm}(t|a_m)\right\}, \end{aligned} \tag{3.4}$$

for $n = 0,1,2,\ldots$.

The main problem with this type of dynamic programming formulation of the problem is that it can be highly intractable from the viewpoint of obtaining analytic solutions to this stopping problem. In order to get a tractable solution we propose that the transition times be set identically to one. What this means is that the procrastinator makes their decision "send-quit-wait" on a daily basis. The expected cost associated with the policy π is given as

$$V_\pi(n) = E_\pi\left[\sum_{n=0}^{\infty} \delta^n C(X_n, a_n)\,|X_0 = n\right], \quad n = 0,1,2,\ldots, \tag{3.5}$$

with the procrastinator's cost function is given as follows

$$C(X_n, a_n) = -R\mathbf{1}\{a_n = 0\} + X_n(a - bX_n)\mathbf{1}\{a_n = 1\}, \tag{3.6}$$

where

$$\mathbf{1}\{a_n = i\} = \begin{cases} 1 \text{ if } a_n = i \\ 0 \text{ otherwise.} \end{cases} \tag{3.7}$$

This a *Markov decision process.*

The timing-strategy π for procrastinating can be understood to be a sequence $\{a_n\}_{n=0}^{\infty}$, representing the sequential send-quit-wait strategy confronted by the procrastinator. Following Ross [15] we define the discounted objective function as follows:

$$V_\delta(n) = \inf_{\pi\in\Pi} V_\pi(n), \quad n = 0,1,2,\ldots. \tag{3.8}$$

A policy π^* is then said to be optimal if

$$V_{\pi^*}(n) = V_\delta(n), \quad \forall n = 0,1,2,\ldots. \tag{3.9}$$

It can be shown (see Ross [15, p121–122]) that if we set

$$(3.10)\qquad V_{\pi}(n) = \sum_{a_n \in \{0,1,2\}} P_{a_n} \left[C(X_n, a_n) + \sum_{m=1}^{\infty} P_{nm}(a) V_{\alpha}(m) \right],$$

then this will imply that the procrastinator's discounted objective function is given by

(3.11)

$$V_{\delta}(n) = \min_{a_n \in \{0,1,2\}} \left\{ C(X_n, a_n) + \delta \sum_{m=1}^{\infty} P_{nm}(a) V_{\alpha}(m) \right\}, \qquad n = 0, 1, 2....$$

Readers familiar with the sequential analysis literature in statistics [3] will realise the connection between the above problem and sequential likelihood ratio testing.

However, this is still a dynamic programming formulation of the problem. One alternative is to solve the optimal stopping problem numerically and a possible procedure is outlined by Pliska [13, p. 178]. An alternative approach, discussed by Taylor and Karlin [16, p. 168–169], is to exploit the properties of Markov chains to reformulate the above dynamic optimization problem as a linear programming problem. From this perspective we note that the state space is finite due to the conference attendance being bounded at k. Manne [10] has provided a methodology for converting a Markov decision processes to a linear programming problem. We now follow this approach by setting $u(n)$ as the reward function associated with the nth submission. The optimization problem is expressed as follows:

$$(3.12)\qquad \max \sum_{n=1}^{k} u(n)$$

subject to

$$(3.13)\quad C(X_n, a_n) + \delta \sum_{m=1}^{k} P_{nm}(a_n) u(m) \geq u(n), \qquad a_n \in A, n = 0, 1, ..., k$$

where

$$(3.14)\qquad C(X_n, a_n) = -R\mathbf{1}\{a_n = 0\} + X_n(a - bX_n)\mathbf{1}\{a_n = 1\}.$$

We solve this by application of linear programming.

Stylized results are obtained by formulating a numerical example in an Excel spreadsheet. Parameters values were chosen to conform with the model (See Table 1).

From the set of actions $\{0, 1, 2\}$ chosen by the procrastinator we can obtain the optimal values for the reward functions for submission at different states. We recall that the states are the total number of conference participants committed to attending the conference at each point in time.

The results suggest that the optimal point to submit is the time just before the conference population reaches its maximum of 30. That is, the

TABLE 1. Model Parameters

Cost Function Parameters	R	a	b
	1	5	0.5
Birth Death Parameters	λ	μ	
	0.5	0.3	
Bounds	k	n	$r = (1 - \delta)$
	15	30	0.06

best time for the optimal procrastinator to submit will be at the last possible moment before the conference programme is full (See Figure 2).

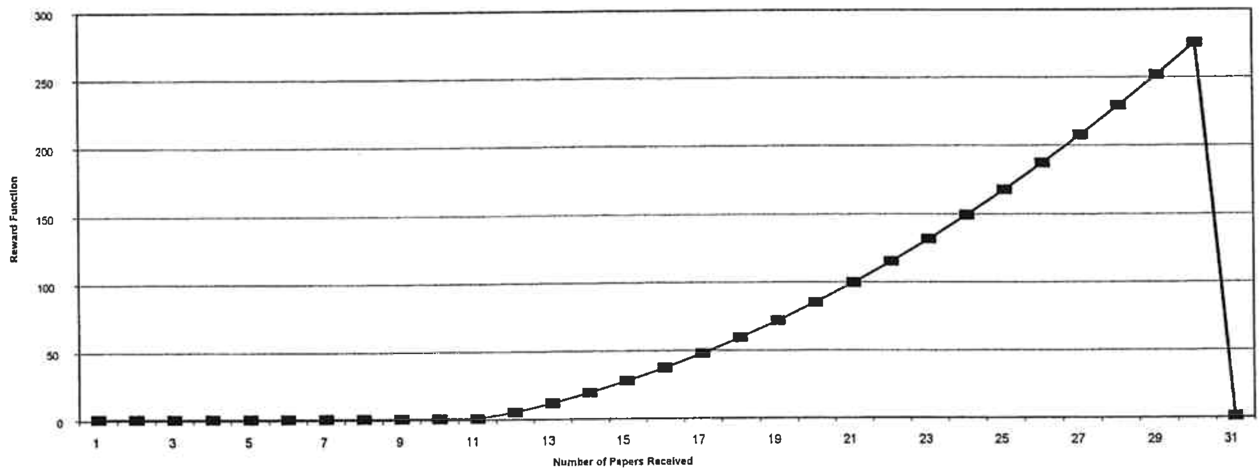

FIGURE 2. Optimal point for submission by the procrastinating participant

4. CONCLUSIONS

This paper has examined the role of procrastination in decisions of optimal timing. We apply techniques employed in optimal stopping to formulate the problem of the optimal procrastinator. We exploit the properties of Markov chains to turn a dynamic programming problem into a linear programming problem. The model is solved for a stylized set of parameter values and results are obtained. The results suggest that the optimal time for a procrastinator to submit a paper to a conference is at the last possible moment. Practically, this implies that someone intending to procrastinate should submit later, rather than sooner, as long as they are not the last to submit. In spite of the fact that time preferences are discounted procrastination still results. Sensitivity analysis needs to be carried out to see if this result still holds with a higher discount rate. However, we have not yet reached a decision on whether to continue this line of research.

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