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# Introduction

The relationship between a supervisor and a subordinate has been studied extensively in the social sciences ([Conrad, 1983](#ref-power)), ([Conrad, 1991](#ref-comm)), ([Liu & Shi, 2017](#ref-trust)) and it’s been found that a subordinate’s action is often influenced by the behaviour of the supervisor. Identity-based motivation theory posits that a relationship of trust and leniency between a subordinate and a supervisor will ultimately lead to both parties being better off in terms of reaching their goals, performance, and mental health ([Liu & Shi, 2017](#ref-trust)). Game theory models provide a useful framework to analyze the interactions between a supervisor and a subordinate ([Osborne, 2004: 1](#ref-book)). A common situation that arises is a subordinate being assigned a task that should be complete before a deadline. Game theory can offer insights as to when a subordinate should submit a task on time or miss the deadline if there is incomplete information.

This article contributes to the literature on games of incomplete information, and dynamic interactions between students and lecturers. We investigate a case where a student is required to submit an assignment with by a certain deadline, but she experiences a crisis and must choose whether to submit her assignment on time or late. We impose a structure of continuous types for both players, with a discrete set of actions. This essay is organised as follows: section briefly discusses the literature on games of incomplete information and some applications. Section presents our model of deadline adherence; and section analyses the results of the game. Section provides an extension of the game and the final section concludes.

# Games of Incomplete Information

In real-life situations, we often don’t have full information before we make decisions [Trabelsi](#ref-2020games) ([2020](#ref-2020games)). [Von Neumann & Morgenstern](#ref-von) ([1944: 30](#ref-von)) first used the term in reference to a game theory model in which parts of the normal form structure are unspecified. However, Von Neumann and Morgenstern deemed further research into such a model as unimportant ([Myerson, 2004](#ref-2004com)). [Luce & Adams](#ref-luce1956) ([1956](#ref-luce1956)) disagreed, and extended on the incomplete information literature by assuming that each player has a perception[[1]](#footnote-1) of the payoff function of the other player. However, games of incomplete information were practically difficult to solve until [Harsanyi](#ref-harsanyi) ([1995](#ref-harsanyi)) developed a general analytical framework.

We follow the approach of [Harsanyi](#ref-harsanyi) ([1995](#ref-harsanyi)) in applying a game-theoretic model of incomplete information, where players have less than full information about each others payoff functions. Based on the Bayesian methodology, both players have expectations in the form of subjective probability distributions. Players have different types, which are randomly assigned and represent their belief about the game being played. However, players do not know the type of the other player ([Trabelsi, 2020](#ref-2020games)). Both players attempt to estimate the probability of each others types, subject to the available information. To solve the outcome of the model, the game of incomplete information will be reinterpreted as a game with complete and imperfect information, by transforming its basic mathematical structure.

# A Model of Deadline Adherence

This section presents a model of deadline adherence, with the purpose of understanding how a student thinks about assignment submissions, and how a lecturer acts when submissions are late. An explanation of the model follows. A student receives an assignment, which is due by a certain date set by the lecturer. While the student is working on the assignment, she experi a crisis and therefore spends less time on the assignment. She has two options: she can hand in the assignment on time or she can hand in late. If she hands in on time, she will get a payoff of , where is her potential pre-crisis mark, and is the negative impact the crisis has on her mark. However, if she submits her assignment late, she has some time to recover after the crisis and reduce its academic impact. Her payoff is if the lecturer gives her a penalty, where is the size of the penalty. She gets a payoff of if there is no penalty. represents the type of the student, where a high suggests a low resiliency to crises, and a low suggests a high resiliency and a better academic recovery. The student observes her own type but does not know the lecturer’s type.

On the other hand, the lecturer is faced with the decision either to give a penalty (), if a student submits late, or not to give a penalty. If the lecturer gives a penalty, he feels bad since the student has gone through a crisis. The size of his disutility depends on the size of the penalty () and how empathetic the lecturer is, where the level of empathy describes the lecturer’s type (). The more empathetic the lecturer is, the higher is. The lecturer observes his own type but not that of the student. The lecturer’s and student’s types are both continuous types, which are independently and randomly chosen by nature at the start of the game from a uniform distribution[[2]](#footnote-2): and . If the lecturer decides not to impose a penalty, he feels good that he did not impose on a student experiencing a crisis, and gets a positive payoff of . However, the lecturer knows that by waving the penalty, he may be encouraging this student, and other students to hand in late in the future. The lecturer would rather deter late hand-ins, and receives a negative payoff for not deterring[[3]](#footnote-3) late hand-ins.

The parameters are all common knowledge. This is a game of incomplete information because the players’ types are not common knowledge. The type spaces are continuous and the action spaces are discrete. Each player needs to choose his/her action based on his/her own type, what each believes the other player’s type is, and the values of . Figure shows the game in extensive form[[4]](#footnote-4). And a summary of the game’s parameters and restrictions are given in figure below.

# Results and Discussion

In order to understand how the lecturer and student will make their decisions given their beliefs, we need to solve for their best responses. A best response for the student would be to hand in on time if the expected payoff from handing in on time is higher than the expected payoff of submitting late. Defining as the probability that the lecturer will give a penalty, a student should hand in on time where: The right hand side is a constant[[5]](#footnote-5). This implies that there is some threshold value of , for which a student should hand in on time. If the student believes that the lecturer will give no penalty (i.e. ), then she should only hand in on time if . Since lies between and , the inequality will never hold and she should always hand in late. From an intuitive stand point, this makes sense: a student can never do worse by handing in late if there is no penalty[[6]](#footnote-6) but she will do better to hand in late if she is resilient in any way () and can partially recover from the crisis.

However, if the student believes that the lecturer will give a penalty with some positive probability () then her decision to hand in on time depends on her level of resiliency, the magnitude of the crisis and the size of the penalty. As the cost of the crisis increases, the threshold value increases (ceteris paribus), and the student becomes more likely to hand in late (unless her she has a very low resiliency). If the mark penalty is high, the threshold value is smaller, and the student is more likely to hand in on time (unless is very resilient: is very low). We can analyse the lecturer’s best response rule similarly. The lecturer should impose a penalty where:  
 The threshold value for the lecturer is the ratio between the deterrent factor and the sum of the crisis cost and the penalty mark. If the deterrent factor is high relative to the cost of crisis and the penalty mark, then the lecturer is more likely to give a penalty (unless he is highly empathetic). If the cost of the crisis large and the mark penalty is high relative to the deterrent factor, the lecturer is more likely to waive the penalty (unless he has very low empathy levels).

While the best response analysis is useful, if we want to understand the outcome of the game and the players’ strategies, we need to solve for the Bayesian Nash Equilibrium (BNE). The full derivations of the solution concepts are given in the appendix ().

After observing her private type, the student chooses the following hand-in pattern:

And the lecturer’s BNE strategy is given by:

When the lecturer and the student play their equilibrium strategies, neither has an incentive to deviate and we get a Bayesian Nash equilibrium. We would interpret the student’s BNE strategy similarly to her best response; however, her strategy profile only depends on her own type and no longer on her beliefs about the lecturer’s type. The lecturer’s best response function and equilibrium strategy profile are the same because the lecturer observes whether the student hands in late or not and therefore has no need to hold beliefs about when the student will hand in.

# Extension

We extend the game explained in section to account for grade inflation. The lecturer has an incentive to inflate a students grades higher grade is associated a more favorable evaluation from the student. Favorable evaluations are linked to an in salary and promotions for the lecturer ([Goswami & Mumit, 2018](#ref-2018grades)). However, inflating a grade is ethically wrong therefore the lecturer incurs cost if he decides to inflate. If the lecturer, then he occurs a empathy cost . A student experiences a cost of for asking the lecturer and the lecturer experiences a cost of of being bothered by the student . If the lecturer decides not to penalize the student, then he will never choose to inflate a students mark. Knowing this, a student that hands in late and receives no penalty will always accept his mark. If a student hands-on time, a lecture will always leave the mark unchanged at the request of the student, therefore the student will always accept the mark. If the lecturer decides to penalize a late student, the lecturer will choose to inflate a student’s mark if the ethical cost is smaller than the empathy cost the lecturer experiences.

If the ethical that the lecturer experiences is bigger than the empathy cost the lecturer experiences for giving a penalty, then the lecturer is strict, otherwise the lecturer is lenient. Therefore, a strict lecturer will not inflate a student mark but a lenient lecture will ([Franz, 2010](#ref-2010grade)).

A summary of the game’s parameter’s and restrictions are shown in table and the game is represented in Figure

# Conclusion

The results of the model are intuitive and provide a useful insight into how student’s think about handing in assignments, and how lecturers respond to late submissions. One shortcoming of the model is its assumption that is common knowledge. Although some lecturers are in touch with their students and would know whether they are experiencing a crisis and how impactful the crisis would be, most lecturers have too many students to know that information.

Extensions, generality Shortcomings

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# Appendix A

# Appendix B

## Payoffs

Student payoffs: Student plays on time if: Student plays late if: Lecturer Payoffs: Lecturer gives a penalty if: Lecturer gives no penalty if:

## Best Responses

Solving for the best responses: Substitute into the student’s best response function - student hands in on time if: Since , cannot be greater than 1. This implies Since , this condition will always hold.

cannot be less than 0: if , otherwise: Best response function for the student: Best response function for the lecturer:

## Bayesian Nash Equilibrium

The Bayesian Nash equilibrium occurs at the point where the best response functions intersect. For the BRFs to cross: BNE strategy for the student BNE strategy for the lecturer

1. This belief does not necessarily need to be correct [↑](#footnote-ref-1)
2. A uniform distribution puts equal chance on any of the outcomes between 0 and 1 happening. [↑](#footnote-ref-2)
3. This deterrent parameter relates to the literature on games of repeated interaction and reputations ([Clark & Montgomery, 1998](#ref-deter)). [↑](#footnote-ref-3)
4. The simultaneous form game can be found in the appendix, [↑](#footnote-ref-4)
5. Since and are known, and is a belief the student holds. [↑](#footnote-ref-5)
6. Handing in late is a weakly dominant strategy. [↑](#footnote-ref-6)