Lobbying and Income Inequality

Experimental Evidence

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Abstract

In this paper we develop a simple two-stage model of lobbying with income inequality and examine our predictions in the laboratory. We found a treatment effect contradicting the theoretical predictions: Low wage subjects paired with high wage subjects over exert in a real effort task, beyond individual rationality, producing for the group at the expense of individual welfare. Neither inequality aversion nor competitive preferences explains the off-equilibrium behaviour. In the second stage, in contrast to much of the literature, subjects tended to exert effort in the contest quite close to SPNE. Delving deeper, we found those that contributed more tax revenue in the first stage exerted more effort in the contest in the second stage, despite it being a strictly dominated strategy. Inversely, those that contributed less exerted less. The effect was observed across treatments. Over-exertion of effort displayed by the higher contributors can potentially be explained by an entitlement effect within the preferences of players, which expresses as a dislike for equal splits of pots, which were not created equally.

Declaration

I declare that except where appropriately acknowledged this thesis is my own work, has been expressed in my own words and has not previously been submitted for assessment.

Signature　　　　　　　　　　Date

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1 Introduction

Human history abounds with examples of resources being wasted in attempts to acquire a share of existing wealth, often with great opportunity cost in terms of productive possibilities. Since the pillaging of the European continent by Alexander the Great, societies and individuals alike have faced a difficult trade-off between the production of wealth, and the acquiring of wealth through other means (Roger et al. 2008). For centuries medieval Europe was plagued by bitter squabbles over land and precious metals, which left little time and energy for economic development, innovation or the generation of new kinds of wealth. Today the rule of law and property rights have partially solved the hold up problem, but the evolution of democratic institutions has turned our focus inward and the battle for resources is predominantly conducted between the citizens of states, rather than between states. Since 'no taxation without representation' the right for citizens to have a say in the direction of public spending has developed into an entitlement, incentivising individuals and multinationals alike to lobby governments for their preferred set of policies, often without regard for overall social welfare.

In the United States, political super PACs lobby exorbitantly to marginally increase the likelihood that their preferred candidate will gain office, often in the hope that future legislation will pose no financial harm to themselves. In 2007 it was estimated that 15,137 lobbyists were currently working in Washington D.C. (Shalal-Esa 2009) all working on the behalf of some interest group or another. As Tullock (1967) originally pointed out, the loss to social welfare that this behaviour generates is not limited to the risk of a non-optimal policy outcome, but extends to the loss of resources that arises through the competitive lobbying process - resources that might have been more productively invested elsewhere. The dilemma for firms and individuals is that the decision not to lobby, almost certainly implies that ones competitors will, meaning policies to ones disadvantage are likely to be implemented.

In 2009 the mining industry in Australia embarked on an expensive lobbying campaign with the intention of ensuring that new legislation would not result in them paying more tax. The end result of the campaign was a massive investment on behalf of the industry to ensure the implementation of policies that greatly resembled those already in existence, not to mention an arguably colossal waste of time and money on behalf of the government to produce a redundant policy.

Although in principle, the ability to lobby ones government for a say in the disposal of public money has the potential for improved outcomes for the less well-off and for society more broadly, in practice this is complicated by the fact that the access to resources required for lobbying are often asymmetrically distributed and a approximately a function of ones productive capacity, previous production decisions, or one's endowment. It is often said that the rich lobby more and more often than the poor. Commenters in the west periodically bemoan the loss of social welfare that arises as results of cooperate lobbying from powerful industries and interest groups. Conventional wisdom would he suggest that the protestations of the commentators seem to be justified.

Some empirical literature has considered the topic. Haile (2005) gives evidence of a negative correlation between inequality and redistribution, suggesting that as inequality increases, the likelihood that elites will allow for legislation, which enables redistribution of wealth, declines [1]

Baker (2015) argues that the recent upward trend in the distribution of income in the United States is driven by skilled professionals in industries such as finance and medicine lobbying for legislation that protects them from international competition at an expense to other parties. Notably, as globalisation has marched on, the general decline in the influence of industrial unions has produced the opposite result for those at the lower end of the earning spectrum.

However, the phenomenon of rent seeking is layered and complex due to confounding factors like institutional quality, culture and history and human psychology. With so many moving parts, there is some contention as to whether clear conclusions can be extracted from large-scale econometric studies, especially given the difficulty in measuring something as hard to define as institutional quality. Experimental economics has been able to offer important insights into the motivational and behavioural mechanics of contests by eliminating external factors and focusing on the behavioural incentives underlying rent seeking. In light of recent trends in the distribution of global income, a deeper analysis of the behavioural motivations and incentives that underpin the social phenomenon of rent seeking is warranted.

In this paper we develop a simple stylised model of production and rent

[1] He also finds that countries with higher levels of corruption have lower tax to GDP ratios and invest less in human capital, which hinders long-term growth, the case in point being Latin American countries which "have long histories of income inequality and find it difficult to raise taxes as policies are twisted toward the benefit of urban elites"(Haile 2005, p.1).

seeking where heterogeneity in wages is possible between agents and examine our theoretical results in a laboratory. In the first stage, agents produce and their output is taxed and combined with that of other players and goes towards a collective pot. In the second stage, the agents fight over the proceeds of their productivity at a cost in terms of their own effort in order to influence the direction of the taxes toward a preferred project. In our set up, the agents are taxed at the same rate, which means that higher earners contribute more tax. We use a standard Tullock contest function (1981) to model the contest for rents. In order to simplify factors that are likely to be endogenous in a more comprehensive analysis, such as institutional quality [2] in our model we set the strength of institutions as an exogenous term. The purpose of this is to boil the issue down to it's fundamental elements. Although our theoretical model is capable of examining different levels of institutional quality, in the laboratory we assume a weak institutional environment in which all tax revenue is up for grabs in the second stage through lobbying. Although of course in reality, governments are never completely for sale, this allows us model a situation and see how people might behave if they were.

Economic agents in our model face two trade-offs: Firstly, what amount of time and energy to invest in creative production now, knowing that in

[2] For recent examples of theoretical literature which focus on endogenous institutional quality, adversely affecting growth via impediments to the poor in terms of access to lobbying see: (Spinesi, 2009). Infante and Smirnova (2009) however present model in which lobbying in the presence of weak institutions can actually be beneficial for growth. Esteban and Ray (2006) theorise however that the misallocation of public resources arises from the inability of policy makers to distinguish worthwhile projects from the noise of wealthy rent seekers, despite their good intentions.

the future I will have to fight for some of the wealth which I am about to create, and in doing so, lose yet more time and energy? And secondly, once the time comes to fight, how much of what I have left in the tank am I willing to give up in order acquire a share of what is now in the collective pot? The goal of our study is to analyse the role that inequality in productive capacity plays in how firms and individuals synchronise their production decisions with their lobbying effort by simplifying the rules of the game. Specifically, we want to look at this, in the case that access to rents is not asymmetrically dependent upon, nor constrained by previous wealth outcomes. Moreover, we want to assume the presence of inequality and a weak institutional environment, such that the entirety of the pot is available to be fought over. The empirical aspect is made possible by testing the model on subjects in the laboratory environment.

Tullock contests were first examined in a laboratory environment by Milner and Pratt (1989), who found that under certain conditions, subjects tended to exert effort beyond the Nash equilibrium. Although over-dissipation of efforts is not strictly observed, there is an extensive body of literature documenting over-dissipation (Sherementa, 2014). Bayer (2016) found however that subjects on average invest quite close to the Nash equilibrium in a Tullock contest when the object of the contest's value is determined via a contribution decisions to a group project, which are sourced from an endowment.

Often in life the value of contested wealth is determined by an exertion of gruelling time and effort on the behalf of those that create it, not simply an investment decision. Tax revenue contributed as a result of every day work is no exception to this. An interesting question is, whether the way in which the value of a prize is determined, produces different effects in terms of how hard subjects are willing to fight for it at a later stage. For example, If the prize were determined during a real effort task. Recent behavioural studies on inequality such as that by Gee, Migueseis And Parsa (2015) and Erkal, and Gangadharan and Nikiforakis (2010) show that the presence of inequality tends to ellicit less support for redistribution measures than when income is determined randomly.

Heterogeneity in abilities among the general population, mean that those that are more able, or possess skills that are valued more highly and therefore earn higher income and usually contribute more tax. If the way in which incomes are determined plays a role for individuals in how hard they are willing to fight for a share at a later stage, then a further question arises: How do people at different income levels make production decisions in a lobbying society? The previous research on inequality in real effort tasks has yielded interesting results, for example, Liu-Kiel et al. (2012) found that when subjects who are receiving a lower piece rate for their efforts become aware of the inequality at a midpoint of the experiment of the experiment, they exhibit an immediate rise in effort, which is later off-set by a slump in the subsequent rounds of the game in comparison to treatments in which the inequality was not revealed.

Tullock contests and real effort tasks have been explored in the context of inequality in previous studies. The contribution of this paper is to combine these elements, which have been studied in isolation and focus on the effect that inequality in wages plays in a contest when the incomes of the players have been determined via the process of a real effort task. We draw upon methods used in previous experimental work, which we use as foundation and motivation for our research. We use the power that a real effort task contains in eliciting a more salient effect on the subjects' sense of ownership of their own productive efforts, to test whether this might have impact the way subjects behave in a subsequent contest, compared to when the object of the contest is determined via an investment choice, drawn from an endowment.

Our experiment consisted of three treatments in which players were randomly assigned one opponent within a subgroup; two in which subjects received the same wage, (either low or high) and a mixed wage treatment. In the mixed treatment subjects were randomly assigned a high or low wage, where one player receiving a high wage implied their partner received the low wage. Production was modelled by a real effort task in the first stage whereby subjects answered increasingly difficult addition problems. Production cost was modelled with an opportunity cost in terms of an endowment of free points, which the subjects forfeit at the rate of one per every second they choose to remain in the first stage. Lobbying effort was modelled by an effort decision in the second stage. The experiment is described in detail in the methodology section.

We find that there is significant over production from low wage subjects who competed against high wage subjects compared to the control group in which both subjects received the low wage. No other treatment conditions exhibited significant differences. In the second stage we find in conjunction with Bayer (2016) that on average players exert quite close to the equilibrium effort and that the level of waste within treatments can be ranked proportionately to the wage differences within treatments. Upon digging deeper we find that subjects who contributed relatively more than their opponent to tax revenue in the real effort task tended to exert relatively more effort in the lobbying stage, a result that hold across wage treatments.

The remainder of this paper proceeds as follows; the next section describes our model. The theoretical model contains the additional element of a public good, which allows us to conduct some welfare analysis. Section 3 outlines the experimental design along with our theoretical predictions and hypotheses. We also discuss in more detail the previous experimental literature. In section 4 we discuss or results and then in section 5 we make our concluding remarks.

2 The Model

In what follows we present a two-stage model of rent seeking with a public goods dilemma. The model draws heavily upon the one developed by Bayer (2016) which examines how players fight over the proceeds of a group project after investing from an endowment.[3] In the first stage, players invest in a productive activity and they are taxed at a common linear rate on their return. In the second stage, players observe the outcome and simultaneously exert effort into contesting for a portion of the total tax revenue taken from them in the previous stage. The share of the tax revenue they regain during the distributional contest is equal to the ratio of the effort they exert to the sum of effort exerted by all players, however players face a cost associated

[3]In our model we replace the endowment with private production, some of which goes to a common pot through taxation while the rest is kept by the players. We also incorporate the added element of a public goods dilemma. Note that if we set our tax rate to one and the institutional quality to 0, our model reduces to one nearly identical to Bayer's model

with lobbying effort exerted in the second stage (Tullock, 1981). Depending on it's institutional nature, the government may choose to allocate some tax revenue towards a public good, which brings an equal amount of utility to all players, while the rest is available for players to fight over.

We are seeking to explain situations in which individuals have an innate proclivity toward competing for a larger share of the tax revenue, therefore we implicitly rule out the possibility of binding contracts or amicable division of the tax take occurring. Player $i's$ optimization problem is defined as:

$$\max_{\{x_i,e_i\}} \quad U(x_i, x_{-i}, e_i, e_{-i})$$

In order to solve this problem, player i has essentially two decisions infront of them. Firstly, how much to invest in production and secondly, how much effort to put into aquiring a share of the total tax take through the lobbying process, after all players have produced and been taxed.

We denote player $i's$ input as x_i and their production function as $f(x_i)$, while effort exerted in the lobbying process is denoted by e_i. The wage that players are paid for their output is p_i and they face the cost of production and a cost for effort denoted by $c_i(x_i)$ and $c_i(e_i)$ respectively. Players are taxed on their production at the linear rate $t \in [0, 1]$, so the total tax take T is equal to $t\sum_{i=1}^{n} f(x_i)w_i$ and the distribution of $(1-r)T$ via the lobbying process is decided through the contest function $\rho(e_i, e_{-i})$. We denote the measure of government responsiveness to lobbying (or institutional quality) by the parameter $r \in [0, 1]$ where an r of 1 describes a situation in which all tax revenue is invested in the public good and an r of 0 describes a situation where every tax dollar is up for grabs through the lobbying process. Player $i's$ utility derived from the public good is denoted by $m \in [\frac{1}{n}, 1]$.

2.1 Timeline

1. Our game $G = \{I, S, U\}$, proceeds as follows: The players $I = \{1, 2, ..., n\}$; all simultaneously engage in productive activity, choosing an $x_i \in [0, \infty)$.

2. The outcomes from the first stage become known to all players including T, the sum of tax which has been taken from all players.

3. Players simultaneously choose the amount of effort $e_i \in [0, \infty)$ they wish to invest in lobbying for a share of T. A strategy for player i is a complete and contingent plan of action $s_i = (x_i, e_i(x_i, x_{-i}))$. The strategy space $S = \{S_1 \times S_2 \times ... \times S_n\}$ is the cartesian product of the strategy sets of all players, where the strategy set S_i is the set of all possible strategies $S_i = \{x_i, e_i(x_i, x_{-i})\}$ available to player i.

4. There is a realisation of a particular strategy profile: $s = ((x_1, e_1(x_1, x_{-1})), (x_2, e_2(x_1, x_{-2}), ..., (x_n, e_1(x_n, x_{-n}))$, which is mapped into real numbers through the payoff function:

$U(x_i, x_{-i}, e_i, e_{-i}) := \{(1-t)f(x_i)w_i - c_i(x_i) - c_i(e_i) + \rho(e_i, e_{-i})(1-r)T + rmT\}_{\{i \in I, i \neq -i\}}$

Resulting in player $i's$ payoff.

A Nash equilibrium for our game is a strategy profile $s = (s_1^*, s_2^*, ..., s_n^*)$ that satisfies:

$$U(s_i^*, s_{-i}^*) \geq (s_i, s_{-i}^*) \forall s_i \in S_i, \forall i \in I$$

Our contest function of choice is the standard Tullock (1981) contest function:

$$\rho(e_i, e_{-i}) := \begin{cases} \dfrac{e_i}{e_i + \sum_{-i \neq i} e_{-i}}, & \text{if } e_i + \sum\limits_{-i \neq i} e_{-i} > 0 \\ \dfrac{1}{n}, & \text{if } e_i + \sum\limits_{-i \neq i} e_{-i} = 0 \end{cases}$$

We can therefore write player $i's$ profit as [4] :

$$U_i = (1-t) f(x_i) w_i - c_i(x_i) - c_i(e_i) + \frac{e_i}{e_i + \sum_{-i \neq i} e_{-i}} t \sum_{i=1}^{n} f(x_i) w_i + rmt \sum_{i=1}^{n} f(x_i) w_i \quad (1)$$

[4]Note: we use U_i as shorthand for $U(x_i, x_{-i}, e_i, e_{-i})$

We also specify functional form for $c(e_i) = e_i$.

2.2 Equilibrium

For a solution concept we use Subgame Perfect Nash Equilibrium. Which differs from the standard Nash equilibrium in that it incorporates sequential rationality.

The order of events require that player i must engage in productive activity in the first stage, before the lobbying in the second. However, in order to choose how much to produce in the first stage, they must decide how much effort to invest in lobbying given any aggregate level of production in the first stage. Any possible combination of (x_i, x_{-i}) in the first stage creates a separate subgame. Therefore, the best response for player i in the second stage for any level of production in the first is determined by taking the first order condition of equation (1) and maximising with respect to e_i:

$$\frac{\partial U_i}{\partial e_i} = -c'(e_i) + \frac{\sum_{-i\neq i}^{n} e_{-i}}{(e_i + \sum_{-i\neq i} e_{-i})^2} t \sum_{i=1}^{n} f(x_i) w_i (1-r) = 0 \tag{2}$$

This gives the optimal lobbying decision for player i in the second stage resulting in a correspondence for both players. Finding the equilibrium efforts in would require us to solve N first order conditions for all possible efforts. However as all players face the same dilemma, we invoke symmetry:

$$e_i(x_i, x_{-i}) = e_{-i}(x_i, x_{-i}) = e^*, \quad \forall i, -i \in I$$

By setting all efforts equal and solving Equation (2) we obtain [5]

$$e_i^*(x_i, x_{-i}) = \frac{n-1}{n^2} t \sum_{i=1}^{n} f(x_i) w_i (1-r) \tag{3}$$

2.3 Some discussions on e^*

Observe that prior to making the assumption of symmetry, the best response for player i to any choice of effort for player $-i$ can be written as:

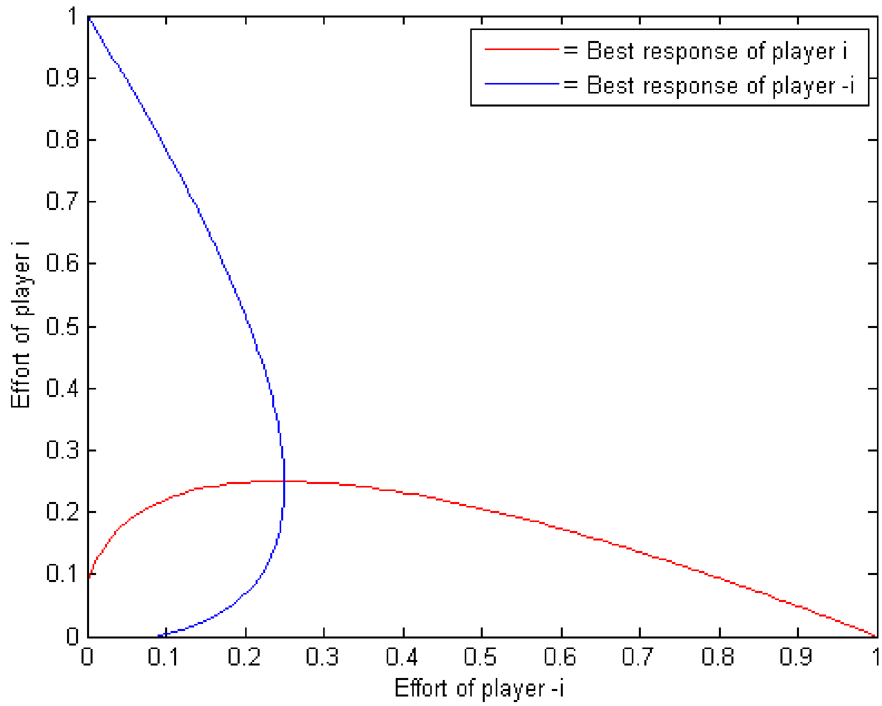
$$e_i(e_{-i}) = \sqrt{\sum_{-i \neq i} e_{-i} T(1-r)} - \sum_{-i \neq i} e_{-i} \tag{4}$$

Note that for any $e_{-i} \geq e^*$ in equation (4), the best response for player i is $\leq e^*$. In other words, the choice of an $e > e^*$ is a strictly dominated strategy and is not a best response to any e_{-i}, even in the case that the other player(s) were to choose an $e_{-i} > e^*$ themselves.

As a simple an illustration, consider the case in which $n = 2$, $I \in \{i, j\}$, $r = 0$ and $T = 1$, the resulting optimal effort would be $\frac{1}{4}$. Figure 1 shows the best response functions for players i and $-i$, for any level of effort from

[5]Note, we ill use e^* and e^*_{-i} as shorthand for $e_i(x_i, x_{-i})$ and $e_{-i}(x_i, x_{-i})$

Figure 1: Best response functions for players i and $-i$



0 to 1. The two best response functions clearly cross at the optimal strategy $\frac{1}{4}$ which is also the maximum possible amount of effort that any player could choose as a best response to the other player. Note that in this case the as $T = 1$ the graph illustrates that in the event of a player lobbying in excess of the actual value of T, the best response for the other player is to choose an $e_i(e_{-i}) = 0$. Also note that the best response function of player i to any e_{-i} is strictly concave, as shown below.

$$\frac{\partial e_i^*(e_j)}{\partial e_j} = \frac{1}{2\sqrt{e_j}} - 1 \geq 0, \quad \forall e_j \in (0, 0.25]$$

and

$$\frac{\partial^2 e_i^*(e_j)}{\partial e_j^2} = -\frac{1}{4(e_j)^{3/2}} < 0, \forall e_j > 0.$$

2.4 The production decision

Now that player i has a rule for how much to lobby given any level of production in the first stage, as well as the expectation that player$-i$ will lobby the same, an optimal level of production can be solved for in the first stage which eliminates the presence of e_i and e_{-i} from the profit equation, which simplifies to:

$$U_i = (1-t)f(x_i)w_i - c(x_i) + \frac{1}{n^2}t\sum_{i=1}^{n} f(x_i)w_i(1-r) + rmt\sum_{i=1}^{n} f(x_i)w_i \quad (5)$$

Player i now maximizes equation (5) by choice of x_i. The resulting first order condition:

$$\frac{\partial U_i}{\partial x_i} = (1-t)f'(x_i)w_i - c'(x_i) + \frac{t}{n^2}(1-r)f'(x_i)w_i + rmtf'(x_i)w_i = 0 \quad (6)$$

For illustration we define $f(x_i)$ as x_i and $c(x_i)$ as $\frac{x_i^2}{2}$, which yields the optimal production decision for player i:

$$x_i^* = (1 - t + \frac{t}{n^2}(1-r) + rmt)w_i \tag{7}$$

The analysis in the discussion below also holds other production functions that satisfy the Inada conditions.

2.5 Some welfare analysis

2.5.1 The social Planner's Problem

In order to have a benchmark for a world in which resources are not wasted though costly lobbying, consider the case in which a social planner constrains e_i and e_{-i} to be zero since lobbying merely functions as a costly allocation mechanism for existing resources and results in a lower social surplus for any e_i or $e_{-i} > 0$. This ensures an even split of the tax revenue put towards private goods between players while eliminating the incentive for players to bear the cost of the effort involved in attaining such a division. A social planner however, would choose parameters that maximise the sum of social welfare regardless of what might be individually beneficial. We can define the social planner's problem as:

$$\max_{\{x_i, e_i, t, r\}} \quad \sum_{i=1}^n U(x_i, x_{-i}, e_i, e_{-i})$$

Summing the profit functions of all players together we have:

$$\sum_{i=1}^{n} U_i = (1-t)\sum_{i=1}^{n} f(x_i)w_i - \sum_{i=1}^{n} c(x_i) + t\sum_{i=1}^{n} f(x_i)w_i(1-r) + nrmt\sum_{i=1}^{n} f(x_i)w_i \tag{8}$$

Therefore the social planner's producton decision of player i is revealed by the first order condition:

$$\frac{\partial \sum_{i=1}^{n} U_i}{\partial x_i} = (1-t)f(x_i)'w_i - c'(x_i) + tf(x_i)w_i(1-r) + nrmt\sum_{i=1}^{n} f'(x_i)w_i \tag{9}$$

Which, when solved with the same functional forms as in the individuals problem yields:

$$x_i^* = (1 - t + t(1 - r) + nrmt)w_i \tag{10}$$

2.5.2 The Social Dilemma

The social planner then chooses parameter settings that maximise the sum of social welfare. Suppose we have $m > \frac{1}{n}$, and individuals value the public project more highly than the private project. First note that:

$$\frac{\partial x_i}{\partial r} = (nmt - t)w_i$$

Production is increasing linearly as r increases. Therefore the social planner sets $= 1$. Next note that, with an $r = 1$ the marginal benefit from an increased tax rate:

$$\frac{\partial x_i}{\partial t} = (nm - 1)w_i$$

So production is linearly increasing in t. In this case the social planner would set the maximum tax rate of $t = 1$ resulting in a production decision of:

$$x_i^* = nmw_i$$

Therefore, the higher n is, the wage and the evaluation of the public project by individuals, the more will be produced. When we compare the x_i^* arising from the social planner's problem to the SPNE production decision in equation (7) and set with $r = 1$. It's clear that, even with very strong institutions, there is under production in the decentralised economy. Why is this the case? In the social planner's problem the utility of every player is taken into account through the term $nm \in [1, n]$ and is reflected in the x^* of all other players, whereas an individual only considers m the utility that they themselves derive from the public good.

2.5.3 Some observations on the SPNE production decision

For the individual, an increase in the tax rate has an impact on production on three fronts; disregarding the second stage, the tax creates an unambiguous disincentive in production. However the ability to regain some tax revenue by fighting for it in the second stage means the disincentive is at least partially offset. The third effect of the tax rate comes via the public good. Depending on the government's allocation of resources between public and private projects, as well as the utility that players derive from the public good, there is an incentive to increase production in the first stage in the knowledge that proceeds of taxation will bring benefits in the second stage, either public or private, even in the case that $t = 1$. Note that as institutional quality r increases, the individual production decision increases. This is because, even in the event of the most unfavourable possible assessment of the public good by players where $m = \frac{1}{n}$, no lobbying is required to attain it, so there are no wasted efforts.

2.5.4 Wasted efforts

In equilibrium the optimal lobbying effort is exerted by all players simultaneously, ensuring that the tax revenue is divided amongst the players evenly, yet the act of exerting effort in lobbying requires that players lose e_i^* in the process, which creates waste. Clearly then both players should prefer to lobby zero and achieve an equivalent share of the private good without having to fight for it, in which case some sort of agreement to lobby zero would seem preferable. A dilemma arises however through the inevitability that if there is any tax revenue to be won and institutions are at all weak, both players have an incentive to deviate from an agreement and lobby a small amount in order to gain of all of the tax revenue. Instead players converge their lobbying efforts on the SPNE and the share of the tax revenue gained from lobbying minus the amount that must be lobbied in equilibrium is strictly less than an even split. There are two situations under which the players are spared from the necessity of wasting resources in the lobbying process; one where $t = 0$ and the other where $r = 1$. Supposing we consider a situation in which institutional quality is very low and taxes are very high, we should expect to see high levels of wasted efforts.

2.6 What effect does inequality in wages have?

The players in our model ultimately have two key decisions to make: How much to produce, and how much to lobby. So how does the existence of inequality effect these decisions?

An interesting aspect of the optimal lobbying amount e_i^* is the degree to which it is affected by w_i and w_{-i}. In the first stage each player makes a production decision, optimizing with respect to their own wage, the wage of the other player does not appear in each players x_i^*. In the second stage a player considers the total tax revenue available through lobbying, but they only consider w_i to the extent that all players must take the same information into account. As such, in the choice of lobbying effort w_{-i} is worthy of the same consideration as w_i. A higher w_i changes player $i's$

production decision, but increases T for all players. Thus, although players may face different wages, resulting in differing levels of production, the optimal strategy in the second stage remains e^* for all players regardless of whether any contributed more tax than other players in the first stage. In other words,

$$\frac{\partial e_i^*}{\partial w_i} = \frac{\partial e_{-i}^*}{\partial w_i}$$

and

$$\frac{\partial e_i^*}{\partial w_{-i}} = \frac{\partial e_{-i}^*}{\partial w_{-i}}$$

If we then consider an environment with very weak institutions where $r = 0$, what effect does inequality in wages or productivity have on welfare? According to our results, when both players exert the SPNE effort, the tax revenue is divided up evenly. Although this comes at a cost to both players in terms of sunk effort, if either were to receive disutility from the existence of inequality, then weak institutions with a higher taxes might actually be preferable, in that it reduces inequality, even at the cost of receiving lower income. What the production decision? According to our results, when a player is maximising their payoff, their production decision should be made in complete independence of any disparity in wages. In other words:

$$\frac{\partial x_i^*}{\partial w_{-i}} = 0.$$

3 Experimental design and hypotheses

Next we take our theoretical predictions and test them in the lab. Firstly, our purpose is to transform our theoretical model into something, which can be tested on subjects. In order to achieve this we employ the use of a real effort task, which induces behaviour from the participants possessing the properties of the functional forms we chose for illustration in our theoretical model.

The real effort task can be described as follows: Subjects are given the task of adding up numbers that appear on a computer screen. The first task they solve is the addition of 2 numbers, after solving that they are shown 3 numbers to add up and the following tasks all involve addition problems which contain one more number than the task before. Thus each problem that the participant solves (up to a maximum of 20) is more difficult than the one before it and necessarily takes the subject more time to solve than the one before it. During each production round of the experiment, participants are given 240 seconds to solve however many questions they choose to. Participants are also allowed to leave the production stage at any point they choose. If they do, they are awarded 1 point for every second that remains on the clock if and when they leave the stage. Effectively this amounts to the players having an endowment of 240 points, which they sacrifice at the rate of 1 point per second every time they choose to answer another question, which in our experiment is the marginal cost of production. Equation (5) in the model section shows the payoff for player i after the optimal lobbying effort e_i^* has been factored in and Equation (6) gives the optimal production decision. Our experimental transformation of equation (5) (with a setting of $r = 0$) can model can be written as:

$$q_i\big(1 - t + \frac{t}{n^2}\big)w_i - c(q_i(\tau))$$

Where $q_i = f(x_i)$ and $c(q_i(\tau)) = c(x_i)$ and τ represents time. The use of a real effort task in this way means that we are modelling the payoff from production (the amount of questions that subjects choose to answer) as linear. However the cost of production $c(q_i(\tau)$, which is effectively the total accumulated endowment points that a player has sacrificed in solving questions, at the point that they decide to leave the stage, is non linear and increasing with time. Taking the derivative of this with respect to q_i and maximising gives:

$$\big(1 - t + \frac{t}{n^2}\big)w_i = c'(q_i(\tau))$$

The term on the left is the marginal benefit from answering another question, which, is linear. The term on the right is the marginal cost of answering an additional question, which is increasing in time due to the increasing difficulty of the tasks. Heterogeneity in abilities means that some subjects will be capable of solving more questions than others. However, the time that it takes a subject to solve the last question that they solve, before leaving the stage tells us how close to optimality they are, regardless of their ability, as the key determinants of this are the wage w_i, the number of opponents n and the tax rate t. When behaving optimally, subjects should leave the stage when the marginal benefit of answering another question is greater than the marginal cost of doing so. In our experiment, this means that when answering a question results in a lower payoff in terms of points than what they give up in terms of endowment points (points they would receive for the equivalent amount of time had they left the stage), then they should leave the stage. We define the amount of time that a subject takes to answer the last question they answer in the production stage as *time_cost* and we will use this variable to construct our main hypotheses.

As participants answer questions, each question they solve costs them a certain amount of endowment points. As the difficulty of the questions increases, the cost that participants incur as a result of answering an additional question is increasing at an increasing rate (assuming that the actual effort that participants put into answering questions is constant through out the stage). The effort decision of the players in the second stage is captured by an investment decision, which limited to between 0 and 5000 for all players.

As we want to examine a setting with very weak institutions, we set $r = 0$ which means that all the tax generated is up for grabs through effort in the second stage. For simplicity, we opt for an n of 2. Our variable of choice for variation between treatments is the wage. We denote $I = \{h, l\}$, where $h =$ the high-wage and $l =$ the low-wage. We assign a high wage of $w_h = 50$ and a low wage $w_l = 30$ in order to make the impact of inequality as salient as possible without inducing a reluctance to participate from subjects. A t of 0.5 was chosen to ensure that the subjects feel the impact of the tax in the first stage and to ensure a significant tax contribution worth fighting over in the second stage.

From the perspective of the players, the stages of one round of the experiment the progress as follows:

1. Players engage in the real effort task in the production stage. This screen contains information about their own wage, the amount they are being taxed and the cumulative total of both of these.

2. After all players have left the first stage or the time limit is up, they are shown the results of the production stage for themselves and for the player they were matched with, including the other players wage, the points that they both earned and how many of their own points was sent to the collective pot.

3. Players are shown a screen on which they choose the level of effort they want to invest into acquiring a share of the collective pot. They are also provided with a profit calculator, which allows them to work out the expected payoff they would receive for any hypothetical choice of their own and the other player's effort.

4. After both players make an effort choice, they are shown the results of the game, detailing how much was gained and lost through effort.

Three wage treatments were run: Two in which subjects were assigned the same wage as their opponent; either $w_h = 50$ or $w_l = 30$ which we will refer to as *low_low* and *high_high* treatments and another mixed group in which subjects were randomly assigned either w_h or w_l, where being assigned one wage implied that the other player was assigned the other wage which we will refer to as either *low_high* or *high_low* :*low_high* if I am referring to a subject who received the low wage within the mixed wage group and *high_low* if I am referring to a subject who received the high wage within the mixed group. This design allows for isolation of the effect that inequality in wages plays independent of the magnitude of the wage.

In each treatment we ran three sessions with between 16 and 24 subjects. In each period, the subjects were randomly matched with a new partner from within a sub group of four. In the mixed wage session's subjects were also randomly assigned a new wage at the beginning of each period. An independent observation consists of the average response of a subgroup of subjects over the three periods, i.e.

$$\frac{\sum_{t=1}^{3}\sum_{i=1}^{n} x_{it}}{T \times N}.$$

The treatments were computerised and written in Z-tree (Fischbacher, 2007). Participants were given written instructions and were also read the instructions aloud by the researcher at the beginning of the experiment. Given the complexity of the task and to eliminate potential confusion, the experiment was preceded by a practice round in which participants could ask questions individually and become acquainted with the various screens and rules of the game. Neutral language was deliberately used in the instructions to avoid eliciting any behaviour as a response to personal associations with words such as 'tax' or 'wage'.

With 188 subjects participating in the experiment over two days, allowed for a total of 66 independent observations; seventeen *low_low*, seventeen *high_high*, sixteen *low_high* and sixteen *high_low* . Subjects were recruited using ORSEE (Greiner, 2015). Participants were mainly undergraduate and postgraduate students of the University of Adelaide and the University of South Australia. Points earned in the experiment were exchanged for Australian dollars at the end of the session. On average, subjects earned a little under \$20 Australian from participating and the experiment, including reading instructions took about an hour. Participants also filled out a routine questionnaire after the experiment, detailing individual characteristics including age, gender and mathematical ability.

3.1 Hypothesis specification

The theoretical results discussed above give rise to some interesting empirical questions, which in light of existing research, we have reason to think might yield different results in a behavioural setting. Our focus is the role that wages play through two channels: Determining the optimal production decisions in the first stage, and determining the optimal lobbying effort in the second stage. Is it realistic to assume that people generally make these decisions without being influenced by the fact that the inequality in wages means certain players are inherently disadvantaged and certain others commit more to the tax revenue as a result? Our first hypothesis is focuses on the production decision of players, the second focuses on the lobbying effort. Discussed below is some of the key literature, which forms the basis for our experimental design and hypotheses. We lay out the our main hypotheses for behaviour in the first stage as follows:

3.1.1 Hypothesis 1

As mentioned earlier, Liu-Kiel et al. (2012) find that low wage subjects exhibit a sporadic rise in productivity, followed by a decrease when they become aware that they are being paid less than an opponent, we might also observe some discouragement effects on our low wage subjects. A key difference in our design however, is that subjects are aware of the presence of inequality from the beginning of our experiment and a new wage is assigned at the beginning of each round, whereas in the Liu-Kiel et al. (2012) study, subjects were stuck with there assigned wage for the duration of the experiment. The permanency of a low wage could potentially elicit different behaviour than our randomly assigned one, as the possibility that the next round could bring better luck might make subjects less likely to reduce their efforts. Their study also extended over ten rounds, the second five of which the subjects were aware of the inequality, overall lasting several hours. The potential for fatigue or boredom to affect energy levels in the later rounds has the potential to exaggerate a discouragement effect. In comparison our experiment consisted of three rounds and a session lasted about an hour, which decreases the risk of fatigue or boredom affecting the results.

In another study Greiner, Ockenfels and Werner (2010) found that once transparency of wages was introduced in a real effort task, both high and low wage participants increased their efforts, although low wage subjects increased quantity at the cost of quality. In contrast to Liu-Kiel et al. (2012) however, they find that inequality elicits an increase in productivity from both the high wage and the low wage subjects. Charness and Khun (2007) on the other hand in a study on wage transparency found no evidence of the effect of wage transparency on the individual productivity.

Fehr and Schmidt (1999) offer a theoretical framework through which off-equilibrium behaviour can be explained by incorporating awareness of inequality in outcomes into the utility of economic agents. They observe that in large markets, people are able to make decisions without directly considering the welfare of others, but in close contact negotiations, they may adjust their decisions to take into account disparities in wealth outcomes between themselves and others. Given that in our experiment, subjects are in close physical proximity and many attend the same university, they may exhibit behaviour explainable by inequality averse preferences. On the other hand, if we observe highly competitive behaviour in which players attempt to maximise the difference in payoffs, it could be explained by competitive preferences.

According to our theory, players following the SPNE should make their production decisions independently from the wage of the other player, so we should expect see no significant difference in the production decision the subjects receiving the low wage in the mixed treatments and the subjects in the low wage control. Likewise we should expect to see no significant difference in the behaviour of the high wage subjects in the mixed group and the high wage subjects in the high wage control group. Our variable of interest is the cost that players are willing to bear in order to answer another question. For the subject assigned w_l optimality requires that players should leave the stage when answering a question costs them more than their marginal benefit. In light of the fact that previous studies have presented mixed results as to the effects of real effort tasks on inequality, we explore the possibility of several different potential production decisions from our subjects.

1. $\boldsymbol{H_{1(N)}}$: **Players follow the Sub-Game Perfect Nash Equilibrium production decision (SPNE).**

$$time\_cost_i = (1 - t + \frac{t}{n^2})w_i$$

   This requires that players anticipate equilibrium effort decisions in the second stage and make their production decision accordingly.

2. $\boldsymbol{H_{1(A1)}}$: **Players make the bounded rational (selfish) production decision ignoring future profits.**

$$time\_cost_i = (1 - t)w_i$$

3. $\boldsymbol{H_{1(A2)}}$: **Players make the bounded rational (selfish) production decision, ignoring the expenditure in the second stage:**

$$time\_cost_i = (1 - t + \frac{t}{n})w_i$$

   This hypothesis has the added caveat that subjects might exhibit this behaviour for different reasons: Firstly, players might be predicting minimal or zero efforts from the other player in the second stage resulting in an even split of the tax revenue between players. On the other hand, players might have 'other regarding preferences' which they express through the act of producing for the benefit of the other player. Although experimentally, there is no way to extricate these to effects, they are both possible under bounded rationality.

4. **$H_{1(A3)}$: Players make the socially optimal production decision:**

$$time\_cost_i = w_i$$

   Here the the players produce to maximise social welfare which, in this case is the joint payoff of the players, without concern for how the tax revenue is divided up in the second stage [6]

5. **$H_{1(A4)}$: The players production decision is influenced by wage inequality:**

   Inequality averse preferences

   Recall that in equilibrium, a player's production decision should depend on that players wage and not the wage of the other player. In our design, we can isolate the impact of both advantageous and disadvantageous wage inequality. This allows us to isolate any potential deviation from this by subjects, as we can compare the production

[6] This comes from the social planners production decision in equation (10) when setting $r = 0$

decisions of the *low_high* treatments with that of the *low_low* treatments, and we can compare the production decisions of the *high_low* subjects to the *high_high*s. If we do observe differences, a potential explanation for this behaviour could be inequality aversion as defined by Fehr and Schmidt (1999). In their model, agents receive utility deductions form observing differences in the monetary payoffs between themselves and the other player. The parameter α_i represents the disutility that player i feels in response to having less than the other player, and β_i represents the disutility that player i feels in response to having more than the other player. Here $\beta_i \leq \alpha_i$ and $0 \leq \beta_i < 1$. Therefore agents experience more disutility from having less than the other player, than they do from observing that the other player has less.

Incorporating inequality aversion into our model with $w_l < w_h$ results in optimal production decisions for the players denoted by [7]:

$$time\_cost_l = \left(\frac{1-t}{1+\alpha} + \frac{t}{n^2}\right) w_l$$

and

$$time\_cost_h = \left(\frac{1-t}{1-\beta} + \frac{t}{n^2}\right) w_h$$

[7] Here for simplicity we make the assumption that subjects make the SPNE effort decision and ignore the effects of inequality aversion on efforts in the second stage.

This results in the player with the higher wage producing beyond equilibrium for the benefit of the other player, despite it being privately damaging. This is because, when inequality factors in utility, the disutility from producing at the SPNE gives less that would be achieved from producing more, and decreasing inequality. The lower wage player on the other hand would decrease their production in the knowledge that, beyond a certain point producing more increases the income of the other player through tax revenue, such that the effect of inequality outweighs the private benefit gained from production in their own utility function.

Competitive preferences

Charness and Rabin (2000) give a potential explanation as to why we might see subjects making a production decision which sacrifices their own payoff for the purpose decreasing the total tax revenue, and as a result, the payoff of the other player. Competitive preferences can be expressed similarly to those of inequality aversion, with the same requirements on α_i and β_i with the main difference being that the sign on β_i is reversed. The essential idea here is that players still receive disutility from having less than the other player but gain utility from having more. In our model this results in a production decision form the higher wage player that maximise the inequality of the results, and a production decision from the lower wage player identical to the one in case of inequality aversion. In this case both players decrease their production decisions downward out of competitiveness, resulting in:

$$time\_cost_l = \left(\frac{1-t}{1+\alpha} + \frac{t}{n^2}\right) w_l$$

and

$$time\_cost_h = \left(\frac{1-t}{1+\beta} + \frac{t}{n^2}\right) w_h$$

The player with the high wage is under producing, sacrificing private benefit for the utility of increasing the distance between them and the other player. The player with the low wage is doing the same, intent on engineering the opposite result.

The predictions of our primary hypotheses for the given values of our parameters are set out in table 1, by treatment condition.

Table 1: Predicted *time_costs* by treatment condition

Wage	$H_{1(N)}$ $SPNE$(selfish)	$H_{1(A1)}$ Ignoring future profit	$H_{1(A2)}$ Ignoring future effort	$H_{1(A3)}$ SociallyOptimal
low_low	18.75	15	22.5	30
low_high	18.75	15	22.5	30
high_low	31.25	25	37.5	50
high_high	31.25	25	37.5	50

3.1.2 Hypothesis 2

For our second hypothesis we are interested in whether players on average tend to exert equilibrium effort. Recall that the theory predicts that the optimal effort decision should be in isolation of the relative contribution that players make to the tax revenue. However, over exertion of effort in Tullock contests has been observed consistently in the literature since Millner and Pratt (1989). This history of over exertion is well documented by subsequent researchers such as Shermenta (2014) who found that in some circumstances over dissipation of effort is so high that subjects occasionally receive a negative payoff [8]. Given that the contest in our experiment is fundamentally a form of costly redistribution and in addition, that we incorporate the effect of a real effort task, which has been shown to increase efforts, we might expect to see significant over dissipation also. Our hypotheses for effort decisions in the second stage are laid out as follows.

1. **$H_{2(N)}$: On average players exert SPNE effort in all treatments e^* in the contest stage**

If we observe this outcome it would imply aggregate effort exerted in the contest stage could be ordered by treatments: High-wage, Mixed and low-wage. This result flows logically from the fact that the amount of tax revenue available for fighting over will be higher in the high wage and mixed treatments than the low wage treatments.

1. **$H_{2(A)}$: Subjects on average depart from the equilibrium effort**

[8] For a detailed chronicle off over dissipation in contests see Dechenaux, Kovenock and Sherementa (2014)

***e^** in the contest stage, either overall or dependent on the treatment.**

Observing this outcome generally or within treatments would imply that aggregate effort exerted in the contest stage could not be ordered by treatments.

3.2 Econometric model specification and tests

To examine our first hypothesis we conduct some non-parametric tests Mann-Whitney-Wilcoxen tests for differences in the medians between treatments, on both *time_cost* and q_i to see if there are any significant treatment effects. Next we conduct some regression analysis on q_i(questions answered). For robustness we run OLS with errors clustered on the individuals, OLS with errors clustered on the matching groups (the sub groups that subjects are allocated to, from which their opponents are selected) and a multilevel model. The purpose of running these statistical models is to allow for heterogeneity, which we expect there to be within individuals and within matching groups. Individuals are likely to have characteristics that will remain constant over the periods of the experiment, which may therefore bias observations in a particular direction. We can also expect some unobserved heterogeneity arising through a group effect. This might occur due to more (or less) aggressive players eliciting responses from their opponents that loop within a group over periods. OLS clustered at the individual level will correct for the non-independence of observations of individuals through periods, while OLS with errors clustered on groups will correct for the group effect. The mixed effects model allows us to control for this potential heterogeneity under the assumption the error terms are uncorrelated with each other and the regressors. In all three specifications, our model contains interaction dummies for the wage treatments as well as dummies for age groups, mathematical ability, gender and a period dummy. Inserting the mathematical ability dummy allows us to control for some of the potential heterogeneity in abilities that will cause subjects to answer more questions than others. The age dummies allow us to control for potential differences in personal costs of effort in the real effort task that might be higher for older participants. The gender dummy allows us to control for differences that may exist in maths education that potentially exist across the population. We also run Wald tests for significant differences between the coefficients of the treatment condition dummies. We then run the same model specifications with *time_cost* as our dependent variable. The benefit of looking at *time_cost* is that, although in q we should expect to see some significance in mathematical ability, *time_cost* is a test for optimality which is not a question of ability. Again we run Wald tests for differences in the coefficients between the treatment condition coefficients.

To examine our second hypothesis we analyse how close participants efforts are on average to the optimal effort by testing the slope and distribution of the optimal effort plotted against the observed effort overall, and between treatment conditions. For deeper analysis of the relationship between effort and production, we construct some additional variables and do some further regression analysis. We define:

$$\phi_i = \frac{e_i}{e^*} = \frac{e_i}{0.25T}$$

as the ratio of the observed effort that a player exerts to the optimal effort given the total tax revenue. Secondly we construct the variable:

$$\theta_i = \frac{c_i - c_{-i}}{c_i + c_{-i}}$$

where c_i the contribution of the individual $= tq_iw_i$. The parameter θ_i gives the relative contribution of tax revenue to the total and can be interpreted in the following way: In the event that the players make equal contributions the relative contribution is equal to zero. Any combination of contributions from player i and player$-i$ results in a $\theta \in (-1, 1)$, a $\theta = -1$ in the case of a 100% contribution from player i, where $\theta = 1$ in the opposite case, so the measure has the benefit of capturing the relative contribution of tax revenue in positive and negative directions [9].

4 Results

4.1 Non-parametric tests

Our most important variable for consideration when looking at our results in the *time_cost*, as it does not contain the same noise of heterogeneity in ability that q does. Figure 2 plots the average *time_cost* for the different treatment effects across three rounds and illustrates a powerful effect. Subjects with the *high_low*, *low_low* and *high_high* wages seem quite close to SPNE at first glance, in general leaving the stage within one or two seconds of the individually *time_cost*. The key contrasting behaviour is between

[9] The exact econometric models specifications can be found in the appendix.

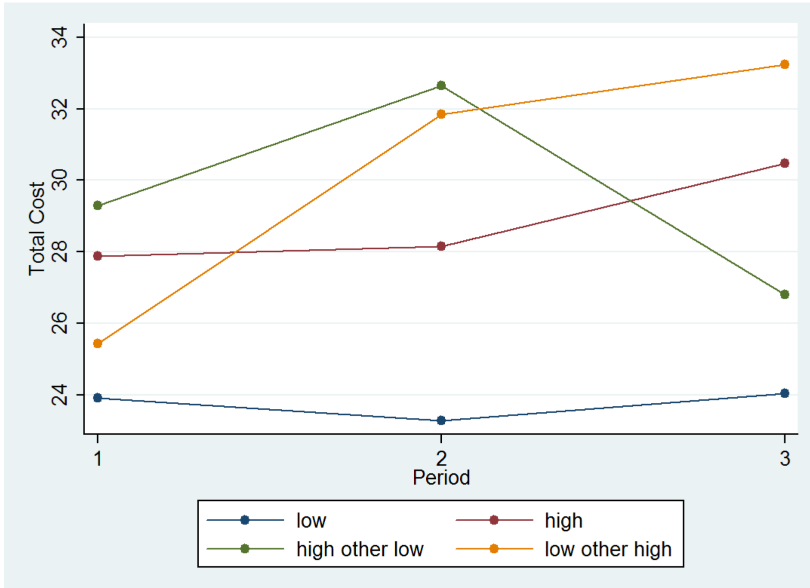


Figure 2: Average *time_cost* by treatment condition and period

the subject assigned the *low_low* wage (where the other player received the same wage) and the subject assigned the *low_high* wage (where the other player received the high wage) in the third period. The *low_high* subjects exert well beyond SPNE *time_cost* and most importantly, well above the observed *time_cost* of the *lowlow* subjects ($p < 0.0776$, M-W test, two-sided). In period 1 there seems to be little difference between the *time_cost* of the *low_low* and the *low_high* subjects, but in both period 2 and 3 the *low_low* subject moves above the socially optimal time cost and end up producing for the benefit of the other player, when it would be optimal to leave the stage. There was no significant difference between the behaviour of the *high_low* wage subjects and the *high_high* subjects, showing that the effect of wage inequality is pronounced only for those that are coming from behind in that respect.

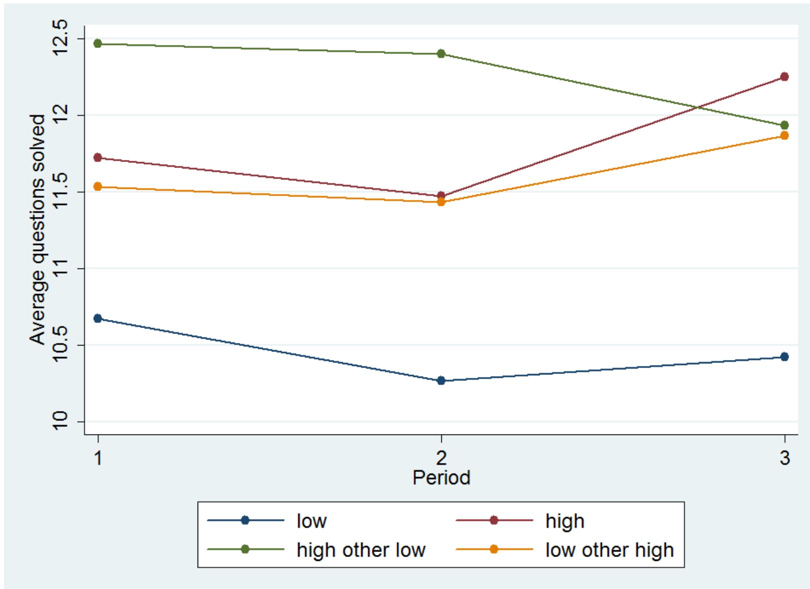


Figure 3: Average q by treatment condition

Next we take a look at the average q by treatment. Theory predicts that we should see no systematic difference between the *low_low* and the *low_high* subjects, as well as no difference between the *high_high* and *high_low* subjects. Results from M-W tests on questions answered, reveals no significant difference in the medians in the treatments. Figure 3 shows the average number of questions answered by subjects within treatments by period. Visibly we can see however, that the *low_high* subjects tend to answer more questions than the *low_low* subjects on average, an M-W test however reveals only weak significance over all. *high_low*, *high_high* and *low_high* subjects on the other hand are quite close to each other on average.

Figure 4 however, illustrates what the M-W test doesn't quite capture. The medians are similar within treatments but the distributions are clearly

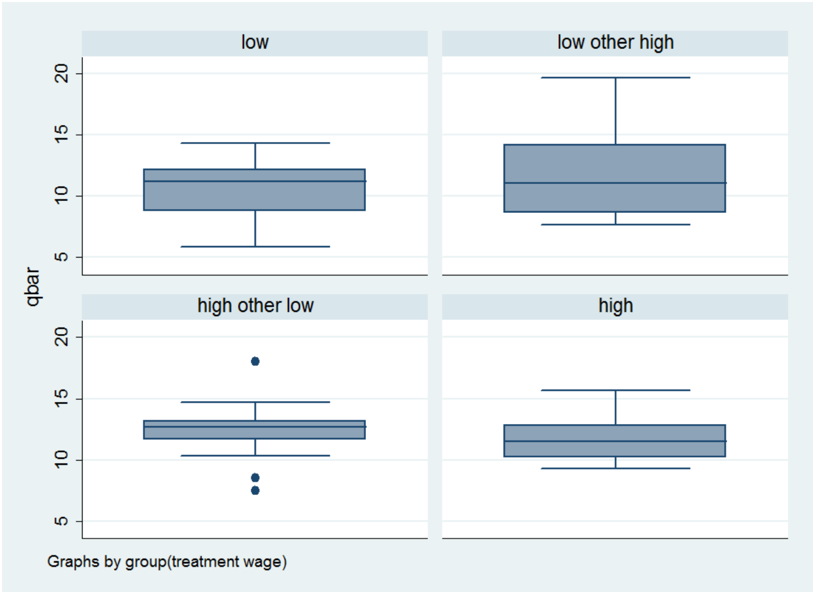


Figure 4: Average q box and whisker (by treatment condition)

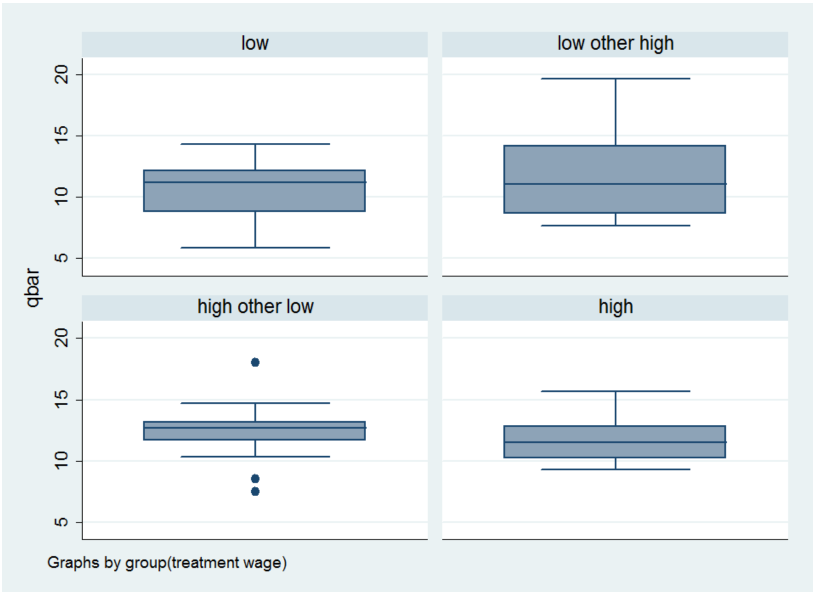


Figure 5: Average *time_cost* box and whisker by treatment condition

different. There is positive skewing in the direction of more questions answered, suggesting less consensus between subjects on the optimal amount of questions to answer within a period given the existence of inequality. The same effect is present in the *time_cost* plot shown in Figure 5, which gives a similar picture for the distribution in the *high_low* case. The presence of inequality, within either the *low_high* and *high_low* subjects seems to elicit more variation in responses than in the case of *high_high* and *lowlow* both in terms of optimal *time_cost* and average questions answered.

4.2 Regression analysis

Firstly we look at the results from our regressions on q_i. The results in table 2 show that the coefficients are all moving in a similar direction, indicating that our results are not dependent on the model specification (the base treatment condition is *low_low*, and the base age group is 16-25). As expected OLS with errors clustered over groups gives slightly higher standard errors. The results indicate that males answer about two more questions on average. The intuitive result that people with mathematical ability answer more questions on average aligns with expectations. All of the wage treatments have a positive effect and are significant to varying degrees, however we are primarily interested in whether there is a significant difference in the effect of any treatments compared with others. Some Wald tests on the wage treatments reveals no significant differences between the *high_high*, *high_low* and *low_high* treatments, but a significant difference between the *low_high* and *low_high* treatments ($p < 0.03$), in contrast to the M-W tests we observe some significance here.

Results from the *time_cost* regressions are shown in Table 3 (again,

Table 2: Regressions for q (questions answered)

	OLS Cluster(ind.)	OLS Cluster(gr.)	Mixed effects
q(questions answered)	coeff/s.e.	coeff/s.e.	coeff/s.e.
low_high	1.5285*	1.5285*	1.8234**
	(0.7904)	(0.8491)	(0.8455)
high_low	2.3799***	2.3799***	2.2137***
	(0.6990)	(0.7842)	(0.7660)
high_high	1.9840***	1.9840**	2.0305***
	(0.6751)	(0.7692)	(0.7633)
age: 25-30	-1.1507	-1.1507	-1.1102
	(0.8383)	(0.9111)	(0.8967)
age:31-40	0.8769	0.8769	0.7644
	(0.7805)	(0.9478)	(0.9185)
age: 41-50	0.7057	0.7057	0.4905
	(1.3668)	(1.3816)	(1.3045)
age: 51-60	0.5003	0.5003	0.2554
	(1.6978)	(1.6767)	(1.5557)
Male	1.4484***	1.4484**	1.4308**
	(0.5388)	(0.6112)	(0.5910)
Math	1.9308***	1.9308***	2.0041***
	(0.6133)	(0.6050)	(0.5763)
period 2	-0.2500	-0.2500	-0.2500
	(0.1844)	(0.1938)	(0.1919)
period 3	0.0638	0.0638	0.0638
	(0.2013)	(0.2173)	(0.2152)
_cons	8.0157***	8.0157***	7.9751***
	(0.7945)	(0.9353)	(0.9089)

$^{*}p < 0.1,^{**} p < 0.05,^{***} p < 0.01$

the base treatment condition is *low_low* and the base age group is 16-25). The coefficients are similar across regressions indicating robustness of our results with less difference in the standard errors between the different regressions, indicating that the effect of the individual or the group is less pronounced when it comes to the amount of time that subjects remain in the stage than the amount of questions they answer. Wald tests on wage treatments reveals a similar story as that found in the M-W tests, showing no significant differences between the *high_high*, *high_low* and *low_high* treatments, but a significant difference between the *low_low* and *low_high* treatments ($p < 0.02$). Interestingly, when it comes to *time_cost*, mathematical ability and gender are no longer significant, this matches with expectations, as when a subject more dependent on behavioural factors and preferences than on mathematical aptitude.

4.3 Results: Hypothesis 1

We are now able to make some conclusions about our hypotheses. Table 4 shows the results of two sided t-tests for our first four hypotheses by treatment condition with p values beneath. Firstly we examine the null hypothesis $H_{1(N)}$ that players on average exert the SPNE *timecost*. For both the *low_low* and the *low_high* treatments we can rule this out for at a 1% level of significance, however for the *high_high*'s and the *high_low*'s we fail to reject the null that these players opt for the SPNE selfish *time_cost*. We reject our $H_{1(A1)}$ that players on average make the bounded rational production decision ignoring profits in the second stage in all four treatment conditions at a 1% significance level for the *low_low* and the *low_high*'s and at a 5% level for the *high_high*'s and the *high_low*'s. For $H_{1(A2)}$, that

Table 3: Regressions for *time_cost* (last question)

	OLS Cluster(ind.)	OLS Cluster(gr.)	Mixed effects
time_cost(last question)	coeff/s.e.	coeff/s.e.	coeff/s.e.
low_high	6.3566*	6.3566**	6.6432**
	(3.6767)	(3.1219)	(3.0290)
high_low	5.6592**	5.6592**	5.3641**
	(2.5201)	(2.3894)	(2.3370)
high_high	4.9182**	4.9182**	4.9114**
	(2.0019)	(2.2382)	(2.2166)
age: 25-30	0.3152	0.3152	0.3228
	(2.6638)	(2.4191)	(2.3970)
age:31-40	1.6522	1.6522	1.6635
	(2.8083)	(2.6639)	(2.6561)
age: 41-50	-0.5499	-0.5499	-0.6151
	(6.2787)	(6.2795)	(6.2188)
age: 51-60	-5.6856**	-5.6856**	-5.6453**
	(2.4884)	(2.7239)	(2.6884)
Male	-0.6494	-0.6494	-0.6541
	(1.9320)	(1.8149)	(1.8001)
Math	-1.8292	-1.8292	-1.8500
	(2.4140)	(2.2033)	(2.1832)
period 2	1.4391	1.4391	1.4391
	(1.5296)	(1.6754)	(1.6589)
period 3	1.7852	1.7852	1.7852
	(1.3423)	(1.4168)	(1.4029)
_cons	24.4432***	24.4432***	24.4636***
	(2.8605)	(3.0932)	(3.0658)

$^{*}p < 0.1,^{**}p < 0.05,^{***}p < 0.01$

Table 4: Results from two sided t-test by hypothesis and treatment condition

Treatment Condition	Observed mean *time_cost*	$H_{1(N)}$	$H_{1(A1)}$	$H_{1(A2)}$	$H_{1(A3)}$
low_low	24.00465	18.75	15	22.5	30
$Pr(\|T\| > \|t\|)$		0.0007	0.0000	0.2518	0.0002
low_high	29.49162	18.75	15	22.5	30
$Pr(\|T\| > \|t\|)$		0.0019	0.0001	0.0273	0.8613
high_low	29.82979	31.25	25	37.5	50
$Pr(\|T\| > \|t\|)$		0.4581	0.0205	0.0009	0.0000
high_high	28.76798	31.25	25	37.5	50
$Pr(\|T\| > \|t\|)$		0.1223	0.0248	0.0000	0.0000

players either make a production decision that anticipates no fighting in the second stage or have some other regarding preferences, we reject at a 5% significance level for the *low_high*'s and at 1% for the *high_high*'s and the *high_low*'s but we fail to reject the possibility that the *low_low*'s make this decision. Finally, the the $H_{1(A3)}$ that any of the players make the socially optimal production decision can be rejected at a 1% level of significance for all treatment conditions except for the *low_high*'s. At least one of our four primary hypotheses can arguably explain the results for all of our treatment conditions. The null of SPNE (selfish) potentially captures the behaviour of the high wage subjects in either treatment condition, however, they are clearly a little under the Nash on average, suggesting some other drivers in their behaviour. The *low_low* subjects on average opt for a *time_cost* that can be explained by $H_{1(A2)}$ - the hypothesis that players either expect zero fighting in the second round or having some other regarding preferences. However, the fact that we only observe this in the *low_high* subjects is cause for caution, as the observed *time_cost*s are not a great deal higher than the SPNE *time_cost*.

The behaviour of the *low_high* subjects seems explainable by the socially optimal *time_cost* at first glance. This means that the *low_high* subjects produce beyond SPNE *time_cost* and more for the benefit of the other player than themselves. It is not clear why this effect should be elicited from the treatment of having a lower wage than an opponent, and that it should only be observed in this treatment. A possibility is that the *low_high* subjects are staying in the production stage longer, in order to contribute more to the collective tax due to an aversion to contributing less than the other player. This would suggest that these subjects viewed the tax as a contribution, rather than a deduction or a punishment.

Now we consider $H_{1(A4)}$ - if either inequality aversion or competitive preferences can explain the behaviour any of our subjects. In our case, this requires applying the basic intuition behind the theories. If our subjects possessed inequality averse preferences, this would require the *low_high*'s to reduce their production decisions slightly and for the *high_low* subjects to increase theirs in an attempt to reduce the gap of incomes between the two players. For the *high_low* subjects, the results are inconclusive in this respect (they have *time_cost*s slightly lower that SPNE on average, but not by much), in the case of the *low_high* subjects, we see precisely the opposite behaviour to what is predicted by inequality aversion, they produce significantly higher than SPNE *time_cost* on average, contributing to the collective pot at a cost to themselves. Note that for competitive preferences to explain the abnormality, we would require again for the *low_high* subjects to decrease their production, which is not what we see. Although we cannot decisively say whether the *high_low* hold competitive preferences, we can rule out inequality aversion and competitive preferences as an explanation of the *time_cost* exerted in excess for SPNE from the *low_high* subjects and the *high_low* subjects. What about the *low_low* and *high_high* subjects? The *low_low* subjects produce above the SPNE on average. It is possible that within this group, subjects feel the urge to produce at a *time_cost* for the benefit of the other player, exhibiting a possible tendency toward inequality aversion. We can also see that the *high_high* subjects produce slightly less than the SPNE *time_cost* suggesting a possible leaning toward competitive preferences.

Our results indicate that there is at least one hypotheses that can potentially explain the behaviour in each treatment condition, however, the fact that there is no one hypothesis that can uniformly explain the our results across treatment conditions means that we cannot make any definitive statements with respect to hypothesis 1.

Figures 6 and 7 show the distributions of *time_cost* across the different treatment conditions, along with vertical lines denoting our first four hypotheses that are labelled along the x axis ('I' for Ignoring future profits), 'N' for SPNE, 'E' for Ignoring efforts and 'S' for the socially optimal production decision). Visually we can see the results of our t-tests confirmed. For the *low_low*'s observations are distributed around discounted future efforts *time_cost* and for the high wage players the observations are distributed around the SNPE *time_cost*.

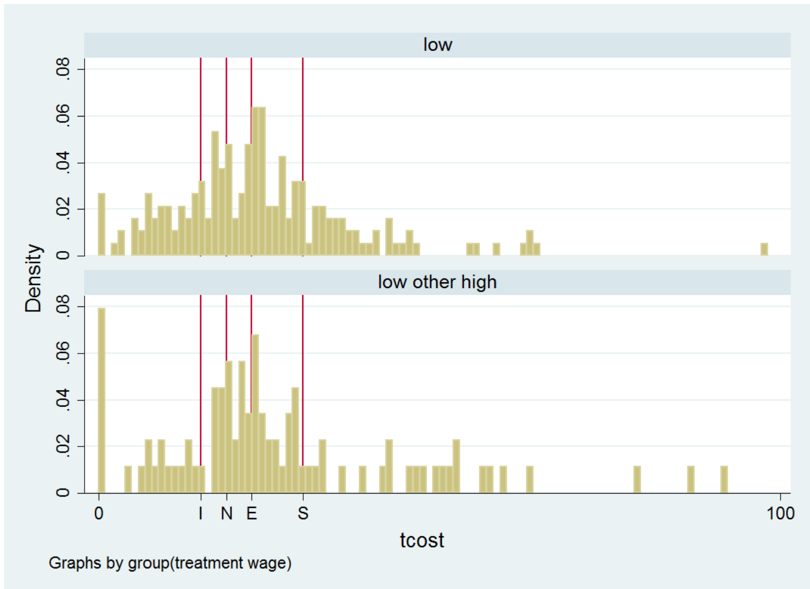


Figure 6: Histogram of *time_cost* with hypotheses(low wage)

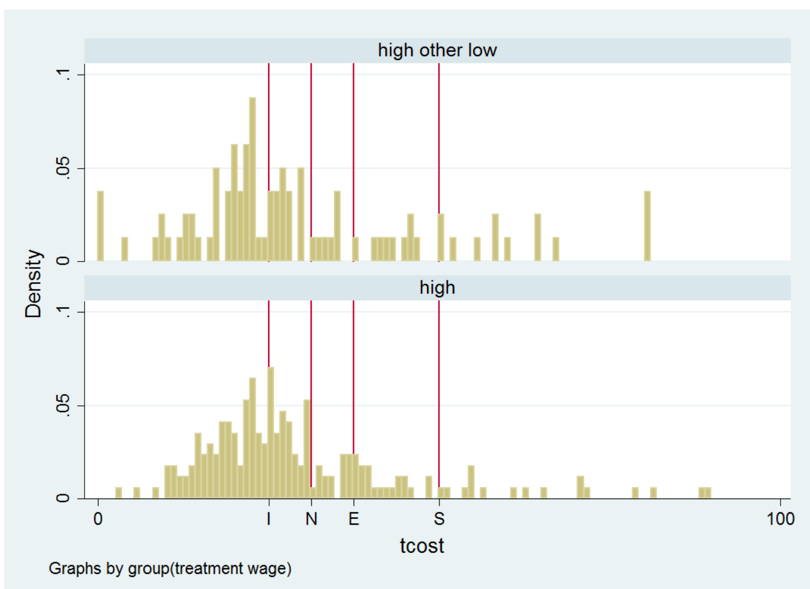


Figure 7: Histogram of *time_cost* with hypotheses(high wage)

4.4 Results: Hypothesis 2

Figure 8 shows the actual observed efforts plotted against the SPNE efforts for all three treatments. Plotted with the scatter is the linear prediction for the observations. A visual analysis reveals that on average the slope of the line of best fit is quite close to 1 across treatments with the possible exception of the *high_low* subjects. In the *low_low* treatment the slope is 0.99 (Std Err = 0.15), the *low_high* has a slope of 0.76 (Std Err = 0.21), The *high_low*'s have a slope of 0.48 (Std Err = 0.28), while the *high_high*'s have slope of 0.8 (Std Err = 0.14). As a whole however the mixed treatments slope becomes 0.62 (Std Err = 0.17) when the *high_low*'s and the *low_high*'s observations are combined. When all treatments are combined the overall slope becomes 0.88 (Std Err = 0.12). This suggests that the over all level of effort exerted is quite close to the SPNE effort on average, as such we fail to reject our $H_{2(N)}$ and also conclude that the average level of waste within treatments is proportional to the magnitude of the wage and can be ordered by treatment. The actual averages of exerted effort per treatment are: low wage (79.94) $<$ mixed wage (111.89) $<$ high wage (152.61). Figure 9 provides a visual representation of the same effect with the average effort plotted against the SPNE Effort.

4.5 A closer look at lobbying efforts

Next we dig a little deeper to see if there is a relationship between the level of effort exerted and the relative contribution to the tax revenue that players make in the first stage. Table 5 displays the results from our model estimation showing that indeed the relative contribution to the tax revenue

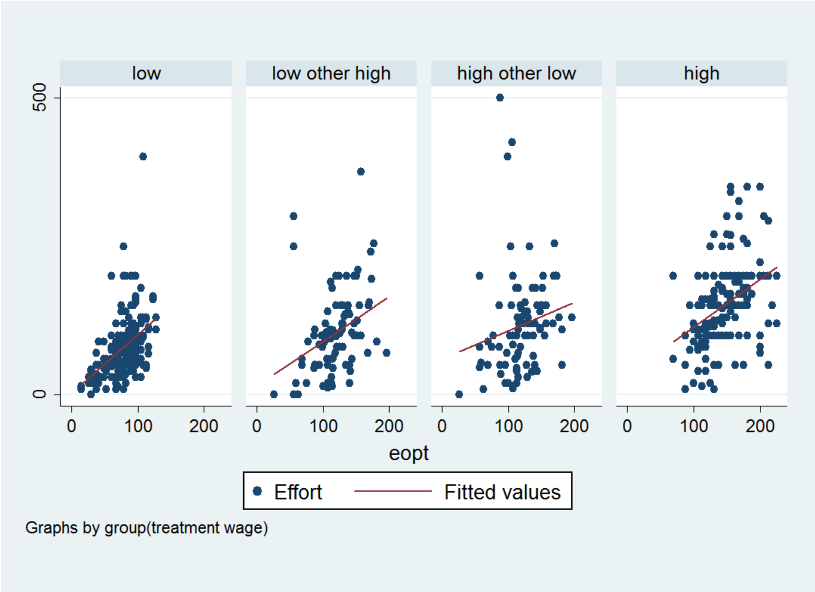


Figure 8: Observed efforts vs. SPNE efforts by treatment condition

Figure 9: Average observed efforts vs. SPNE efforts by treatment condition

does have an effect on the parameter ϕ (the fraction of observed effort over the optimal effort), that subjects invest into the fighting for a share of that tax in the second stage. The effect is significant in all three periods yet none of the treatments have a significant effect on ϕ, which means that the role that θ pays in affecting ϕ holds in all of the treatments regardless of the treatment. There are two factors that affect the amount of tax revenue that subjects contribute to the overall tax-take: heterogeneity in ability and wage inequality. In the *high_high* and *low_low* treatments, the amount of questions that subjects answer relative to the other player determines whether a subject pays more tax. In the mixed wage treatments, the dominant effect should be whether the subject was assigned a higher wage than the other player, although it is also possible that in cases of very high verses very low ability, or in cases where subjects drop out far earlier than equilibrium, the relative amount of questions answered might also play a role. Regardless, The measure of relative contribution to the tax: θ_i captures both of these effects. The result gives some evidence that the relative contribution to the total tax has a significant effect on how hard players are willing to fight for a share of that tax in the second stage. Table 5 shows that in all three periods the relative amount that players contribute to the tax revenue increases the extent to which they are willing to fight for a share of the tax revenue in the second stage. The reverse is also true for the subjects who contributed less on average to the overall tax revenue - on average they tend to lobby under SPNE efforts in the second stage. The effect is significant in all three periods at a 5% level.

Table 5: Estimation results : mixed

Variable	Coefficient	(Std. Err.)
ϕ =(Fractiion of Effort/optimal effort)		
low_hgh	-0.057	(0.155)
high_low	-0.072	(0.176)
high_low	0.038	(0.071)
age:26-30	0.060	(0.082)
age:31-40	0.040	(0.120)
age:41-50	-0.080	(0.112)
age:51-60	-0.326**	(0.142)**
Male	-0.068	(0.052)
Math	0.086	(0.065)
2.period	0.092*	(0.051)*
3.period	0.129***	(0.041)***
period 1#θ	0.421**	(0.169)**
period 2#θ	0.278**	(0.117)**
period 3#θ	0.307**	(0.149)**
Intercept	0.909***	(0.076)***

$^{*}p < 0.1, ^{**}p < 0.05, ^{***}p < 0.01$

4.6 Discussion

The result that efforts in the second stage are related to contributions from the first is somewhat surprising. Note that the SPNE lobbying effort in our model provides a bound on the range of possible best responses that players can exert in given any level of effort of the other player. As such, any level of lobbying effort above the SPNE is a strictly dominated strategy and cannot be a best response to any level of effort exerted by the other player (even one that is itself above the Nash). On the other hand, this is not a statement that we can make with regard to the effort of the lesser-contributor, as it is of course possible that an effort decision less than the SPNE lobbying decision is a best response to one from the other player [10]. In light of this observation, we can deduce with some degree of certainty that the relationship between relative contribution and the fraction of lobbying effort, is being driven by the higher contributors rather than the lower contributors. What possible explanation can we give for this behaviour? Although this outcome cannot be explained within our theoretical framework, previous experiments have given evidence the use of real effort tasks in contests can produce interesting effects.

Some of the existing research suggests that inequality in the experimental setting can to illicit non-optimal behaviour from subjects. Gee, Migueseis And Parsa (2015) found that subjects tended to give less support for redistribution when inequality arises due to real effort as opposed to luck. Erkal, Gangadharan and Nikiforakis (2010) similarly find that subjects competing in a real effort task are less likely to be in favour of redistribution

[10] This was show in 'some discussion on e^* in the model section

if they performed better than others, although the effect disappears if subjects know about and factor the second stage into their production decision or income is determined randomly[11].

We can conjecture that the preference, underlying the apparent aversion to redistribution that real effort tasks capture in these studies, might be capable of explaining the results we observe in our study and others. There is perhaps incorporated in the preferences of the players, something which we could describe as an entitlement effect, which expresses as a dislike for witnessing the even split of a pot, when contributions to that pot were not even.

[11] For some interesting studies on asymmetries in contests see March and Sahm (2016) who observe a discouragement effect on subjects that face a strong opponent in asymmetric contests but no effect on the stronger player's behaviour. Fonseca (2007) finds evidence that in a two player Tullock contest, the advantage of being able to move first in a sequential game leads to more able players exerting beyond the equilibrium effort.

5 Conclusion

In this paper we develop a simple model of lobbying and inequality and examine our theoretical predictions in the laboratory. We find results that contradict those predicted by our theoretical model in two respects: In the firsts stage we observe a treatment effect in which, low wage subjects who are paired against a high wage subject, work significantly harder than low wage subjects who are paired with another low wage player. As a result these subjects ended up working beyond what was individually rational, effectively supplying more tax revenue for the collective pot at the expense of their own welfare, contributing to higher social welfare as a result.

We find that neither inequality aversion nor competitive preferences explains the off-equilibrium behaviour of the over contributing low wage subjects. In the second stage we found in contrast to much of the literature, that on average subjects in all three treatments tended to exert effort in the contest quite close to the SPNE effort. After digging deeper, we found that although the broad average was close to the Nash, those that contributed more tax revenue in the first stage tended on average to exert more effort in the contest in the second stage and inversely, those that contributed less tended to exert less effort in the second stage. This was an effect that we observed in all three treatments. Over-exertion of effort displayed by the higher contributors can potentially be explained by an entitlement effect within the preferences of players, which expresses as a dislike for equal splits of pots, which were not created equally.

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6 Appendix

6.1 Non parametric tests

Table 6: Ranksum *time_costlow_low* = *low_high* Overall

treatment	obs	rank sum	expected
low —	17	258	289
high/low —	16	303	272
combined —	33	561	561
adjustment for ties	0.00		
adjusted variance	770.67		
z =	-1.117		
$Prob > \|z\| =$	0.2641		

Table 7: Ranksum *time_costlow_low* = *low_high* period 1

treatment —	obs	rank sum	expected
low —	17	281	289
high/low —	16	280	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	0.00		
adjusted variance	770.67		
z =	-0.288		
$Prob > \|z\|=$	0.7732		

Table 8: Ranksum *time_costlow_low* = *low_high* period 2

treatment —	obs	rank sum	expected
low —	17	240	289
high/low —	16	321	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	0.00		
adjusted variance	770.67		
z =	-1.765		
$Prob > \|z\|=$	0.0776		

Table 9: Ranksum *time_costlow_low* = *low_high* period 3

treatment —	obs	rank sum	expected
low —	17	240	289
high/low —	16	321	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	0.00		
adjusted variance	770.67		
z =	-1.765		
$Prob > \|z\|$=	0.0776		

Table 10: Ranksum *qlow_low* = *low_high* Overall

treatment —	obs	rank sum	expected
low —	17	266.5	289
high/low —	16	294.5	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	-0.13		
adjusted variance	770.54		
z =	-0.811		
$Prob > \|z\|$=	0.4176		

Table 11: Ranksum $qlow\_low = low\_high$ period 1

treatment —	obs	rank sum	expected
low —	17	260.5	289
high/low —	16	300.5	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	-1.67		
adjusted variance	768.99		
z =	-1.028		
$Prob > \|z\|$=	0.3041		

Table 12: Ranksum $qlow\_low = low\_high$ period 2

treatment —	obs	rank sum	expected
low —	17	266.5	289
high/low —	16	294.5	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	-1.67		
adjusted variance	768.99		
z =	-0.811		
$Prob > \|z\|$=	0.4172		

Table 13: Ranksum $qlow\_low = low\_high$ period 3

treatment —	obs	rank sum	expected
low —	17	253	289
high/low —	16	308	272
combined —	33	561	561
unadjusted variance	770.67		
adjustment for ties	-1.80		
adjusted variance	768.86		
z =	-1.298		
$Prob > \|z\|$=	0.1942		

Table 14: Wald test q (mixed regression coeff)

low other high/low other low	
chi2	4.65
$Prob > chi^2$ =	0.0310
.high other low/high other high	
chi2	0.06
$Prob > chi^2$ =	0.8062
high other high/low other high	
chi2	0.06
$Prob > chi^2$ =	0.8024
high other high/low other low	
chi2	7.08
$Prob > chi^2$ =	0.0078

Table 15: Wald test *time_cost* (mixed regression coeff)

low other high/low other low	
chi2	1) =
$Prob > chi^2 =$	0.1701
high other low/high other high	
chi2	0.02
$Prob > chi^2 =$	0.8864
high other high/low other high	
chi2	0.71
$Prob > chi^2 =$	0.4006
and high other high/low other low	
chi2	5.20
$Prob > chi^2 =$	0.0226

6.2 Some observations on the tax and institutional quality

The effect that a change in the tax rate has on the optimal lobbying effort is not immediately obvious. A higher tax rate implies a higher e^* in the second stage holding T constant, however the higher tax may have worked to yield a lower T in the first stage. Suppose we specify $f(x_i) = log(x_i)$ and $c(x_i) = x_i$, with the optimal production decision subbed in, the optimal lobbying decision can effectively be written as:

$$e_i^* = \frac{n-1}{n^2} t \sum_{i=1}^{n} log((1 - t + \frac{t}{n^2}(1-r) + rmt)p_i)w_i(1-r)$$

Table 16: Parameters for Figure 10 & 11

n	m	w_1	w_2	r	t
2	0.5	10	10	$\in (0, 1)$	$\in (0, 1)$

Figure 2 shows the optimal lobbying effort for different r and t combinations, given the optimal production decision shown in Figure 1 which occurred in the first stage for the same combination of r and t, given the settings of the other parameters shown in table 1. This shows that for certain values of r there is a t which maximizes the total tax revenue collected and as a result, for the same combinations of t and r, there is also a maximum $e*$.

Also interesting is the effect that r simultaneously plays. As r increases, the incentive to lobby in the second stage is reduced, but the same r increasing in the first stage provides the players with an incentive to produce more in the knowledge that they will not have to lobby as hard for it in the second stage.

Figure 10: Optmal production decision for given t and r

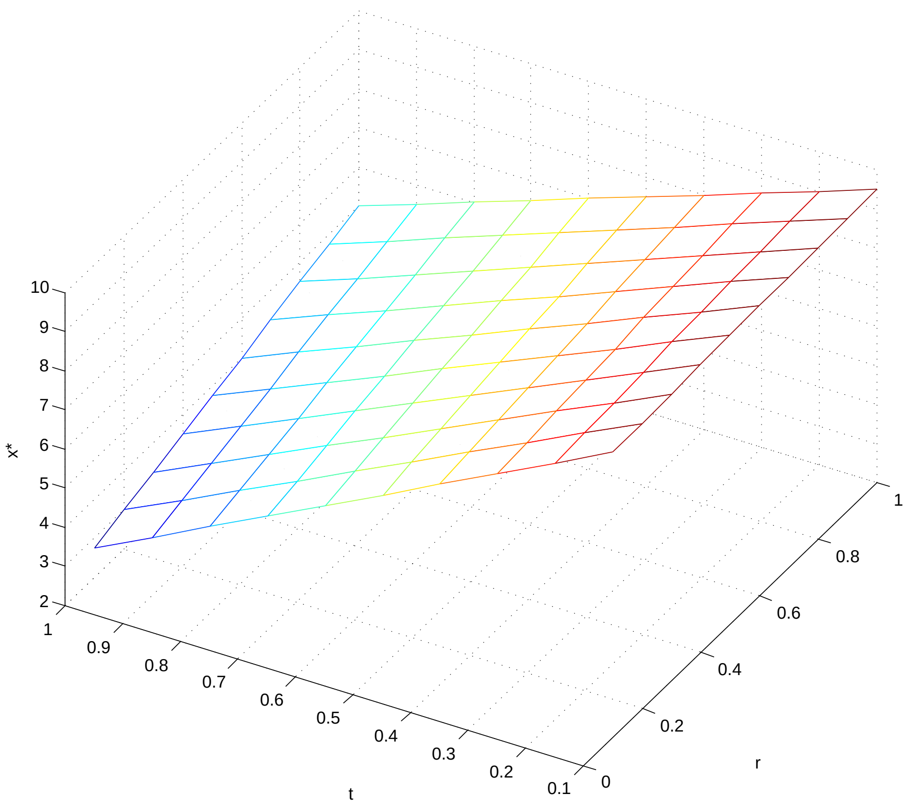
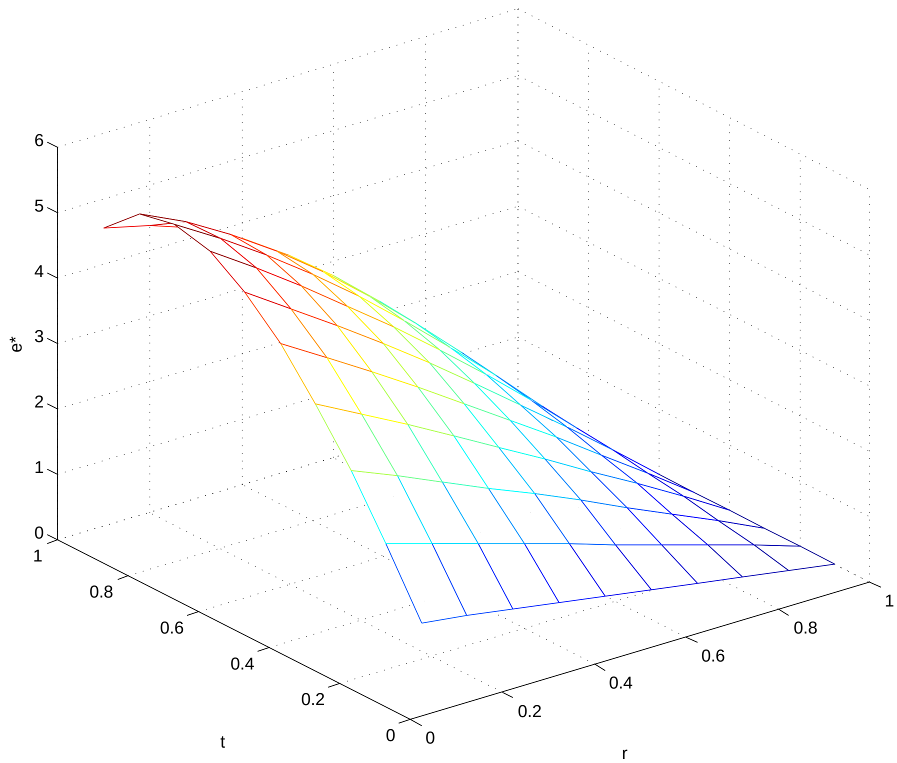


Figure 11: Optmal Lobbying effort for given t and r



6.3 Econometric models

1. **OLS with clustered errors (individual)**

   $q_i = \alpha + \beta treatment\_condition_i + \delta_1 age_g + \delta_2 gender_g + \delta_3 math_g + \delta_4 period_t + e_{i,t,g}$

   $e_{i,g,t} \sim NID(0, \sigma^2_{i,g,t})$

2. **OLS with clustered errors (matching group)**

   $q_i = \alpha + \beta treatment\_condition_i + \delta_1 age_i + \delta_2 gender_i + \delta_3 math_i + \delta_4 period_t + e_{i,t,g}$

   $e_{i,g,t} \sim NID(0, \sigma^2_{i,g,t})$

3. **The multi-level model**

   $$q_{i,g,t} = \alpha + \beta treatment\_condition_i + \delta_1 age_{i,g} + \delta_2 gender_{i,g} + \delta_3 math_{i,g} + \delta_4 period_t + e_{i,g,t} + u_i + v_g$$

   Where it assumed,

   $$u_i \sim NID(0, \sigma^2_i), v_g \sim NID(0, \sigma^2_g), e_{i,g,t} \sim NID(0, \sigma^2_i, g, t)$$

To examine the *time_cost* we run the same model specification with *time_cost* as the dependent variable.

1. **OLS with clustered errors (individual)**

   $time\_cost_i = \alpha + \beta treatment\_condition_i + \delta_1 age_g + \delta_2 gender_g + \delta_3 math_g + \delta_4 period_t + e_{i,t,g}$

   $e_{i,g,t} \sim NID(0, \sigma^2_{i,g,t})$

2. **OLS with clustered errors (matching group)**

   $time\_cost_i = \alpha + \beta treatment\_condition_i + \delta_1 age_i + \delta_2 gender_i + \delta_3 math_i + \delta_4 period_t + e_{i,t,g}$

   $e_{i,g,t} \sim NID(0, \sigma^2_{i,g,t})$

3. **The multi-level model**

$$time\_cost_{i,g,t} = \alpha + \beta treatment\_condition_i + \delta_1 age_{i,g} + \delta_2 gender_{i,g} + \delta_3 math_{i,g} + \delta_4 period_t + e_{i,g,t} + u_i + v_g$$

Where it assumed,

$$u_i \sim NID(0, \sigma_i^2), v_g \sim NID(0, \sigma_g^2), e_{i,g,t} \sim NID(0, \sigma_i^2, g, t)$$