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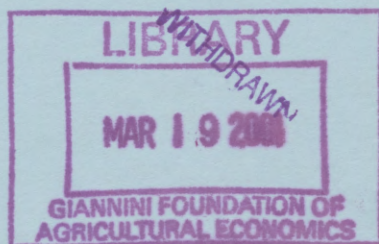
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THE UNDERLINING GAME

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THE UNDERLINING GAME

by

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Abstract

Academic institutions may go beyond observing lexicographic ordering of authors in attempting to determine relative contributions to joint research. The present article examines incentive issues arising when applicants for promotion are requested to underline the name of any principal author(s). This mechanism is not generally incentive compatible. Recognizing the generally sequential nature of contribution reporting, a scheme which induces global truthful revelation is developed. Punishment is imposed on prior movers making claims of authorship seniority which are contradicted by subsequent movers. Where applications are simultaneous, contradicted claims of seniority lead to group punishment in that no author is promoted.

JEL classification: C720, D820

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I wish to underline the importance of the helpful suggestions made by Jeremy Clark and Paul Walker (in lexicographic order) in the preparation of this article without attaching the blame that accompanies co-authorship.

December 2000

1. Introduction

Given that the number of applications for promotion in academic institutions in a given year appears to systematically exceed the number of successful applicants, it would appear that salary and academic status are close to the heart of many academics. Particularly in universities, research performance is frequently an important criterion in determining the success or failure of a given application. Promotion encourages those who contribute more rather than less in terms of quantity and quality of published research. Quantity is relatively easily verifiable. Quality may also be able to be monitored at relatively low cost by using the services of qualified disinterested outside agents. This process, however, cannot easily be extended to determining the respective contributions of the joint authors of a particular article, say, whichever journal publishes the article.

In the absence of mechanisms which require academic staff to reveal their relative contributions to joint research outputs, how are contributions assessed? According to McAfee and McMillan (1991, p. 571), equal credit is usually assigned to each author of a co-authored paper, and this assignment rule is not optimal from the perspective of the employer. Authors, however, have an opportunity to voluntarily signal relative contributions via authorship ordering on title pages. Engers et al. (1999) suggest that as far as articles in economics are concerned, there is an overwhelming tendency for the ordering to be lexicographic rather than on the basis of relative contributions. This pattern is also discernible if less emphatic among a number of other social science fields, but is less common in physical and medical sciences.¹ As a signal, alphabetical ordering is mixed, since the prominence of Dr Aaron Aardvark, say, in an article

¹ See Engers et al. (1999) and Zuckerman (1968) for evidence on this issue.

written in conjunction with Dr Zena Zigo, may be due either to luck (or design) or to Dr Aardvark's superior contribution. While it may be thought that Dr Aardvark is fortunate in lexicographic primacy, it is not so since employers must discount Dr Aardvark's primacy as possibly arising from chance rather than superior productivity, whereas a paper authored by Zigo and Aardvark presumably sends a deliberate message signalling the superior contribution of Dr Zigo.² Engers et. al. examine conditions under which either ordering rule might constitute an equilibrium in a cooperative Nash bargaining context. They show that relative contribution ordering cannot be an equilibrium, partly because this rule signals strongly who is the main contributor and a Nash-bargained surplus yields a more even distribution of rewards than would a market allocation. A lexicographic ordering, however, can be an equilibrium and, under some circumstances, may be the only one. Since name reversals penalize authors whose names occur early in the alphabet and these authors are undercompensated by their primacy in a lexicographic ordering, an equilibrium may well involve authors sending murky signals even though the effect is to induce a lower quality of research where employers place a high weight on the likelihood of lexicographic ordering compared to relative contribution ordering.³

If lexicographic orderings produce mixed signals, organisations may respond by imposing requirements that attempt to raise the signal to noise ratio. For example, Spiegel and Keith-Spiegel (1970) found that attitudes among psychologists were largely consistent with those laid down in the *Ethical Standards of Psychologists* of the American Psychological Association

² Of course, this could also be a mixed signal, arising from a convention involving "ladies first". This particular convention, however, does not appear to apply in academic authorship.

³ Engers et al. (1999) argue that less effort will be applied since individual effort spillovers on to the payoffs of other authors will not be accounted for under lexicographic orderings.

(1970) whereby the major contributing author is required to be first listed and credit is to be assigned only to those who have contributed to the publication, in proportion to their contribution.⁴ On the other hand, Over and Smallman (1970) reported that for some journals, alphabetical ordering is a requirement for publication. Employing organisations, however, if not insisting on a uniform ordering practice, may go beyond observing ordering of authors on publications in attempting to determine relative contributions. The present article examines some of the incentive issues created by one such attempt at the University of Canterbury in New Zealand.

In an attempt to obtain otherwise private information on the relative contributions to co-authored research for purposes of assessing applications for either promotion or study leave, the University of Canterbury adopted a policy in 1997 whereby applicants are requested to provide additional information concerning their published research. Where published research bears the name of more than one author, the standard application forms request applicants to "underline the name of any principal author(s)". If no author is underlined, applicants are advised that "it will be assumed that all authors contribute equally to the publication".⁵ A major incentive problem arises because this mechanism is not incentive compatible in the sense that it is generally not the case that a self-interested applicant will send truthful messages to an employer concerning their research contributions.⁶ It is possible in some circumstances, however, to devise incentive compatible revelation schemes which induce truthful revelation by co-authors regarding

⁴ In the 1999 *Calendar* of the University of Canterbury, 80 percent of the Department of Psychology's listed publications were jointly authored, but only 28 percent of these exhibited alphabetical ordering of authors.

⁵ See <http://regyweb.canterbury.ac.nz/section/doc/staff/leave.doc>, p. 2, condition C and Application form99 academic promotions.doc (June 1999), p. 3, condition C.

⁶ As a disclaimer, the reader should note that I make no allegations of untruthful revelations by any of my colleagues at the University of Canterbury.

authorship seniority.

The essence of the problem is that joint research involves team production where the employer (the principal) is unable to observe the efforts of individual team members (the agents) except at prohibitive cost. Consequently, the employer may face excess claims of credit for joint production. This is a generic problem of moral hazard in teams, addressed by Holmstrom (1982). There, the principal could only observe the group's output, and individual team members had an incentive to shirk and free ride on the efforts of their colleagues. The problem is resolved in this context by the principal sharing the value of output among the team members such that each member's share exceeds their respective costs of input supply if output is no smaller than some target level, otherwise the entire group is penalized in that all agents receives a zero payoff.

Group penalties have received considerable attention in related problems. For example, Meran and Schwalbe (1987) demonstrated that either pollution emission standards or efficient effluent tax policies can be implemented as a Nash equilibrium even where firms' individual effluent discharges are unobservable. Collective penalties which are independent of the discharges of individual firms inflict punishment on all firms if total discharges exceed a given standard. Alternatively, all firms face a penalty which drives each firm's profits to zero if observed aggregate emissions exceed the sum of reported emissions under an emission tax system where firms are taxed on the basis of their reported emissions, and where an incentive to under-report is otherwise evident.⁷ Group penalties have also been suggested by Shavell (1985, 1987) for

⁷ A related approach is the two-stage *compensation mechanism* of Varian (1994), where individual firms are required to pay taxes based on the marginal social costs of the externalities they generate as reported by the remaining affected firms, and where affected firms receive compensation on the basis of the externalities reported by their producers. Varian also applies his compensation mechanism to the provision of pure public goods, the problem of inducing a monopolist to produce the socially optimal output level, the regulation of duopoly, and inducing co-operation in Prisoner's Dilemma games.

resolving incentive problems in the economic analysis of torts involving uncertainty of causation. In such cases, the courts cannot determine with certainty which of a group of potential tortfeasors (including Nature as a potential contributing 'party') is at fault. A group penalty whereby each potential injurer is liable to fully compensate the victim induces each potential injurer to take due care in order to avoid liability, whereas a rule which involves liability-sharing would dilute the incentive of each to take due care. While potential injurers are penalized for injuries they may not have caused (emphasizing the apparently harsh nature of group penalties), the critical point is that penalties are not required to be enforced in equilibrium, since they optimally induce the behaviour required to prevent the necessity of their enforcement.

In the present article, group penalties will be adopted in a modified sense, although it is evident they could be applied more generally. Unlike the typical contributions to the literature on group incentives, I emphasize the generally sequential nature of contribution reporting, concluding that punishment should be imposed on prior movers making claims of authorship seniority which are not supported by subsequent movers but which lead to their promotion. The group is punished in such situations since a prior claim of seniority effectively removes the promotion prospects for subsequent applicants. Where applications for promotion are simultaneous, contradicted claims of seniority lead to group punishment in that no author will receive promotion.

Organisation is as follows. Section 2 examines incentive problems in a basic version of what seems natural to call the *underlining game* where only two co-authors are present. Section 3 proposes a method of inducing truthful revelation when applications are sequential and the parties are in agreement as to who is the true principal co-author. Section 4 discusses the issue of mechanism design when applications are simultaneous. Section 5 considers mechanism design when the parties agree that no principal author exists, while the possibility of bargained solutions are discussed in Section 6. Section 7 discusses some implications of further relaxation of the

assumptions, and recommendations and concluding remarks are contained in Section 8.

2. The Underlining Game

Consider an article involving two co-authors employed by the same organization and that seniority is not in dispute.⁸ If applicants always made truthful disclosures, applicants would underline their name only when they are the true senior author, or else they would underline the name of the true senior author (ie, their co-author), or else they would fail to underline either name when authors truly make equal contributions. Promotion prospects would be enhanced for truly senior authors in that higher (expected) payoffs would be associated with higher reported (and true) contributions to output, which is presumably the organization's objective. The question is whether or not applicants will report truthful messages. If costs of verification are zero, applicants could do no better than reveal truthfully, since untruthful disclosures would always be discovered. It is likely that some form of penalty would be attached to a verified untruthful disclosure, and since detection is certain, there is no compensating positive expected return to falsehood. Verification costs, however, are likely to be prohibitive, and are so assumed in what follows.

For simplicity, consider applicants for promotion who are certain they will receive promotion by their university if identified as the senior author of a particular piece of work, and

⁸ I follow Engers et. al. (1999) in assuming that individual effort cannot be detected by an inspection of the joint article but that the two authors can identify their relative contributions. This contrasts with approaches in the literature dealing with self-reporting requirements whereby false reports can be detected by costly auditing; see, for example, Alm et al. (1992), Malik (1993), Kaplow and Shavell (1994), and Livernois and McKenna (1999).

who are equally certain that they will not be promoted if not identified as senior author.⁹ Further, suppose that they assume (correctly) that their co-author is not also applying for promotion at the same time. There is a strong incentive for a junior author to claim to be a senior author if there is a significant prospect that such a claim will be accepted.

Should the university accept claims of seniority in such circumstances? If it were confident that its employees always revealed the truth, claims should always be accepted. But if employees do not always reveal the truth, the university will soon face a set of inconsistent claims whereby, over time, more than one author will claim seniority. While such claims may result from genuine mistake, the university is likely to become suspicious if inconsistent claims are frequent rather than isolated. Genuine mistakes might only result when the contributions of each author are approximately equal, but many articles may be co-authored by minor contributors. The university, while seeking to separate on the basis of merit rather than merely pool the applicants, cannot confidently separate applicants on the basis of their disclosures alone.

One possibility would be to inquire of a co-author whether an applicant's disclosure is truthful. For example, if A and B are co-authors, and A identifies him/herself as senior author, the university might inquire of B whether B agrees with this assessment. Since B is also an employee of the university, and if B never intends to apply for promotion (or for employment elsewhere), and B is the true junior author, B may as well reveal that fact. But if B intends to apply for promotion in the future, in the absence of a strong aversion to lying, B's best response is the denial of A's claim whether or not A's claim is truthful. If A has lied, B cannot gain by lying, ie, verifying that A has told the truth when A has actually lied, since a future claim of

⁹ More generally, a higher expected payoff for being identified as a principal author of a given article, and a lower expected payoff for being identified as junior contributor, could be assumed without appearing to alter the problem in any fundamental sense.

authorship seniority by B would not be believed even though it is at that later juncture a true claim. If A has told the truth, however, B's future prospects are diminished by telling the truth, so B will falsely claim to be senior author. Thus, B will fail to support A's claim whether or not A's claim is valid. 'Failure to support A' is a dominant strategy for B independently of the validity of A's claim. In spite of the fact that both A and B know the truth of their respective claims, their representations have no useful informational content in the circumstances. The university may as well suppose that the contributions of the authors are equal and pool the authors. This may mean providing promotion to both or neither but not to the 'deserving' party alone. In terms of mechanism design, the university may as well have saved time and ink by not requesting disclosure.¹⁰

To formalise in a one-shot game context, suppose that the true senior author ("TS") is first mover while the true junior author ("TJ") is second mover (ie, applies for promotion at a later date). TS is constrained to a feasible strategy triple $\{\underline{TS}, \underline{TJ}, \overline{TS}\}$, where \underline{TS} means that TS (truthfully) underlines his/her own name as senior author, \underline{TJ} means that TS underlines TJ's name as senior author, and where \overline{TS} means that TS does not identify either author as having seniority.¹¹ Further, suppose that TJ can either observe or correctly infer the message sent by TS, either because TJ is a member of the relevant department's internal assessment committee (or is advised by a committee member), or because the outcome of the message sent by TS (eg, a successful rather than a failed application) sends a unique signal which effectively identifies the contents of

¹⁰ If authors believe that employers will give credence to claims of seniority, such claims will be made voluntarily without any employer requirement to identify senior authors.

¹¹ The strategy \underline{TS} & \underline{TJ} is ruled out. Hopefully, the statutory requirement of being a "good employer" under s 77A of the State Sector Act 1988 does not require a university to consider promoting somebody who claims that there are two principal authors of a paper with two authors! Such inconsistency might 'be brought to the applicant's attention'.

the message.¹²

Regarding payoffs, I assume that if TS is promoted, TS receives a payoff net of effort costs $\alpha_s > 0$, while if TS is not promoted, TS receives a net payoff $\varphi_s < 0$. If TJ is promoted, TJ receives a net payoff $\alpha_j > 0$. If effort cost functions are similar across authors, it is reasonable to suppose that $\alpha_j > \alpha_s$.¹³ If TJ is not promoted, however, TJ receives a net payoff of zero.¹⁴ Further, it is assumed that any applicant reporting truthfully when truthful revelation fails to advance their material self-interest receives $\epsilon > 0$, otherwise truthful revelation *per se* yields nothing. Also, untruthful revelation which serves an applicant's material self-interest yields a payoff $\delta < 0$, otherwise lying *per se* yields nothing.¹⁵ It is assumed that the university's interests are served by the promotion of the senior author (as a reward for effort and to maintain incentives for additional future effort by prospective senior authors) but not by the promotion of the junior

¹² Thus, the resulting game involves complete information. It would clearly be interesting to extend the present analysis to cases involving incomplete information.

¹³ A more general approach would clearly treat the effort decision as endogenous. Strictly, the present analysis is probably more appropriate where the university unexpectedly introduces an authorship seniority reporting requirement, given that effort decisions have been made under a different set of incentives.

¹⁴ TJ must receive at least a zero net payoff in order to participate in research, but the assumption of a zero net payoff is effectively a simplifying normalization.

¹⁵ Thus, it is assumed that applicants may suffer some disutility from guilt if they lie to advance their own cause, but will not act maliciously or lie at random, while if the truth advances the cause of a co-author, they are assumed to be no worse off on account of their actions. These assumptions are necessary to allow the possibility that free riding by junior authors on senior authors will not (always) occur, consistent with the evidence from the experimental literature on public goods where general free riding is reported not to occur; see the survey in Ledyard (1995). General free riding, however, is often reported to be approached (if not reached) in studies which replicate one-shot experimental sessions, although Cadsby and Maynes (1999) recently find that in experiments with threshold public goods, convergence of contributions to the threshold occur if rewards are sufficiently large. In an experimental context involving group incentive programmes, however, Nalbantian and Schotter (1999) report that a shirking equilibrium is approached towards the end of their experiment when incentive plans provide strong incentives to shirk.

author (whom we assume receives rewards in another manner, say an annual salary increment or at least no decrement). The university, however, is assumed to prefer that both be promoted rather than neither being promoted when a senior author exists, although respective net payoffs are negative in each case. If no senior author exists, the university receives a positive net payoff only if neither co-author is promoted, and would prefer that only one be promoted to both being promoted in these circumstances. Finally, it is assumed that the differential net payoff to the university from promoting a true senior author rather than both co-authors exceeds the net payoff to the junior author less that author's losses resulting from lying. The university's net payoffs are as follows:

β_1 if TS exists and TS is promoted whereas TJ is not promoted.

β_2 if TS exists and both TS and TJ are promoted.

β_3 if TS exists and neither TS nor TJ are promoted.

β_4 if TS exists and TS is not promoted whereas TJ is promoted.

β_5 if TS does not exist and neither co-author is promoted.

β_6 if TS does not exist and one or other co-author is promoted.

β_7 if TS does not exist and both co-authors are promoted.

The following restrictions are imposed:

$$\beta_1 > 0 > \beta_2 > \beta_3 > \beta_4.$$

$$\beta_5 > 0 > \beta_6 > \beta_7.$$

$$\beta_1 - \beta_2 > \alpha_j - (\epsilon - \delta).$$

Consider in turn the resulting extensive form game tree illustrating the university's 'naive' revelation mechanism, where the true senior's direct payoffs precede those of the true junior, followed by the payoffs to the university. Figure 1 illustrates the case where TS is first mover, and Figure 2 illustrates the case where TJ is first mover.

FIGURES 1 & 2 ABOUT HERE

Suppose TS is first mover. Independently of the choice of strategy by TS, TJ's best response is the truthful message TS if $\alpha_j + \delta \leq \epsilon$, otherwise TJ reports the untruthful message TJ. While a dominant strategy exists for TJ, which of TS or TJ will be reported is parameter-dependant. Absent a passion for the truth or severe feelings of guilt from lying so that $\delta, \epsilon \approx 0$, it will be in the junior author's self-interest to claim senior authorship in order to gain promotion.¹⁶ Note that TJ's promotion does not come at the expense of TS. Thus, if TS reports truthfully, TS is promoted as a result. Should TS falsely claim either that TJ is the senior author, or else deny the existence of a senior author, TS will not be promoted. TJ, however, will be promoted by reporting TJ, but not by reporting either TS or T \bar{S} . Under no circumstance will TJ claim that neither author is senior, since this falsehood yields a payoff of zero to TJ. Although TJ has misrepresented, TJ does not gain anything thereby, and must do better either to tell the truth and receive ϵ (if $\alpha_j + \delta \leq \epsilon$) or to lie in one's self interest and receive $\alpha_j + \delta$ (if $\alpha_j + \delta > \epsilon$). If TJ's dominant strategy is to report truthfully, TS will also report truthfully in order to receive α_s from promotion. Alternatively, if TJ reports TJ, TS will again report truthfully. Thus, independently of whether TJ will subsequently support a truthful claim by TS or not, a dominant strategy for TS is to claim senior authorship. The equilibrium of this game is either a sequence of reports {TS, TS} by TS and TJ, respectively, or a sequence {TS, TJ} by the two co-authors. The parameters α_s, δ , and ϵ will determine which of these two equilibria will emerge, while the magnitude of the payoffs α_s and ϕ_s to TS, and any of the payoffs to the university, are immaterial to this result.

The university is not indifferent between the competing equilibria given that TS reports truthfully. If TJ reports truthfully, the university's payoff is β_1 , whereas if it pays TJ to lie, the

¹⁶ I follow the usual convention of assuming that agents will report truthfully if they are indifferent between the outcomes produced by truth and falsehood.

university's payoff is β_2 ($0 < \beta_1$). Further, the social payoff is maximized by choice of the strategy pair $\{\underline{TS}, \underline{TS}\}$ since the social payoff is $\alpha_s + \varepsilon + \beta_1$ which exceeds the social payoff $\alpha_s + \alpha_j + \delta + \beta_2$ when the strategy pair $\{\underline{TS}, \underline{TJ}\}$ is chosen. For the latter, society loses the benefits of truth-telling *per se*, and suffers the costs of lying *per se*, while the monetary gains to inappropriately promoting TJ fail to compensate for the direct costs of promotion plus the costs in terms of diluted incentives for future joint research. The greater net payoff to being junior (as opposed to senior) yet both receiving promotion leads to a scramble to be the junior author, and both the quantity and quality of output is expected to suffer thereby. Unequal effort, however, may be a socially efficient allocation among the parties.

Turning to the case where TJ is first mover, it is clear that whatever TJ elects to report, a truthful report of \underline{TS} by TS yields a payoff of α_s to TS rather than the lower (negative) payoff of φ_s which occurs when TS fails to make a valid claim of seniority. Truth-telling is again a dominant strategy by TS. Knowing this, the first-moving TJ will report \underline{TS} if $\alpha_j + \delta \leq \varepsilon$, and \underline{TJ} if $\alpha_j + \delta > \varepsilon$. The two equilibria, and the conditions under which one or other will occur, is identical to the case where TS is first-mover. Again, only the full truth-telling equilibrium is socially optimal.

Although the university's reporting mechanism can produce efficient equilibria such that only a true senior author receives promotion, such an outcome is not the only possibility. Further, the efficient outcome relies on truthful reporting by individuals who have strong incentives to do otherwise. While truthful reporting in these circumstances may occur, it is unlikely that truthful reporting can be relied upon in all circumstances. Even if academic staff all look like a George Washington, regrettably, some of them may be a well-disguised Pinocchio with a capacity to check the growth of one's nose. Consequently, attention turns to a search for mechanisms which are incentive compatible in that they induce truthful revelation in all circumstances.

3. An Incentive Compatible Revelation Mechanism

The naive mechanism described above can induce persons who have no strong aversion to lying and who would actually prefer to tell the truth, to lie in their self interest. Since an author may sometimes be senior and sometimes junior, lying is not a general best response, so such persons will not be habitual liars in that they will tell the truth when there is either a small or zero payoff to lying. To achieve global truth-telling, however, the revelation mechanism must be modified so that junior authors are induced to reveal as such, while truth-telling senior authors maintain their current practices. One mechanism which achieves this outcome requires the employer to punish the first mover should it be revealed that the parties make inconsistent claims regarding authorship seniority. Thus, if author A is first mover and claims to be senior, and at a subsequent stage this claim is contradicted by author B, then author B is not promoted even if B is the true senior author and reveals truthfully, while author A (who has initially been promoted) is demoted to his/her original or lower status at a reduced level of pay prior to the application for promotion. Figure 3 illustrates the case where TS is first mover, while Figure 4 deals with the case where TJ is first-mover, where the total net payoff in present value terms for a 'disgraced' first mover is $\psi < 0$.

FIGURES 3 & 4 ABOUT HERE

Proposition 1

The only subgame perfect equilibrium is mutually truthful reporting, and which yields the socially optimal aggregate payoff $\alpha_s + \varepsilon + \beta_1$.

To establish Proposition 1, suppose first that TS is the first mover. In Figure 3, if TS truthfully reports TS, TS is promoted while the second-moving TJ cannot subsequently be

promoted and hence cannot gain by reporting falsely. As second-mover, the true junior author's payoff is maximized at ϵ by truthful reporting. If TJ had denied the claim of seniority by TS, either by claiming seniority or denying the existence of a senior author, TJ would not be promoted since TS had already been promoted on the basis of claimed seniority (which happens to be truthful). The junior author's falsehood would no longer be self-serving where \underline{TJ} is reported since the payoff to reporting \underline{TJ} is zero, as for the case of reporting \overline{TS} for which misrepresentation is never self-serving for a junior author. Secondly, if TS makes a false claim of seniority for TJ by reporting \underline{TJ} , the best response for TJ is to support this claim if $\alpha_j + \delta > \epsilon$. The senior author will not be promoted and receives $\varphi_s < 0$ for making a non-self-serving false report. The junior author will be promoted and receives $\alpha_j + \delta > 0$. If TJ reports truthfully, the cause for TS is not advanced (since TS did not claim seniority at the time of application), and TJ would only receive ϵ for a truthful report. If TJ denies seniority by either co-author, the payoff for TS is again unchanged while TJ receives a payoff of zero for a false, but not self-serving, report. If $\alpha_j + \delta \leq \epsilon$, TJ will truthfully report \underline{TS} , but the payoff of $\varphi_s < 0$ for TS is not enhanced since TS loses permanently the prospect of promotion if no claim of authorship seniority accompanies an application. Finally, if TS makes no claim of authorship seniority for either co-author, TS is not promoted and receives $\varphi_s < 0$, while TJ can do no better than to report truthfully that TS is senior author, since a truthful report yields ϵ for TJ while an untruthful report of either \underline{TJ} or \overline{TS} yields a payoff of zero. Here, TJ cannot be promoted since TS has made no prior claim of authorship seniority on behalf of TJ, while TS cannot be promoted since TS made no seniority claim at the time of application. In this case, the university's payoff β_3 is independent of TJ's report. While its preferred option is to promote TS, the senior author has closed this option by reporting \overline{TS} . In so doing, however, there are no promotion prospects for TJ either, and so the worst of all worlds whereby TJ is promoted and TS is not is avoided.

In sum, if TS reports \overline{TS} , the senior author can confidently expect TJ to truthfully report \underline{TS} , but TS receives only $\varphi_s < 0$ whatever TJ reports. Instead, if TS reports \underline{TJ} , the senior author must expect TJ to follow suit unless the junior author has either a sufficient passion for truth, or a sufficient distaste for lying, or that the payoff for promotion is sufficiently inconsequential. But even if TJ truthfully reports \underline{TS} , the senior author receives the same payoff $\varphi_s < 0$; this payoff is received by TS whenever TS makes a false claim, independently of TJ's response. If, however, TS truthfully reports \underline{TS} , the senior author receives $\alpha_s > 0$ if supported by TJ, and the junior author will subsequently provide support for this claim in order to feel a little jollier by a truthful revelation rather than misreporting in a manner which cannot enhance TJ's promotion prospects.

Now let the junior author be the first-mover. In Figure 4, if TJ reports truthfully, the best response for the second-moving senior author is to support this truthful claim. Thus, TJ's reporting \underline{TS} is a necessary condition for the promotion of TS, and TS must do worse by denying a truthful claim by TJ. Whatever is the response by TS, however, TJ receives $\varepsilon > 0$ for a truthful report. If TJ reports \underline{TJ} , however, TS will report \underline{TS} in order to receive $\varphi_s + \varepsilon$ from a truthful report rather than φ_s from a false report since a truthful report is no longer in the material self-interest of the true senior author.¹⁷ If TJ reports \overline{TS} , the senior author can do no better than the truthful report \underline{TS} , since a falsehood by TS will not enhance this author's promotion prospects. Thus, a report of \underline{TS} is a dominant strategy for the second-moving senior author. Recognizing this, the first-moving junior author will truthfully report \underline{TS} , since a falsehood will subsequently be revealed by the senior author and the junior will be demoted. Again, mutual truth-telling is the only subgame perfect equilibrium to this game.

¹⁷ Indeed, the senior author is most unlikely to be well-disposed towards the junior author who has thwarted the former's promotion by a false claim of seniority, and hence is most unlikely to support the junior author's claim.

The incentive compatible reporting mechanism described above 'works' by removing the payoff to co-authors who would otherwise be willing to lie if their self-interest would thereby be served. The current mechanism employed by the university is such that while falsehood may improve outcomes for junior authors whose passion is other than for the truth, such falsehood does not harm outcomes for senior authors, while supportive truthful revelations by junior authors fails to enhance outcomes for senior authors. There are strong incentives for junior authors to make false reports, given that the university cannot verify claims.

The truth-telling mechanism appears to require positive support for claims of authorship seniority. As with the current mechanism, it is assumed that without a current claim of seniority, no co-author will be promoted. Strictly, given a positive cost of making an application, there is no point in a junior author ever applying for promotion. While the model could be made more realistic by introducing a variable quantity of outputs such that the probability of promotion was enhanced by more frequent rather than less frequent seniority of co-authored articles, the mechanism has the nice property of deterring socially inefficient applications from junior authors without affecting the application rate from senior authors. While academic staff are typically free to apply for promotion in any given year, applicants may receive strong negative signals concerning their promotion prospects if they have not spent a sufficient period at certain salary/status bars.¹⁸ Although not promoted, such authors are nevertheless awarded a salary

¹⁸ Thus, in March 2000 in its Promotion Criteria at <http://www.canterbury.ac.nz/campusinfo/vacancies/intro.htm> the University of Canterbury advised that it would be exceptional for an applicant who had not spent at least one year at the appropriate salary bar or top of salary range to be promoted (although a draft of revised promotion criteria in April 2000 proposed weakening "exceptional" to "unusual"), while accelerated promotion for staff below the Associate Professor/Reader level required evidence of exceptional achievement in both teaching and research.

increment which appears largely independent of their productivity.¹⁹ Suppose that a junior author arrives at a salary bar prior to a senior author. In terms of the incentive compatible mechanism, while the junior author would receive promotion at the time of application were the junior author to claim seniority, since such a claim will not subsequently be supported by the senior author, the junior author will subsequently be disgraced. In knowledge of this outcome, the rational junior author will not apply for promotion. This does not diminish the senior author's prospects since the senior author will truthfully report seniority when the salary bar is reached, and will be promoted in consequence. Alternatively, if the senior author had been promoted at an earlier date, *ceteris paribus* the junior author will not apply at a later date since the junior author's productivity has been insufficient for promotion. Although the senior author is not directly supported, the absence of an application by the junior author permits the correct inference of seniority of the prior claimant. Thus, the issue is not one of support for a claim of seniority; rather, it is the absence of a non-supporting message from a co-author that determines whether or not a promoted author is able to continue to enjoy the benefits conferred thereby. A supported message is of little consequence *per se*, since it is only truthful supported messages that form part of the equilibrium. For example, a claim of non-existence of a senior author which is subsequently supported when a true senior author exists does not form part of an equilibrium.

It might be argued that an incentive compatible mechanism is otiose in that in an organisation emphasizing collegiality among academic staff, global truth-telling may be expected. For those sceptical of such claims, it might be noted that the mechanism loses nothing even if everyone always reports truthfully, since it is both consistent with global truth-telling and induces global truth-telling where the latter would not occur voluntarily. Thus, under the current regime,

¹⁹ Cumulative productivity, however, including seniority of co-authored articles, may be critical in determining promotion prospects once the ladder has been climbed.

the university must be entirely confident that the payoff from promotion net of the disutility from reporting falsely is less than the value of truth-telling in all possible instances. Both the university in general and staff members who are likely to have superior information about their co-authors' reporting behaviour may not be entirely confident that global voluntary truth-telling will rule. Under the incentive compatible mechanism, however, neither the university nor any co-author need have any information concerning the values of the critical parameters ϵ and δ . Under this mechanism, however, it will not be possible to determine who would have reported truthfully under the current mechanism.

One adverse side effect is that implementing the mechanism may create resentment among staff towards the employer who would presumably not introduce the system absent any suspicion of false reporting among staff. An interesting empirical question would be the rate of incompatible claims of seniority under the current mechanism.²⁰ Unfortunately, detection of incompatible claims is likely to be met with arguments that the claims were made in good faith by co-authors who 'truly believed' in their own seniority. This places the university back at square one regarding verification of claims. A claimed 'true belief' is not verifiable under the current regime. Authors have strong incentives under an incentive compatible mechanism to ensure there is a solid basis for any claim of 'true belief' since unsupported claims of seniority will carry a significant punishment.

The punishment rule may appear to have certain unattractive features. For instance, it might be argued that if the senior author makes a prior true claim of seniority, and the junior author does not support this claim, the senior author is punished severely in spite of making truthful revelations while the junior author escapes scot free. Examples such as these, however,

²⁰ The University of Canterbury has not examined this issue and was unwilling to make available the data required to undertake this exercise.

ignore the critical fact that the strategy pair $\{TS, TJ\}$, say, for senior and junior, respectively, do *not* form part of an equilibrium and hence should never be observed. Nevertheless, adoption of this scheme would probably be well served by an opportunity for appeal in order to prevent unfortunate outcomes resulting from mistake. Thus, if the senior author reveals TS and the junior author inadvertently reveals TJ , say, the senior author is punished by the mistake while the junior author is not. Being non-malicious, however, junior authors will voluntarily change their messages to truthful correct messages.

In the case where the junior author is first mover, it has been assumed that the senior author will report truthfully as second mover and fail to support any claim of seniority made by the junior author. The assumption is that the senior author receives a small, but positive payoff of ϵ for a truthful report which is not in the senior author's self interest. A small positive payoff is all that is necessary here. More generally, it seems reasonable to suppose that when a senior author detects that a junior author has falsely claimed seniority the result of which is to stymie the senior author's future promotion prospects, the senior author may not be entirely unhappy in making an application for promotion which is guaranteed to be unsuccessful but which in the circumstances results in the junior author's disgrace. If the game was one of incomplete information, however, the senior author would be uncertain as to the nature of the junior author's report. It would then appear that efficiency is served by a rule which requires disclosure of applications among relevant co-authors.

The incentive compatible mechanism, however, may not be fully robust to the presence of gratuitously malicious behaviour. For example, suppose that a junior author really obtains significant pleasure from the humiliation of a senior co-author. While it might be hoped that examples of malice would be absent or extremely rare, a severe penalty on the junior author's failure to support a prior claim of authorship seniority by the senior author would deter malicious

behaviour. Unfortunately, the university does not know who is the first mover, and so must penalize the second mover for a failure to support a prior claimant. This, however, dilutes and may remove the desirable incentives which keep the first mover honest under the incentive compatible scheme. Under this scheme, authors at least have an incentive to select their partners judiciously and are in a superior informational position *vis a vis* their employer in so doing.

4. Simultaneous Applications

Academic institutions may permit employees to apply for promotion at will, subject to an annual promotions round. If co-authored research is common, it must be expected that a reasonable proportion of applications for promotion in a given year will include more than one author of an article or articles. If so, the underlining game is now represented by a normal form game. The 'naive' underlining game is illustrated in Figure 5.

FIGURES 5 & 6 ABOUT HERE

Against any strategy chosen by the junior author, the senior author's best response is to truthfully claim to be senior author. Against this dominant strategy, the junior author's best response is to untruthfully report II if $\alpha_j + \delta > \epsilon$, otherwise report truthfully. The same potential incentive failures present in the sequential application game rear their ugly heads. If $\alpha_j + \delta > \epsilon$, a unique Nash equilibrium exists where both co-authors claim seniority and both receive promotion even though a true senior author exists. This author, however, cannot be identified in this process, and the outcome is socially suboptimal.

Since there is no first mover, the penalty process adopted in the incentive compatible mechanism described in section 3 cannot be applied. There, a first mover claiming senior authorship and who was not subsequently supported by a co-author was demoted and effectively

fined so that in present value terms, the payoff to misrepresentation was lower than for reporting truthfully. When both parties report simultaneously, however, the university should simply fail to promote any author claiming seniority when this claim is unsupported by a co-author.

Proposition 2

The unique Nash equilibrium is mutually truthful reporting, and which yields the socially optimal aggregate payoff $\alpha_s + \varepsilon + \beta_1$.

To establish proposition 2, note that in Figure 6, if TS reports TS the best response for TJ is also to report TS. Since the junior author cannot be promoted in this case, the best response is to support the senior author's claim and receive the payoff of ε for a truthful report. If TS reports TJ, the junior author will also report TJ if $\alpha_j + \delta > \varepsilon$, otherwise the junior author will report truthfully. If TS claims that no senior author exists, the junior author again reports truthfully. If TJ truthfully reports TS, the senior author will clearly support such a claim in order to receive promotion. If TJ either falsely claims seniority or fails to underline either name, the senior author's promotion prospects are dashed. The senior author's best response is the truthful report TS, thus thwarting the junior author's promotion prospects. A truthful claim of seniority by the senior author is a dominant strategy, and the junior author will offer support. A unique Nash equilibrium exists where both parties report truthfully and the social optimum is achieved.

5. The Case of Uniform Contributions

Consider the case where both authors agree that their contributions have been equal. Suppose that applications are sequential, and that the naive incentive structure applies. Since no true senior author exists, the parties can be labelled A and B, respectively, and their labels switched without

any consequence to outcomes. Since neither author has provided differential effort, I assume that the payoff to any author receiving promotion (and who is not subsequently demoted) is $\alpha > 0$. Figure 7 illustrates the case of the naive incentive scheme and Figure 8 deals with the corresponding incentive compatible scheme, where payoffs to A precede those to B.

FIGURES 7 & 8 ABOUT HERE

From inspection of Figure 7, it is evident that the equilibrium is identical to the case where one or other party is the true senior author and both parties agree as to which is senior. B will claim authorship seniority if $\alpha + \delta > \varepsilon$, otherwise B will truthfully report that no senior author exists. Whatever B reports, however, A will claim authorship seniority if $\alpha + \delta > \varepsilon$. Further, it is obvious that the same outcome is predicted under simultaneous applications. The assumed homogeneity of these parameters across authors implies that either both authors will report truthfully in equilibrium, or that neither will report truthfully. This is distinguished from the previous case where a true senior author exists, since the net payoff for a truthful claim of seniority was assumed to be positive. If these parameters differ across authors, it is clear that one or other may be promoted in equilibrium, the author being promoted being that person with the lesser regard for the truth *per se*.

Application of the incentive compatible mechanism whereby an unsupported prior claimant of authorship seniority is punished by demotion and salary reduction again results in general truthful reporting in equilibrium. If A falsely claims seniority and is initially promoted, B's best response is a truthful report denying the existence of seniority for either author. Should A falsely claim seniority for B, B's best response is to support this claim if $\alpha_j + \delta > \varepsilon$, otherwise B will report truthfully. If A reports truthfully, B cannot receive promotion by claiming seniority and does best by supporting A's claim that no senior author exists. Since A receives a higher payoff from truth-telling than claiming authorship seniority for B, and knowing that B has no incentive

to support a claim of authorship seniority by A, it pays A to report truthfully and for B to support this claim. Again, it is evident that this result extends to the case of simultaneous applications where no author is promoted unless a claim of authorship seniority is supported. Again, it seems reasonable that the social payoff is maximized at $2\varepsilon + \beta$, in the truth-telling equilibrium.

6. The Possibility of a Cooperative Solution

In the case of sequential applications where one or other party is the true senior author, the incentive compatible mechanism induces truthful revelations in equilibrium and only the senior author receives promotion. While a senior author may feel inclined to share her good fortune with her junior partner, the latter is prevented from gaining at the senior author's expense, or, in the naive scheme, at the expense of more valuable use of the funds such as, say, technical support for academic staff in the chemistry department should the university promote all those claiming authorship seniority.

Where neither party is senior author, however, and given that the costs of negotiations between the parties are likely to be small, the question arises as to whether the parties might not do better by attempting to find a solution in contract. There is a cooperative surplus $\alpha + 2\delta$ available if one party falsely claims authorship seniority and is supported by the other in the hope of personal gain. Suppose this surplus is positive, and that first-mover A claims to be senior and this claim is subsequently supported by B when both know that no senior author exists, and if both reported truthfully under the incentive compatible mechanism, each author would receive ε . Any bargaining arrangement which yields a division of $\alpha + 2\delta$ between A and B yielding a payoff greater than ε for each author leads to both parties being better off than if they both told the truth. Such arrangements would upset the truth-telling equilibrium.

Bargained promotions, however, are unlikely to be robust. The first mover might be either A or B. Suppose it is A, who has agreed to claim senior authorship, and does so. B subsequently supports A's claim and asks for her share of A's increase in salary. A, however, may refuse to compensate B since their agreement would not be legally enforceable. If there were any true senior author, both parties would reveal that person as such under the incentive compatible scheme, and the senior author would have no incentive to enter a contract in which they received anything less than the full payoff for promotion. A negotiated contract could only arise when there is no true senior author, and so any promotion received in these circumstances could only have occurred as a result of misrepresentation by the parties. The courts will not enforce such contracts since although they may be in a worse position than the university in determining authorship seniority in general, the courts will hopefully recognise that self-interested parties will only write such contracts in order to gain from opportunistic behaviour.

In essence, the parties have to agree who is to receive promotion and receive the direct reward from the university. The promoted party has a strong incentive to cheat on any agreed side-payment to the co-author. Further, the conclusion is similar for the case of simultaneous applications. The unenforceability of contracts is likely to eliminate most, perhaps all, attempts to obtain promotion through this form of deceptive practice.

7. Some Possible Qualifications

The underlying game as described above is static, and it must be recognized that academic staff work together in a repeated employment situation. Research pairs or teams do not typically form and then disassemble following the publication of a single piece of work. It might then be argued that reputation may be a sufficient deterrent to junior authors to claim seniority, since they can

expect future punishment in the sense of not being invited to do further research, and their promotion prospects in the future may be consequently dimmed by being sent to Coventry, as it were. If so, perhaps the mechanism described in this paper may transpire to be redundant.

Reputation effects, however, are unlikely to be a very promising avenue for attenuating the adverse incentive effects in the unmodified underlining game unless a suitably severe 'punishment' strategy on the junior author (eg, refusing to cooperate in further joint research) can be exacted. For punishment to be effective, however, some way of establishing initial tacit collusion must be found, discount rates must be relatively low, while at the beginning of every possible future period there is a significant probability that the parties will engage in joint research. Since the parties are mortal and the assumptions required for an effectively eternal dynastic research team would seem to stretch credibility somewhat, the first mover in such a game would appear to enjoy a considerable advantage. If the game is repeated a finite number of times, say, Selten's chain store paradox ensures that the last mover can confidently engage in opportunistic behaviour since the expected future penalty is zero. Knowing this, each preceding time the junior author makes an application the senior author will assume correctly that the current period is the last period in which the parties will be acting as a team, and so the repeated game collapses to its static equivalent.

If co-authors are not employees of the same university, they might be considered disinterested parties and be in a good position to verify claims of seniority. For example, if A claims seniority when A is in fact junior, will not B deny the claim? The problem is that co-authors are unlikely to be disinterested parties. If B reveals the truth, A is worse off and the prospects of their working together again look poor, in spite of the fact that they may both be better off by combining their efforts in research. Further, even if there is no positive payoff to B for exposing A, unless B has a passion for the truth, B can do no better than support A since B's payoff is

independent of B's revelation, truthful or otherwise. If A can do B favours in terms of promoting visits or future employment, incentives for B are further diluted.

It may be that the university is unwilling to enforce penalties. For example, although employment contracts frequently provide for a fixed amount of notice on each side, it appears extremely rare that universities take legal action for damages when resigning employees fail to provide sufficient notice. The enforcement of penalties for misrepresentation of the work of others, however, is another matter. Universities typically outlaw dishonest practices such as plagiarism among their students, and frequently punish such practices with a range of penalties including the refusal to mark work and give credit, reprimands, fines, suspensions or expulsions. Sanctions are typically imposed on staff who plagiarise the work of their students. In a recent dramatic example, the editors of *Kyklos* (International Review for Social Sciences) responded to a claim of plagiarism first by offering the alleged offender the opportunity for explanation and having concluded that the forthcoming explanation was unsatisfactory, offered a public apology to the true author and readers of the journal, along with publishing a summary of the article and making the full version available on the world wide web. Punishment of the malfeator involved publishing the offending author's name, refusing to accept any future paper submitted by this author, requesting the leading citations and abstracting indexes to delete references and citations to the offending article, informing other leading journals in economics of the outcome, and advising senior administrators in the offending author's employing institutions of the circumstances.²¹ The parallel with false claims of authorship seniority for personal gain is clear, except that in the absence of incentive compatible reporting mechanisms, detection of false claims of authorship seniority is an order of magnitude more difficult than false claims of authorship in

²¹ Cf., Frey et. al. (1999).

cases of plagiarism. In any case, squeamish administrators who may be loath to even contemplate literally exacting penalties on offending academic staff could resort to the simple expedient of requiring all staff to provide an annual return by a given date of their cumulative research output, including identifying principal authors where relevant. The effect would be to reproduce the simultaneous version of the underlining game, and rational behaviour under the incentive compatible mechanism would induce global truth-telling. Unsupported claims of principal authorship would simply be met by a failed application rather than reduction to the ranks under the sequential version of the game.

In the present context, the mechanism of McAfee and McMillan (1991) must be noted. These authors deal with a quite general model admitting both moral hazard and adverse selection, the latter arising because of unobservable ability differences among team members. The latter aside, however, McAfee and McMillan argue in favour of a contract with different properties to that of Holmstrom (1982). In the present context, their concluding section is enlightening, asking how the chairman of their department should apportion merit pay for their article, arguing that if the authors' respective abilities were public knowledge, each should receive 100 percent of the credit even if relative contributions were unknown.²² Such a contract would induce efficient effort levels from each author since each could be assured of capturing the full value of any increase in their own effort. Since such a contract would break the budget at the margin, however, each author would pay the employer an amount which made each indifferent as to participating in the

²² Of course, if their chairman knew the answer to this question, the chairman would have presumably pre-empted McAfee and McMillan by having already published the result! It is noteworthy, however, that both authors were employed by different institutions by the time their paper was published, raising a more complex problem involving multiple principals regarding incentives for their future joint research.

scheme.²³ A junior author would then be willing to pay more than a senior author to participate in a scheme that offered a high reward for less effort than that provided by a colleague.

While attractive in principle, such contracts appear rather uncommon in practice, since they can only be enforced via a credible commitment on the part of the principal not to jeopardize the production process. The university might be able to prevent senior authorship of a sufficient number of high quality articles emerging by refusing authors access to complementary inputs such as equipment or research assistance, or by dissimulating *ex post* as to the required quantity or quality of output since these outputs are not traded in competitive markets. McAfee and McMillan suggest that commitment might be endogenised through reputation, but many employees may be reluctant to put up cash-in-advance and hope that their employers do not take the money and run. Further, liquidity constraints may be binding, preventing authors from putting up a sufficient upfront payment such that the principal is willing to offer such a contract, since capital markets are likely to be highly imperfect from this perspective. Nevertheless, a similar problem arises with the incentive compatible mechanism described in the present article, since the university must have the capacity to enforce the penalty when an alleged senior author is promoted. Either earnings must be garnished, or it may be possible to establish a trust fund under the management of a disinterested party whereby the financial rewards from promotion are not transferred (including interest accrued) until a promoted author's claims have been verified. This should not create liquidity constraint difficulties that might otherwise emerge.

²³ With unknown abilities, the optimal contract typically calls for output shares to be less than 100 percent, especially if there is a wide dispersion in authors' abilities, but with output shares still typically summing to more than 100 percent. The optimal output share is increasing in an author's ability in part to discourage low-ability employees from economising on their participation payments by overstating their ability. This is achieved by having such employees face a payment function that is highly sensitive to additional effort, which in turn is assumed to be more costly to less able employees.

Finally, while the incentive compatible mechanism has been developed only in the context of a two-person team, the rule of 'no permanent promotion without support from all co-authors' should extend directly to n-person research teams.²⁴ If, however, the university wished to offer rewards on the basis of degree of seniority as opposed to the presence of seniority, joint authors might be required to report their share of contribution to each jointly-authored article. In these circumstances, however, while it might be expected that a best response for any author is to reveal truthfully if all other research team members report truthfully under a penalty mechanism similar to that described above, it may also pay to report untruthfully in response to untruthful reports of other team members. For example, if author A claimed a contribution share of 75 percent when the truth is a contribution share of only 60 percent, author B's best response may be to claim a share of 25 percent rather than the true share of 40 percent in order to avoid receiving nothing. The binary nature of the distinction between senior and junior authors, along with the assumed decision to reward senior authors only at the margin prevents the emergence of multiple equilibria in the version of the underlining game addressed in this paper.

²⁴ Multiple co-authorship appears most common in bench science subjects. For example, in the Department of Chemistry at the University of Canterbury, of the 110 publications reported in the University's 1999 Calendar, over 80 per cent were co-authored, and while the modal number of co-authors was two (representing over one quarter of all publications), the mean and median number of co-authors was three, representing some 19 per cent of all publications and equal to the number of sole-authored works (of which distinct authors represented only 38 per cent). Some 20 per cent of publications had four co-authors, several articles carried five or six authors, and there was one article each carrying 7, 8, and 10 co-authors respectively.

8. Concluding Remarks

The underlining game is a mechanism whereby members of a research team (who are multiple agents of a single principal, a university, say) are required to report whether or not they have been the major contributors in a joint production process where individual contributions cannot be observed by persons outside the team, and where additional rewards in the form of promotion are offered for authorship seniority. Reporting can be either sequential or simultaneous. In the unmodified underlining game, the unverifiability of individual contributions to team research gives junior authors a valuable bargaining chip. Recognizing this, senior authors will seek to become junior authors, shifting effort on to others. Not all can be junior simultaneously, however, so that if joint research continues, the reporting rule creates incentives for equal contributions at low levels of effort. This may well be inefficient, leading to low levels of joint research and discouraging allocation of effort in terms of comparative advantage across different research projects. Joint research may be efficient because of gains through specialization and synergies resulting from collective efforts generating economies of scale and scope. Ultimately, promotion may be refused for all participants because of an insufficiency of research of good quality, with limited numbers of low-quality articles either produced with equal efforts or else researchers retreating to sole-authored research.

This article introduces an incentive compatible mechanism which refuses the reward of ongoing promotion to authors who make unsupported claims of authorship seniority, thereby inducing truthful reporting and discouraging opportunistic behaviour by junior authors. In the case of sequential reporting, the argument is established only for the case of a game of perfect information. Imperfect information could arise if there were uncertainty as to the nature of the messages sent by prior applicants. If subsequent applicants cannot inspect these messages, or

cannot always infer the message sent by an earlier applicant from the outcome of the promotion decision, the problem is more complex and worthy of further research. Problems arising from imperfect information, however, can be avoided by a policy of compulsory disclosure to all team members of messages sent to the principal by any given team member.

This article, however, does not address the important problem where multiple authors may be employed by different, possibly rival, institutions. An employer cannot punish a first mover, for example, should it be revealed that the parties make inconsistent claims regarding authorship seniority but jurisdiction over the first mover is absent. Joint ventures might alleviate this problem, however, although mergers seem unsatisfactory given the distribution of co-authorship across a wide range of institutions and fields. Further, the composition of both research programmes and research teams, and the effort levels of the researchers are properly endogenous, but have been treated as being exogenous. Exogeneity of effort might be justified in part by the presumably unanticipated requirement of identification of authorship seniority, but ongoing application of the requirement will clearly affect current and future effort decisions. While the related literature typically treats effort as endogenous, the choice of what and with whom to research under alternative incentive mechanisms appears largely unexplored.

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FIGURE 1: Naive Reporting Scheme when True Senior Author is First Mover

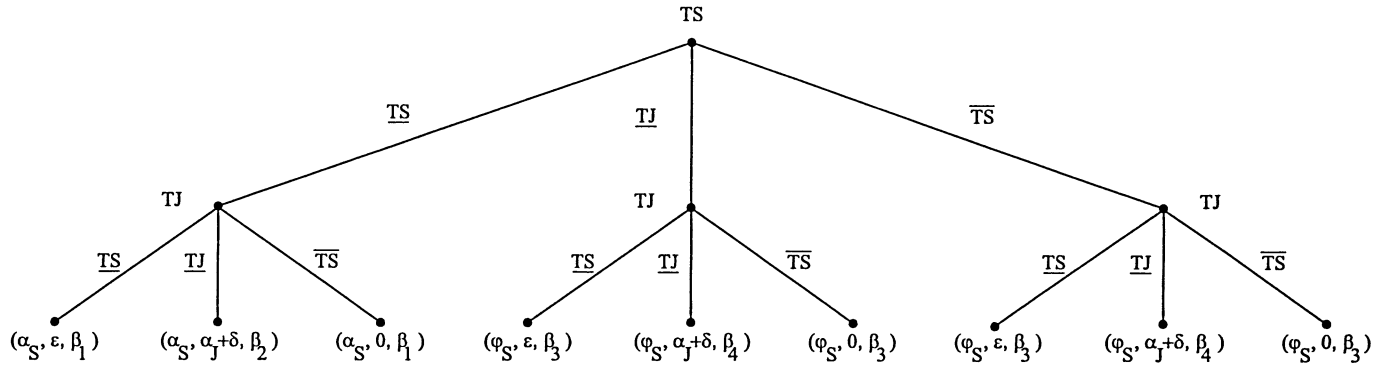


FIGURE 2: Naive Reporting Scheme when True Junior Author is First Mover

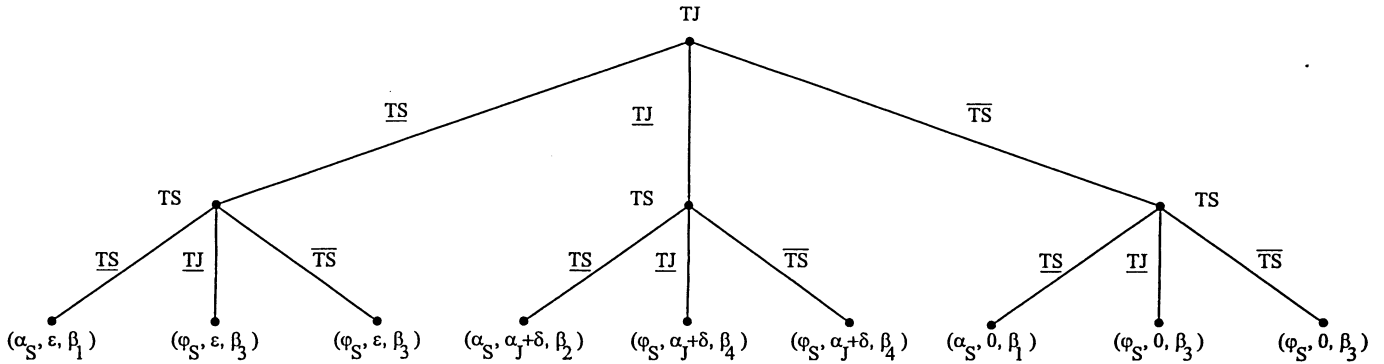


FIGURE 3: Incentive Compatible Reporting Scheme when True Senior Author is First Mover

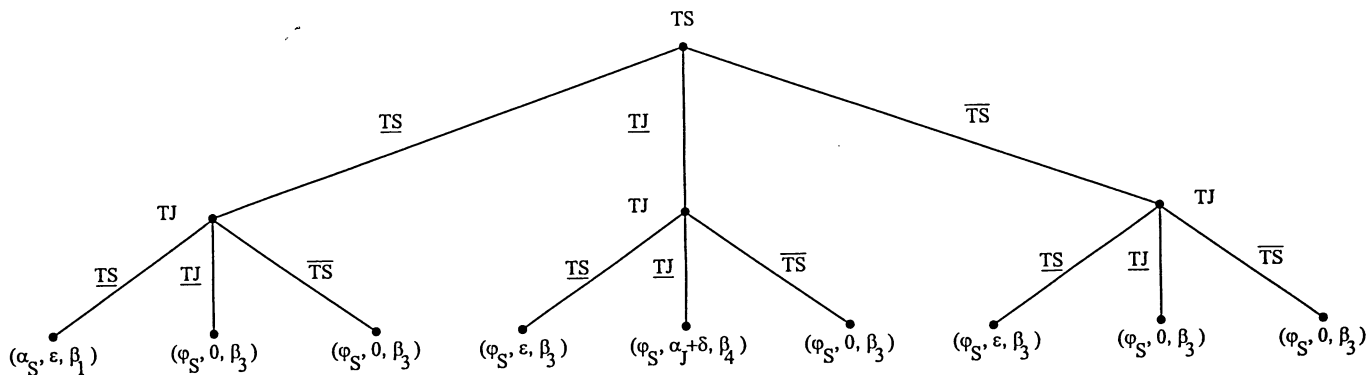


FIGURE 4: Incentive Compatible Reporting Scheme when True Junior Author is First Mover

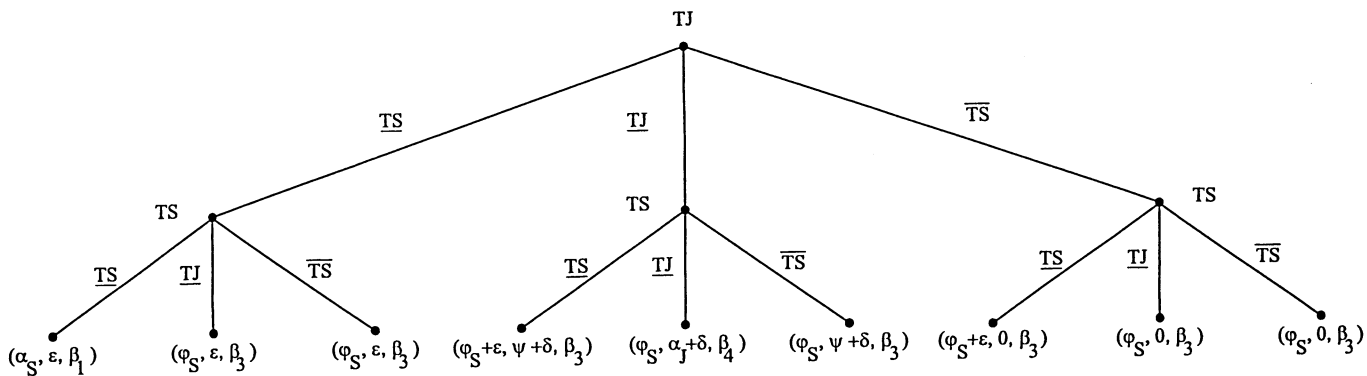


FIGURE 5: Naive Reporting Scheme under Simultaneous Applications

		<i>Junior's Strategies</i>		
		TS	TI	TS
<i>Senior's Strategies</i>	TS	$(\alpha_s, \varepsilon, \beta_1)$	$(\alpha_s, \alpha_j + \delta, \beta_2)$	$(\alpha_s, 0, \beta_1)$
	TI	$(\varphi_s, \varepsilon, \beta_3)$	$(\varphi_s, \alpha_j + \delta, \beta_4)$	$(\varphi_s, 0, \beta_5)$
	TS	$(\varphi_s, \varepsilon, \beta_3)$	$(\varphi_s, \alpha_j + \delta, \beta_4)$	$(\varphi_s, 0, \beta_5)$

FIGURE 6: Incentive Compatible Reporting Scheme under Simultaneous Applications

		<i>Junior's Strategies</i>		
		TS	TI	TS
<i>Senior's Strategies</i>	TS	$(\alpha_s, \varepsilon, \beta_1)$	$(\varphi_s + \varepsilon, 0, \beta_3)$	$(\varphi_s + \varepsilon, 0, \beta_3)$
	TI	$(\varphi_s, \varepsilon, \beta_3)$	$(\varphi_s, \alpha_j + \delta, \beta_4)$	$(\varphi_s, 0, \beta_3)$
	TS	$(\varphi_s, \varepsilon, \beta_3)$	$(\varphi_s, 0, \beta_3)$	$(\varphi_s, 0, \beta_3)$

FIGURE 7: Naive Reporting Scheme when no Senior Author Exists

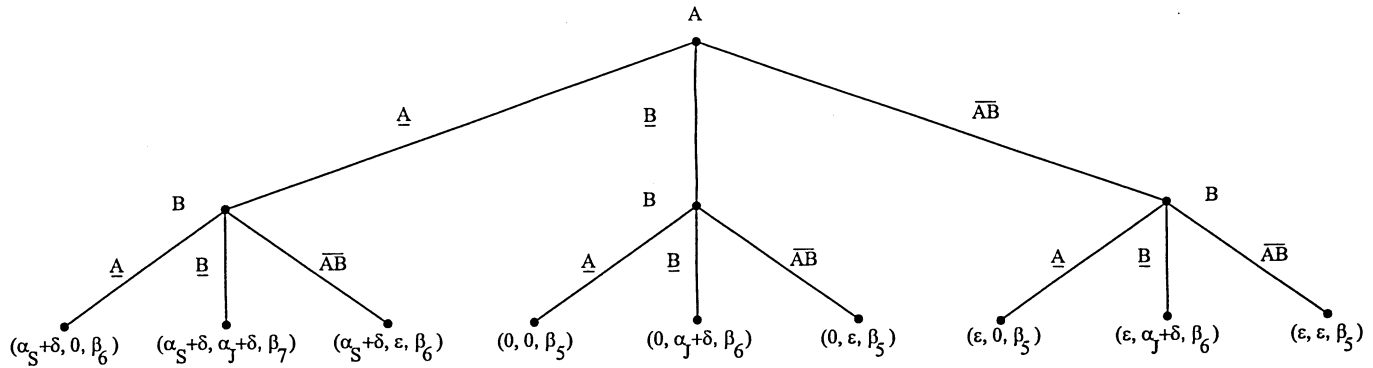
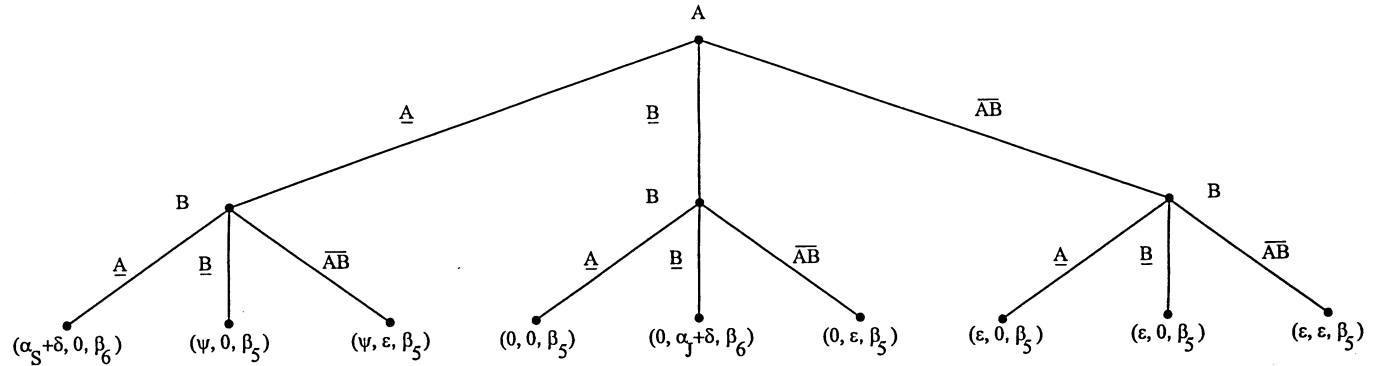


FIGURE 8: Incentive Compatible Reporting Scheme when no Senior Author Exists



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