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Sequential Advocacy

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Sequential Advocacy*

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Abstract

Information collection in political and judicial processes is often delegated to several agents, each of whom is expected to defend a specific interest. This paper provides a rationale for a striking feature of information collection in such advocacy systems, namely that information collection is often sequential. If two agents search simultaneously, the incentive to continue searching is affected by the information found by the other agent. Full information collection then requires that the principal leaves rents to the agents. If agents search sequentially, rewards can be made conditional on the information found in earlier stages. Therefore, a sequential advocacy system reduces the rents that agents receive. It comes, however, at the cost of either a more sluggish decision-making process or less information collection.

Key words: Information collection, advocates, sequential search, budgetary process.

JEL Classification: D80, D83, K41.

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1 Introduction

In several organizations, agents are not expected to maximize the stated goals of their organization. Rather, they have specific tasks. A typical example can be found in courts. Trials are an instrument of getting the truth. However, it is not the primary task of lawyers and prosecutors to get the truth. Lawyers are expected to defend their clients, while prosecutors are expected to make cases against the defendants. Another example of such an advocacy system can be found in politics. We hope that the government promotes the public interest. Ministers, however, have specific tasks. The minister of industry, for example, is not expected to defend the environment. He is there to advocate the interest of industry.

Dewatripont and Tirole (1999), henceforth DT, provide an appealing rationale for advocacy systems. They argue that advocacy systems facilitate guiding the behavior of agents who are hired to collect information. The basic idea behind their argument is as follows. Proper decision making often requires information on the pros and cons of policy alternatives. The decision maker hires agents to collect information. Because decisions are easier to verify than information, the decision maker has to motivate agents by offering decision-based rewards. With decision-based rewards, however, it is hard to motivate a single agent to search for both the pros and cons of policy alternatives. The reason is that conflicting pieces of information cancel each other out. From an agent's perspective, having found no information is equivalent to having found two pieces of conflicting information. An advocacy system solves this problem. When one agent collects information on the cons and another agent collects information on the pros, it is relatively easy to provide the two agents incentives to search for information.[1]

This paper extends DT's analysis to stress the importance of a striking feature of advocacy systems. In advocacy systems, information collection is often sequential.[2] A prominent example can be found in politics. Budgetary processes have a clear

[1] DT's analysis can therefore been seen as an information rationale for adversarial legal systems. Shin (1998) and Palumbo (2000) also compare the relative merits of adversarial and inquisitorial legal systems.

[2] In some cases, information collection is sequential by nature. For instance, a prosecuting attorney must have evidence before a case against a suspect can be made anyway, see e.g. Daughety and Reinganum (2000). Our paper focuses on cases in which information collection can in principle take place simultaneously as in DT.

sequential nature. In most European countries, spending ministries first prepare for the submission of their budget proposals. At this early stage of the budgetary process, spending ministries are expected to be advocates of increased appropriations (Von Hagen and Harden, 1994). As advocates, the spending ministries supply information crucial to other agents in the process (Ott, 1993). At a later stage of the budgetary process, the ministry of finance evaluates budget proposals. The ministry of finance is expected to search for arguments for cuts in the budget proposals: it is expected to be an advocate of decreased appropriations.

To provide an explanation for why information collection in advocacy systems is often sequential, we augment the DT model by allowing the different pieces of evidence to be found, and presented, at different moments in time. To capture this feature of information collection processes, we divide the time available for collecting information into two stages. The implication of this extension is twofold. First, since rewards are decision-based, the discovery of evidence in favor of one cause at an early stage affects the incentive of the other agent to continue collecting information at a later stage. Full information collection requires that each agent has an incentive to continue investigating her cause in period 2, when information about the other cause has been found in period 1. We show that this forces the decision maker to leave rents to the agents. Second, the extension enables us to analyze a sequential advocacy system, in which one agent investigates her cause in the first stage, and the other agent investigates her cause in the second stage. We show that a sequential advocacy system reduces the rents agents receive. The reason is that a sequential advocacy system enables the decision maker to offer the agent collecting information in the second stage a decision-based reward scheme conditional on the information found in the first stage. When sufficient time is available, a sequential advocacy system yields full information collection and minimizes the rents left to the agents. It comes, however, at the cost of a more sluggish decision-making process. When time is limited, a sequential advocacy system eliminates rents but comes at the cost of less information collection.

Apart from DT, our paper is related to several other papers. Milgrom and Roberts (1986) identify the conditions under which interested agents supply private information to a principal. They consider a situation where agents cannot manipulate information but can conceal it. They make a distinction between a sophisticated and an unsophisticated principal. A sophisticated principal understands the motives of agents. He makes inferences from concealment of information. By assumption, an unsophisticated principal becomes informed only if he actually receives information. The existence of several interested agents with conflicting preferences increases the likelihood that an unsophisticated principal receives information. Hence the principal benefits from the existence of several interested parties. An important difference between our paper and that by Milgrom and Roberts is that in ours agents have to exert costly effort to get information. A direct implication is that agents only look for information if they want to supply it. Hence, in equilibrium information is never concealed.

The collection of verifiable pieces of information is central in Rotemberg and Saloner (1995). They study the role and origin of conflicts between the production and the sales department of a firm. The firm has to choose between extending existing production and the introduction of an additional product. The two departments disagree: the production department prefers extending production, while the sales department favors the introduction of an additional product. Rotemberg and Saloner show that when the firm is biased towards extending production, the sales department first searches for evidence supporting the introduction of a new product. Only if the sales department delivers evidence, the production department searches for evidence in favor of extending production. The reason for this sequence is saving on search costs. Without evidence in favor of the introduction of a new product, the firm wants to extend production. Initially, the production department thus has no incentive to search for information. In our paper there would also be an obvious reason for sequential information collection if the decision to be made were binary. Then, a decision maker inclined towards the status quo would want to be informed first on the possible pros of a new project before asking an agent to search for the cons. In this way, the decision maker reduces expected search costs.

Finally, there is a large literature on the transmission of information that can be manipulated. Crawford and Sobel (1982) show that communication between a sender and receiver of information improves when their preferences are more congruent. Ottaviani and Sorensen (2001) examine how the order of speech affects the aggregation of information from different experts. They consider a situation where experts have the same preferences but different abilities. As experts care about their reputation, herding problems might occur. Our paper deviates from the cheap-talk literature in that we assume that information cannot be manipulated.

We proceed as follows. Section 2 describes the model. Next, Section 3 presents the optimal wage scheme under simultaneous information collection. Section 4 makes the case for a sequential advocacy system. Section 5 concludes.

2 The Model

In DT, a decision maker makes one of three decisions: A, B and SQ. The decision maker's preferences depend on two independent parameters: $\theta_A \in \{-1, 0\}$ and $\theta_B \in \{0, 1\}$. Each parameter is equal to zero with probability $1 - \alpha$. Under full information, the decision maker would choose decision A when $\theta_A + \theta_B = -1$, decision B when $\theta_A + \theta_B = 1$, and SQ when $\theta_A + \theta_B = 0$.

To learn θ_A and θ_B, the decision maker can hire two agents. Each agent investigates one cause. To investigate a cause ($i = A, B$), each agent must incur unverifiable disutility of effort K. We augment the DT model by splitting the time available for research in two periods ($t = 1, 2$). The costs of investigating in period 1 and period 2 are denoted by K_1 and K_2 , respectively. If $|\theta_i| = 1$ and K_t is incurred, an agent learns nothing in period t with probability $1 - q_t$ and obtains hard evidence that $|\theta_i| = 1$ with probability q_t. If $\theta_i = 0$, an agent cannot learn anything. For simplicity, we assume that $q = q_1 = q_2$. Our assumptions have the following consequences. If K_1 is incurred, an agent finds evidence in period 1 with probability $x = \alpha q$. When an agent has not found evidence in period 1 and K_2 is incurred, he finds evidence in period 2 with probability $\hat{x} = \hat{\alpha} q$, where

$$\hat{\alpha} = \frac{\alpha(1 - q)}{1 - \alpha q} < \alpha. \tag{1}$$

At the end of period 2, the decision maker selects the decision. Like DT, we make the following three assumptions. First, the decision A (B) is optimal if there is evidence that $\theta_A = -1$ ($\theta_B = 1$), but there is no evidence that $\theta_B = 1$ ($\theta_A = -1$). Second, decision SQ is optimal either if $\theta_A = -1$ and $\theta_B = 1$ or if no information has been received. Third, K_1 and K_2 are sufficiently small, so that the benefits of investigating potentially exceed the costs of investigating.[3] These three assumptions ensure that the decision maker wants each agent always to investigate her cause, and that the decision depends on the information supplied by the agents. In addition, to reduce straightforward algebra we assume that $K_1 = K_2 = K$.

As in DT, the agents' effort and pieces of evidence are unverifiable. As a consequence, the organization has to rely on decision-contingent rewards. Even though pieces of evidence are unverifiable, they are observable. Agents cannot forge or conceal information. Agents are risk neutral and rewards are non-negative. Agent i, in charge with cause i, receives w_I^i, if the decision maker selects $I \in \{A, B, SQ\}$.

3 The Optimal Wage Scheme

In DT, an advocacy system generates full information collection without abandoning rents to the agents. This section shows that when information may become available at different times full information collection implies that rents are abandoned to agents.

We focus on one contract for two periods which is set at the beginning of period 1. We can show that offering a contract in period 2 conditional on the evidence found in period 1 is not optimal. Then both agents would have an incentive to postpone exerting effort to the second period.[4]

We first argue that in the augmented model, full information collection requires that the contract must reward the agents when the decision maker selects status quo. Suppose that in period 1, both agents have investigated their cause and that agent i has found evidence in favor of cause i, while agent j has not found evidence in favor of cause j. In this case, the decision maker chooses either status quo or decision i. Full information collection requires that agent j prefers investigating to

[3]The first assumption requires that $(1-\breve{\alpha})\, L_I - \breve{\alpha} L_E > 0$, where $\breve{\alpha}$ is the posterior probability that $|\theta_i| = 1$ after two periods of searching, L_I is the cost of choosing status quo when either A or B is the efficient choice (*inertia*), and L_E is the cost of choosing one of the causes when status quo is the efficient choice (*extremism*). The second assumption implies that $[1 - 2\breve{\alpha}(1-\breve{\alpha})]\, L_E + \breve{\alpha}(1-\breve{\alpha})(L_M - 2L_I) > 0$, where L_M is the cost of choosing cause A when cause B is the efficient choice or vice versa (*misguided activism*). This condition is satisfied if $L_M > 2L_I$. The third condition requires that the total cost of information collection (which depends upon the incentive scheme chosen) do not exceed the benefits of information. With full information collection, these benefits are: $2L_I\,[\alpha(1-\alpha) - \alpha(1-q)(1-q)(1-x)(1-\hat{x})(1-\breve{\alpha})] - x\alpha(1-q)(1-q)2L_E(2-q)$.

[4]The formal proof is provided in Appendix 1, see also footnote 6.

not investigating in period 2. The incentive constraint is:

$$\hat{x} w_{SQ}^{j} + (1 - \hat{x}) w_{I}^{j} - K \geq w_{I}^{j}. \tag{2}$$

Clearly, as in DT, it is optimal for the decision maker to set $w_I^j = 0$.[5] Equation (2), therefore, reduces to:

$$w_{SQ}^{j} = \frac{K}{\hat{x}}. \tag{3}$$

Equation (3) implies that full investigation requires that the decision maker must reward the agents when he selects status quo. The reason is obvious. Once evidence has been found in favor of cause i, the decision moves away from decision j. Consequently, if agent j were not rewarded for SQ and agent i has found evidence in period 1, she would not have any incentive to investigate her cause in period 2.[6]

Let us now determine the lowest rewards that induce agent j to exert effort in period 2, when neither agent has found evidence in period 1 and both agents have exerted effort in period 1. Let β denote the probability that agent i chooses investigating in period 2. When agent j chooses investigating, her expected utility is:

$$\begin{aligned} &\left[\beta \hat{x}^2 + \beta(1-\hat{x})^2 + (1-\beta)(1-\hat{x})\right] w_{SQ}^{j} + \left[\beta \hat{x}(1-\hat{x}) + (1-\beta)\hat{x}\right] w_{J}^{j} - K \\ &= \left[1 - \beta\hat{x} + 2\beta\hat{x}^2 - \hat{x}\right] w_{SQ}^{j} + \hat{x}(1-\beta\hat{x}) w_{J}^{j} - K. \end{aligned} \tag{4}$$

When agent j chooses not investigating her expected utility is:

$$\left[(1-\beta) + \beta(1-\hat{x})\right] w_{SQ}^{j} = (1 - \beta\hat{x}) w_{SQ}^{j}. \tag{5}$$

From (3), (4) and (5), it directly follows that the cost-minimizing reward scheme

[5] The nonliability constraint excludes $w_I^j < 0$.

[6] The decision maker could offer a new contract at the beginning of the second period when one of the agents has found a piece of evidence in the first period. However, if agents cannot conceal information, the opportunity to offer a new contract induces agents to postpone investigating to the second period. See Appendix 1. Introducing a third agent would resolve this. Then, in period 1 the decision maker induces two agents to search after contrary goals without rewarding the status quo. If one piece of evidence is found in period 1, a contract rewarding the status quo is offered to a third agent, which yields full information collection. With dynamic increasing returns to effort, however, it may be optimal to use two agents rather than three agents.

that induces agent j to investigate her cause in period 2 is given by (3) and:

$$w_J^j = 2\frac{K}{\hat{x}}. \tag{6}$$

Because the model is symmetric, an analogous reward scheme applies to agent i.

We have derived the rewards that induce the agents to exert effort in period 2, given that both agents have exerted effort in period 1. It is straightforward to verify that (3) and (6) also induce both agents to investigate their cause in period 1. The reason is that the cost of investigating are the same in period 1 and 2 ($K_1 = K_2$), while the expected benefits of investigating are smaller in period 2 than in period 1 ($\hat{\alpha}q = \hat{x} < x = \alpha q$).[7]

We can now calculate the rents each agent enjoys. Straightforward algebra shows that each agent enjoys rents:

$$U^j = \frac{1-\hat{x}}{\hat{x}}K - (1-x)K = \left[(x-\hat{x}) + (1-x)(1-\hat{x})\right]\frac{K}{\hat{x}} > 0. \tag{7}$$

The cost-minimizing wage scheme abandons rents to the agents for two reasons. The first reason is that agents must be rewarded for the status quo to induce them to continue investigating their cause in the second period when one of the agents has found evidence in the first period. Rewarding the status quo, however, introduces the possibility of receiving a reward without exerting any effort. Hence, to induce agents to exert effort, rents must be left. The second reason for leaving rents to the agents is a declining probability of finding evidence over time. To induce an agent to continue searching for two periods requires that rewards are based on the posterior probability of finding evidence in period 2, which is lower than the prior probability. Consequently, the rewards overcompensate for the cost of searching if evidence is already found in the first period.

With two periods available for searching, an advocacy system abandons rents to the agents also if agents can only provide information at the end of period 2 (so that the first reason is not valid anymore). Then, analogous to DT, the decision maker sets $w_{SQ}^i = w_I^j = 0$ ($i \neq j$) and $w_I^i = K/\left[\hat{x}(1-x)(1-\hat{x})\right]$. Each agent then enjoys

[7] The optimal contract given by (3) and (6) does not change if rewards are allowed to be contingent on delay in decision-making. The formal proof is provided in Appendix 2.

rents:

$$U^j = (x - \hat{x})\frac{K}{\hat{x}} > 0. \tag{8}$$

The difference between (7) and (8), which equals $(1-x)(1-\hat{x})\frac{K}{\hat{x}}$, gives the rents that arise because agents must be induced to continue investigating when information about one cause has become available.

4 The Case for Sequential Information Collection

In this Section we extend the model of Section 3 by allowing for the possibility that the agents search for evidence in favor of their cause sequentially. For example, a spending ministry first tries to find arguments for a higher budget. Subsequently, the finance ministry searches for arguments for cuts in the budget proposed by the spending minister. Finally, the Prime Minister (or the council of ministers) makes the final budget decision.

Specifically, we assume that agent a investigates in period 1 and that agent b investigates in period 2. We maintain the assumption of decision-based rewards. However, the sequential setting enables the policy maker to condition agent b's rewards on the evidence found by agent a. As we will see below, the implication is that for agent b the difference between decision-based rewards and information-based rewards vanishes.

Let us first determine the cost-minimizing wage scheme for agent b. Two cases have to be distinguished: (1) agent a has found evidence in favor of his case in period 1, and (2) agent a has not found evidence. In the former case, the decision moves away from B. In the latter case, the decision moves away from A. The organization can induce agent b to investigate by setting $w^b_{SQ} = K/x$ and $w^b_A = 0$ when agent a has found evidence in favor of his cause. It sets $w^b_B = K/x$ and $w^b_{SQ} = 0$ when agent a has not found evidence. These wage schemes induce agent b to exert effort, without leaving rents.

In period 1, agent a prefers investigating to not investigating if:

$$\left[x^2 + (1-x)^2\right] w^a_{SQ} + x(1-x)w^a_A + x(1-x)w^a_B - K \geq (1-x)w^a_{SQ} + xw^a_B \tag{9}$$

The left-hand side of (9) gives agent a's expected reward when he chooses investigating. The right-hand side gives the expected reward when he chooses not investigating. The cost-minimizing wage scheme that satisfies (9) is $w_B^a = w_{SQ}^a = 0$ and $w_A^a = K/[x(1-x)]$. It is easy to show that this wage scheme fully extracts agent a's rents.

A comparison between the advocacy system of Section 3 and the sequential advocacy system shows that the former leaves rents to the agents, while the latter does not. However, by nature, a sequential advocacy system does not induce full investigation as each cause is investigated for only one period. When time is available, extending the search period easily solves this problem. For example, we can allow agent a to search for information in period 1 and 2 and agent b to search for information in period 3 and 4. As in Section 3, full information collection then requires that the rewards to the agents depend on the posterior probabilities of finding evidence rather than on the prior probabilities. Consequently, rents are left to the agents.[8] These rents are smaller than in Section 3, because rewards can be set conditional upon the information found in earlier stages. The difference between (7) and (8) gives the benefit of an extended sequential advocacy system relative to the advocacy system of Section 3.

5 Conclusions

In this paper, we have provided a rationale for the sequential nature of information collection in advocacy systems. Information about different causes may become available at different times. When information collection takes place simultaneously by different agents, the detection of evidence favoring a particular cause by one agent affects the incentive of the other agent to continue collecting information in favor of her cause. Full information collection then requires that rents are left to the agents. A sequential advocacy system enables the decision maker to design a reward scheme which fits with the information already found in earlier stages of the information collection process by the other agent. This implies that a smaller

[8] It is worth noting that these rents also arise if rewards are directly based on the information provided rather than on the decision. As above, rewards based on the moment of finding information are not optimal as agents may either conceal information or postpone searching until the last period.

amount of rents needs to be abandoned to the information-collecting agents. A sequential advocacy system is, therefore, cheaper than an advocacy system with simultaneous information collection. However, it comes at the cost of either a more sluggish decision-making process or less information collection. The choice between a simultaneous and a sequential advocacy system thus ultimately entails a trade off between the cost of information collection on the one hand, and the quality and/or quick availability of information on the other hand.

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Appendix 1

In Section 3, we have focussed on one contract for two periods which is set at the beginning of period 1. We have shown that the status quo must be rewarded and hence rents are left to the agents. Offering a second contract in period 2 conditional on the evidence found in period 1 seems a natural way to avoid leaving these rents. In this Appendix we show that the possibility of a second contract induces agents to postpone effort.

First we derive the contract offered in period 2 if only one piece of evidence is found in period 1.[9] Recall from Section 3 that to induce agent j to continue searching, the decision maker sets $w_I^j = 0$ and:

$$w_{SQ}^j = \frac{K}{\hat{x}} \tag{A1}$$

Let us now derive the contract offered to both agents at the beginning of period 1. Note that this contract applies for both periods in case no evidence is found in period 1. We start with the second period. Suppose no evidence has been found in period 1. To induce agent j to continue searching in period 2, the following incentive constraint should hold:

$$\begin{aligned} & \beta\left[\hat{x}(1-\hat{x})w_J^j + (1-\hat{x})\hat{x}w_I^j + \hat{x}\hat{x}w_{SQ}^j + (1-\hat{x})(1-\hat{x})w_{SQ}^j\right] \\ & +(1-\beta)\left[\hat{x}w_J^j + (1-\hat{x})w_{SQ}^j\right] - K \\ \geq\; & \beta\left[\hat{x}w_I^j + (1-\hat{x})w_{SQ}^j\right] + (1-\beta)w_{SQ}^j \end{aligned} \tag{A2}$$

where β denotes the probability that agent i chooses investigating in period 2. Clearly, it is optimal for the decision maker to set $w_I^j = w_{SQ}^j = 0$. Hence, (A2) reduces to:

$$w_J^j = \frac{K}{\hat{x}(1-\hat{x})} \tag{A3}$$

Is the reward as stated in (A3) sufficient to induce agent j to start searching at the beginning of period 1? The total expected benefits for agent j of searching in both

[9] If two pieces of evidence are found, there is no reason for offering a second contract. If no information is found, the initial contract is sufficient.

period 1 and 2 are:

$$\gamma\left[x(1-x)(1-\hat{x})w_J^j+(1-x)x\hat{x}w_{SQ}^j+(1-x)(1-x)\hat{x}(1-\hat{x})w_J^j\right]$$
$$+(1-\gamma)\left[x(1-x)w_J^j+(1-x)\hat{x}(1-x)w_J^j\right]-K-(1-x)K \quad \text{(A4)}$$

where w_{SQ}^j and w_J^j are defined by equation (A1) and (A3), respectively and γ denotes the probability that agent i chooses investigating in period 1. The total expected benefits for agent j of searching only in period 2 are:

$$\gamma\left[xxw_{SQ}^j+(1-x)(1-\hat{x})xw_J^j\right]+(1-\gamma)x(1-x)w_J^j-K \quad \text{(A5)}$$

After some straightforward algebra it follows from (A4) and (A5) that agent j has an incentive to postpone exerting effort to the second period if:

$$\gamma\left(\frac{x^2}{\hat{x}}\right)K>(1-\gamma)(1-x)\left[\frac{\hat{x}-x}{1-\hat{x}}\right]K \quad \text{(A6)}$$

Using $\hat{x}<x$, it is easy to see that this condition always holds. Hence, both agents have an incentive to search only in the second period.

Appendix 2

In this Appendix we show that when we allow for the possibility that rewards are contingent on delay in decision-making, the optimal contract as stated in Section 3 does not alter.

Recall that the optimal contract with simultaneous advocacy is described by $w^j_{SQ} = \frac{K}{\hat{x}}$, $w^j_J = 2\frac{K}{\hat{x}}$ and $w^j_I = 0$. To induce an agent who has not found evidence in the first period to continue searching in the second period we must have $w^{j,2}_{SQ} = \frac{K}{\hat{x}}$ as in Section 3 (the additional superscript refers to the moment of decision-making). Moreover, when rewards are contingent on delay, it is still optimal to choose $w^j_J = 2\frac{K}{\hat{x}}$ as cause J is never chosen after one period of searching. Let us now derive $w^{j,1}_{SQ}$. The expected benefits of searching in both period 1 and 2 for agent j are:

$$\gamma \left\{ \begin{array}{c} xxw^{j,1}_{SQ} + x(1-x)(1-\hat{x})w^j_J + x(1-x)\hat{x}w^{j,2}_{SQ} + +(1-x)x\hat{x}w^{j,2}_{SQ} \\ +(1-x)(1-x)\left[\hat{x}\hat{x}w^{j,2}_{SQ} + (1-\hat{x})(1-\hat{x})w^{j,2}_{SQ} + \hat{x}(1-\hat{x})w^j_J\right] \end{array} \right\} \quad \text{(A7)}$$
$$+(1-\gamma)\left[\begin{array}{c} xxw^{j,2}_{SQ} + x(1-x)w^j_J + (1-x)\hat{x}(1-x)w^j_J \\ +(1-x)(1-\hat{x})(1-x)w^{j,2}_{SQ} + (1-x)\hat{x}xw^{j,2}_{SQ} \end{array} \right] - K - (1-x)K$$

where γ denotes the probability that agent i chooses investigating in period 1 and the rewards $w^{j,2}_{SQ}$ and w^j_J are defined above. The expected benefits of searching only in period 2 are:

$$\gamma\left[xxw^{j,2}_{SQ} + (1-x)(1-\hat{x})xw^j_J + (1-x)(1-\hat{x})(1-x)w^{j,2}_{SQ} + (1-x)\hat{x}xw^{j,2}_{SQ}\right]$$
$$+(1-\gamma)\left[xxw^{j,2}_{SQ} + (1-x)xw^j_J + (1-x)(1-x)w^{j,2}_{SQ}\right] - K \quad \text{(A8)}$$

After some straightforward algebra, it follows that to induce agent j to search in both periods the following should hold:

$$\gamma xx\left(w^{j,1}_{SQ} - w^{j,2}_{SQ}\right) \geq 0 \quad \text{(A9)}$$

Clearly, costs are minimized by setting $w^{j,1}_{SQ} = w^{j,2}_{SQ} = \frac{K}{\hat{x}}$.