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Who pays taxes? Liturgies and the *Antidosis* procedure in Ancient Athens

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Abstract Ancient Athens developed a constitutional democracy. A core, time invariant political economy problem is that of providing public services when wealth is imperfectly know. I model theoretically a unique institution developed in Ancient Athens known as the *Antidosis*. It allowed a citizen on the list of tax-payers to challenge a citizen not contributing to replace him and make the public goods contribution. The challenged citizen, rather than allow the claim to go before a jury trial, could choose to swap wealth with the accusing tax payer. I argue this acts as a screening mechanism and improves upon the asymmetric information problem the government has in identifying who is indeed those who have the highest wealth to provide the tax revenue to finance the public services.

Keywords Antidosis · Classical Athens · Liturgy · Public finance · Public goods · Taxation

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1 Introduction

Democratic societies develop institutions to facilitate proper functioning of their government. The core political economy problems are the same in the past as today. Legal institutions must solve asymmetric information problems. Political

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institutions must deal with rent-seeking and public goods provision, among others. Rigorous analysis of historical institutions provides researchers the opportunity to improve upon our understanding of mechanisms to deal with society's common, time-independent economic problems.

Ancient Athens developed the one of the first democracies. Starting with Solon's constitution implemented in 594 B.C., the Athenian society flourished.[1] It became the economic power of its time and the center of international trade. Music, theater, and sports were enjoyed by the *demos* ("people"). Political institutions extended the franchise and constitutional governance prevailed. Legal institutions were developed to enforce contracts, protect property rights, resolve private disputes, and punish crime. Mathematics, science, and philosophy proliferated. The formal study of the ancient institutions of Athens provides a point of comparison to modern institutions developed in constitutional democracies. When distinct from modern mechanisms, the contrasts provide the opportunity to evaluate alternative institutional solutions to our shared political economy problems.

High among the priorities of democratic governance is designing mechanisms to properly finance public services. Unlike modern societies, there was no central government in Classical Athens levying taxes and budgeting expenditures to publicly-provide goods and services. Instead, wealthy citizens privately provided most of the public goods (known as a liturgy).[2] Examples of liturgies include funding naval defense, choral performances, and theatrical festivals. Administrators coordinated the contributions by allocating services to individuals on the list of wealthiest families in the *polis* ("city-state").

An asymmetric information problem arises with such an institution. How does one insure that it is, in fact, the wealthiest that provide the public goods? To address this problem a rather unique mechanism, known as the *antidosis* procedure, was developed. While the next section provides details, a brief description can be given. A citizen on the list responsible for providing a contribution can initiate the *antidosis* by identifying another who he believes is wealthier. The "accused" may, rather than accept the responsibility or challenge it in court, elect to exchange wealth with the tax-payer. If the wealth exchange is selected, then the tax-payer (now presumably with the greater wealth) performs the liturgy. What incentives does this institutional feature create? How effective can we expect it to be at properly assigning public duties?

[1] One can date the beginnings of constitutional governance to Drako in 621 B.C. as it is the first (known) time that the power of the elite in Ancient Athens was restrained. Alternatively, the Classical period in Athens is frequently dated from the introduction of Kleisthenes' constitution in 508 B.C. This constitution was developed when the tyranny of Pisistratus (and his sons) was overthrown by the Athenian people with the help of Sparta. This tyranny was a departure from Solon's constitution and Kleisthenes' objective was to re-install the laws of Solon. Aristotle's *Constitution of Athens* attempted to lay out the historical constitution of Solon. Thus, dating the origination of the unique constitutional democracy to Solon is appropriate. See Robinson (1997) for a discussion of other Greek societies who developed democratic governments as well. It is by far the best documented though.

[2] It is worth qualifying the statement. Non-wealthy citizens made contributions as well. These contributions were typically through providing labor. Thus, the *antidosis* procedure is used for identifying the citizens who provide monetary payments to the public.

An analysis of the *antidosis* mechanism was first done by Kaiser (2007). She provides a well-developed, extensive-form game of the interaction between the challenged citizen and the challenging tax-payer. Her model provides clear equilibria outcomes where an environment where the *antidosis* exchange avoids trials can be differentiated from situations where the dispute persists into the courtroom. An econometric analysis investigates data from known, contested liturgies in Classical Athens and identifies which factors are statistically related to the likelihood of unresolved disputes.

While Kaiser (2007) provides an interesting and important contribution to our understanding of Athenian institutions, the theoretical framework, though, does not fully address the role of information in the mechanism. Researchers on taxation in Classical Athens have emphasized that accurate, publicly-available information on wealth was lacking (Carmichael 1997). The modeling approach adopted in her work is to differentiate observable wealth from actual wealth. Only the former is relevant if the exchange is not made and the dispute goes before a jury. The latter matters for final payoffs received. Trial outcomes are modeled as an exogenous probability of the jury siding with the plaintiff.[3]

While a reasonable, simplifying assumption, one is unable to evaluate the effectiveness of the institution in this environment. The *antidosis* mechanism was needed to elicit private information and its effectiveness at dealing with the asymmetric information problem is not addressed. In her theoretical model, absent unequal disutilities from paying the liturgy, no disputes go to trial as a mutually-agreeable exchange arises. This, of course, does not match the empirical observation that disputes did advance to the courtroom. The unequal disutility experienced by the two parties is motivated by heterogeneous non-monetary munificence from the social esteem generated by the public contributions. While these social preferences are clearly important in Classical Athens, a citizen could have volunteered for the liturgy, as some did, without having a formal, legal challenge instigated. The goal here is to provide a theoretical model of the *antidosis* procedure that can explain both the prevalence of jury trials as well as the use of the asset-swapping mechanism. With a model that can identify the environments under which each arise, the welfare consequences of the framework can be studied. Rather, the focus of the analysis in Kaiser (2007) is on the determinants of disputes resulting in law-court proceedings where, in this work, the emphasis is on the role of asymmetric information on properly assigning liturgical responsibilities.

Here, I relax the assumption of exogeneity in jury decisions. I consider the Athenian citizens on the jury as people interested in having the liturgy performed by the individual with the greatest wealth. At trial, only imperfect signals of the true discrepancy in wealth is observed. Prior to the trial, though, the challenged citizen must make the decision on whether to exchange wealth, based on his expectations regarding the signal that will be received by the jury. Consequently, a screening

[3] Throughout, modern terminology such as plaintiff, jury, trials, courtrooms, etc. will be used to ease the exposition. When possible the names of the Athenian institutions will be used. I do not engage in the debate over whether it is more proper to refer to trials being presided over by judges or jurors and I do not elaborate on the many procedural differences between modern courts and those in Classical Athens. For more details on Athenian courts, see MacDowell (1978) and McCannon (2010a, b, 2011).

mechanism arises where those who have relatively less wealth tend to prefer the exchange and those with relatively more wealth proceed to trial. Hence, a quasi-separation occurs. The modeling approach adopted is derivative of Bjerk's (2007) work on screening through plea bargaining in modern courtrooms, and as adopted by McCannon (2010a) in the study of homicide trials in Classical Athens.

Formally investigating the screening mechanism allows one to evaluate the effectiveness of the institution without relying on differences in social preferences. Two primary results arise. First, the design of the mechanism deters frivolous claims. By allowing the challenged to exchange wealth, a rich tax-payer would be deterred from trying to wrongfully shifting his fiscal responsibilities. Thus, mistakes are not created. Second, in an environment where the registry of the wealthiest is frequently incorrect, if the discrepancy of wealth is not too great, the richer citizen will choose to exchange assets. As a result, the individual with the liturgical responsibility pays that liturgy from the greater estate. Consequently, proper assignment of tax paying arises. These outcomes mark the improvements created by the *antidosis* procedure over simply holding a court trial. In short, the exchange feature of the *antidosis* procedure deters frivolous cases and the screening it provides increases the likelihood that the one with greater wealth pays the tax. These results contribute to the work of Kaiser (2007) in the economic analysis of this non-standard, public finance mechanism.

The work contributes to a growing literature of an economic analysis of ancient Greek institutions. One strand of this literature investigates the economic factors that lead to the formation of democracy.[4] Fleck and Hanssen (2006) focuses on the principal-agent problem faced by the Athenian elite, while Fleck and Hanssen (2009) apply a similar logic to the rise in women's rights in Sparta. Similarly, McCannon (2012) credits the role of wealth volatility and social insurance on the development of Athenian democracy. The role of military tactics and sporting events on the rise of democracy in Greece is discussed by Kyriazis and Paparrigopoulos (2014) and Kyriazis and Economou (2015), respectively. The motivation for direct democracy and appointment by lot is analyzed by Levy (1989), Tridimas (2011, 2012), and Carugati et al. (2015). Fleck and Hanssen (2013) argue that growth-promoting tyrannies in Archaic Greece lead to democracy in the Classical period.

A second strand in the literature uses economic theory to understand the functioning of specific democratic institutions developed. McCannon (2010b) and Guha (2011) formally model the mechanism used to convict and sanction criminals, as was made famous in the trial used to prosecute Sokrates. D'Amico (2009) discusses the use of prisons in Athens. The specific institutional features of homicide trials are modeled in McCannon (2010a). The variation in size and composition of juries is studied by McCannon (2011). Ostracism is evaluated by Tridimas (2016). The public finance considerations in Athens has been explored extensively (Lyttkens 1997; Kyriazis 2009; Tridimas 2013). The work presented here and that of Kaiser (2007) fall into this literature as well.

[4] Relatedly, the study of the formation of the *polis* has received separate attention (Lyttkens 2006).

A third strand of research on Ancient Athenian institutions focuses on the market activity. Examples include an analysis of the role of values on entrepreneurship (Bitros and Karayiannis 2008) and on the quality of legal institutions and social norms on economic development (Karayiannis and Hatzis 2012). How the Athenian institutions lead to its development as the first modern economy is discussed in Halkos and Kyriazis (2010).

A brief description of public financing and the *antidosis* procedure is provided in Sect. 2. Section 3 presents the formal model with the objective of capturing the role of asymmetric information on decision making. Section 4 analyzes the equilibria, while Sect. 5 concludes.

2 *Antidosis* procedure

First I provide a summary of public financing in Ancient Athens, along with an elaboration on the *antidosis* procedure is provided. The interested reader is encouraged to consult MacDowell (1978) and Hansen (1991) for details and further discussion.

Rather than develop a central administration to collect and distribute tax revenues on a regular basis, public goods were, for the most part, privately provided. Wealthier individuals performed liturgies (*leitourgia*) where they provided the financial contribution to provide a specific service to the *demos*. This would include services such as choral and theatrical festivals for all Athenians to enjoy free of charge, or to provide financing for the Athenian team competing in international events such as the Olympics (*arkhitheoros*). Additionally, an important type of liturgical requirement was a trierarchy. A trierarchy is the providing the funds needed to finance a ship in the Athenian navy. See Kyriazis and Zouboulakis (2004) for a detailed economic analysis of the impact of the trierarchy on the Athenian economy. Thus, even state defense was provided privately. See Lyttkens (1997), Kyriazis (2009), and Tridimas (2013) for further discussions of public financing in Athens.

A list of the heads of the richest households (known as an *oikos*) was maintained. The citizens on this list were frequently referred to as *leitourgountes* ("tax-payers"). Initially in the Classical period (508-322 B.C.) the exact number of *oikoi* making up the *leitourgountes* class is not perfectly known. MacDowell (1978) estimates that in a typical year (no war) approximately one hundred liturgies were provided. After 411 B.C. a panel of 1200 individuals was listed to share the burdens of the trierarchy.[5] Furthermore, during times of war a special tax, known as an *eisphora*, was levied on Athenian citizens. The 300 richest families were required to, in essence, pre-pay the tax, known as the *proeisphora*, and then collect from their fellow citizens.[6]

[5] Athens lost the Peloponnesian War in 404 B.C. The war dramatically reduced the elite's wealth and with obvious losses to its labor force coupled with trade restrictions placed on Athens by Sparta, incomes can be expected to be significantly lower. Thus, the expansion in the tax base was done to lower the tax burden on the elites.

[6] Hansen (1991) categorizes liturgies into three groupings: festivals, trierarchy, and *proeisphora*.

Magistrates in charge of the different public goods would select individuals to perform each of the liturgies for the year. Athenian law provided for some exemptions, such as excusing those currently overseas or serving on the city's governing council (known as *arkhons*). Also, restrictions were placed on the frequency of being asked to perform liturgies forbidding, for example, being made to contribute in two consecutive years. Furthermore, individuals could volunteer to contribute to a liturgy. One may choose to do this, for example, to build social capital to be used in city politics. As a famous historical example, Demosthenes the orator, lawyer, and leading political figure in the fourth century B.C., began his political career by generously financing the annual festival in 349 B.C. (Davis 1967). See Carmichael (1997, 2009) for an economic analysis of the role of munificence in the success of Athenian liturgies.

The Athenian government lacked the ability to effectively monitor the wealth of its citizens and, therefore, needed a mechanism to ensure that it was, in fact, asking the wealthiest families to provide the public finances. Cohen (1992) discusses how the popularity of bankers in the *polis* was due, in no small part, to the motivation to conceal wealth from taxation. Classical Athens relied heavily upon law-courts to manage affairs. Not only were private harms and disputes (known as a *dike*) and prosecutions for harm done to the public (known as a *graphe*) resolved in trials, but courts were used to deal with a number of other administrative responsibilities. As an example, to audit outgoing administrators/magistrates a procedure, known as *euthyna*, took place to allow citizen to evaluate and challenge the quality of the duties discharged over the previous year.

A mechanism known as *antidosis* was developed to deal with the asymmetric information problem arising between citizens, with knowledge of their personal wealth, and the administrators, with the goal of having the richest families provide the public goods. In an *antidosis*, a *leitourgos* makes a claim that another citizen, who is not on the list of tax-payers, is wealthier than he is and submits a formal request to the magistrate overseeing the liturgy. He petitions for the citizen to replace him on the list, handing over the liturgical responsibility.

In the next step, the challenged citizen may, of course, concede that his wealth is higher and become a tax-payer. If he does not make this concession, then one of two actions can be taken in an attempt to avoid having to make the payment. The first action is to allow the challenge to proceed to court and let a jury decide who is, in fact, wealthier. This trial was a special type of *dike*, known as a *diadikasia*, where neither party was the plaintiff or the defendant, but, rather, both were on equal terms. Juries in Classical Athens were typically comprised of 500 citizens who, after hearing arguments and taking in the evidence, used simple majority voting. See McCannon (2011) for a discussion of composition and variation of juries in Classical Athens and Fleck and Hanssen (2012) for a discussion of the lack of a role for experts in Athenian legal institutions. Thus, the *demos*, acting through its juror-representatives, could decide who should be responsible for performing the liturgy.

The second action available to the citizen who was challenged to replace the *leitourgos* on the list was quite unique. The challenged citizen could simply opt to swap wealth with the tax-payer. All wealth (capital, livestock, grain, slaves, etc.) of the *leitourgos* would be given to the citizen and all of the citizen's wealth would go

to the *leitourgos*. If, indeed, the citizen was wealthier, then the *antidosis*, which is the Greek word for "exchange", allowed for the greater wealth to be transferred to the party responsible for performing the liturgy. This allows for a proper assignment of tax-paying responsibility.

If the challenged citizen choose to exchange, then both parties were first required to take an oath that they would not hold anything back. Then, within 3 days, each had to provide a list of all assets and liabilities. Each could inspect the house and barns of the other to verify the contents. Either party could later initiate a *dike* if it was believed that the other withheld wealth from the exchange. The speech *Against Phainippos* (Demosthenes XLII) is a surviving example of such a dispute.[7]

It is this unique feature on the Classical Athenian institution which is the subject of investigation here. How effective would we expect this mechanism to be, over simply allowing a jury of Athenian citizens to make an evaluation? What potential benefits to the *polis* were generated from this seemingly unusual institution? To answer these questions a formal model of the asymmetric information is developed.[8] The *antidosis* procedure is evaluated as the screening mechanism that it is to understand, theoretically, how it affects public financing.

3 Theoretical model

Consider a game between three players. For clarity refer to them as L (for *leitourgos*), C (for citizen), and J (for jury). Suppose that player L has initiated an *antidosis* procedure against player C claiming that C's wealth exceeds that of L's. If the conflict reaches the jury, they collectively make an assessment of who has more wealth. Since in Classical Athens jury decision making utilized simple majority voting rules (McCannon 2011) the Median Voter Theorem applies (Black 1948; McCannon 2010b). In it, if a population of voters who differ in their beliefs or preferences each cast a vote (in a trial, for a candidate for office, on a response to a referendum, etc.), then the outcome is determined by the preferences of the median voter; i.e., the individual whose preference lies at the median position. Thus, the jury can be thought of a single player. See Friedman and Wickelgren (2006) for an application and discussion of this "Bayesian Jury" modeling approach.

The sequence of decisions is rather straightforward. First, given that L has decided to initiate the *antidosis* procedure, C decides whether to swap assets, denoted by action S, or to proceed to trial, denoted by action T.[9] Second, given that

[7] It is worth pointing out that, as noted by Hansen (1991), there is not any surviving historical account of the change in property actually taking place. This, though, can be expected since what is frequently observed is court speeches and the swapping of assets avoids this.

[8] Halkos and Kyriazis (2010) also consider asymmetric information in Classical Athens. They model the conflict between Persia and Athens as a signaling game.

[9] Of course, a third option is available. The citizen could simple concede and pay the tax. Since there is no evidence of a "trial penalty" to contesting the claim before a jury of Athenian citizens, an assumption that the probability of a jury verdict, not in favor of the citizen, is less than one results in going to trial dominating the concession. This does assume, though, that there is no benefit to taking on the liturgical responsibility. While public notoriety could be gained, the citizen could have volunteered for the liturgy, without having to be charged by the tax-payer. Thus, taking on the liturgy after being contested would be

L initiated the procedure and C choose to proceed to trial, J decides whether to keep player L on the roll of taxpayers or to list player C. To economize on notation, denote the choice set as $\{L, C\}$.

Regarding payoffs, the primary variable of interest is the difference in the wealth of players L and C. Denote the actual gap as w_{true}. A positive value of w_{true} reflects a situation where the non-taxpayer actually does have more wealth than the one currently paying taxes. The greater this value the larger the wealth gap between the two. Consequently, a value of $w_{true} = 0$ reflects *oikoi* of equal wealth, while $w_{true} < 0$ coincides with proper taxpaying as player L is indeed wealthier.

Figure 1 depicts a simplified game tree of the interaction. The payoffs of the decision maker, C, is provided at the terminal nodes.

The *antidosis* procedure was important in Classical Athens because wealth levels were not perfectly known by the *demos*. Suppose that the citizen knows his own wealth and, for simplicity, also knows the wealth of the taxpayer. The jurors, though, are not able to perfectly observe this. Due to the lack of information available to those outside the *oikos*, members of the jury can assign likelihoods to different values for w. Suppose, then, the assessment made is

$$w_1 = w_{true} + \theta \tag{1}$$

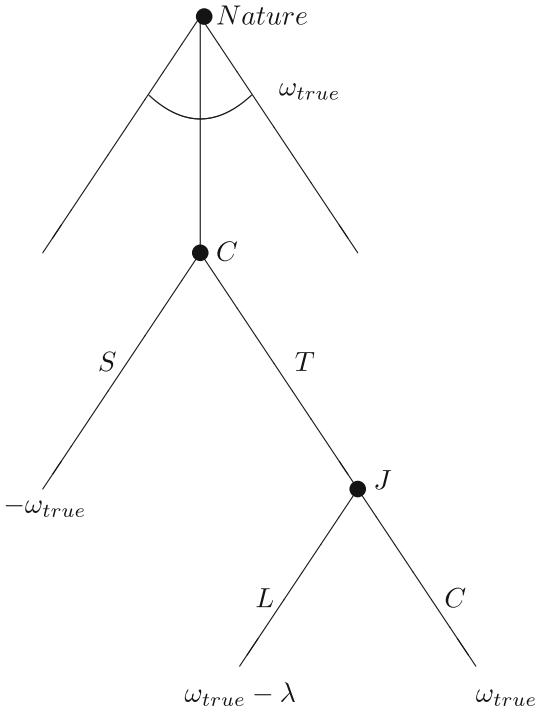
where θ is an error term drawn from a cumulative distribution function, denoted $F(\theta)$. One can imagine an economic environment where possible values of w_1 take any value in $(-\infty, \infty)$. More accurate beliefs coincide with a distribution function with a smaller variance and unbiased beliefs. Assume the mean value is equal to zero, $E\theta = \int \theta \, dF(\theta) = 0$.

Thus, at the decision node for C, the true discrepancy of wealth is not perfectly known to the other players, but the signal is available. C, of course, knows both the value of w_{true} and w_1 and can base his decision on both variables. This provides the basis of information to make the decision to proceed to trial or exchange assets. It is not crucial for the analysis that C knows L's wealth. I could include C's beliefs about the possible difference in wealth where w_{true} is, then, the expected value. Under an assumption of risk neutrality decision making is unaffected. The assumption that C knows w_1 is a result of common knowledge where all players know the prior beliefs of J.

If the case goes to trial, a common assumption of litigation decision making is that the arguments at trial improve the quality of the information, as compared to the environment before the trial. See Bjerk (2007) and McCannon (2010a) for examples and discussions. Therefore, again, the jury is not perfectly informed of the wealth discrepancies between the two. They observe a signal w_2. To model the improvement in the quality of the evidence, suppose that if $w_{true} > 0$, so that C is in fact wealthier, then $w_2 = w_1 + \varepsilon$ where ε is a realization of a random variable. Let H denote the cumulative distribution function for ε. Furthermore, assume

Footnote 9 continued
selected if there was a sufficient loss in social capital by challenging the responsibility. This issue is not addressed here.

Fig. 1 Game tree



$H(\varepsilon) = 0$ for $\varepsilon < 0$ so that the trial phase "clarifies" information. Alternatively, if $w_{true} < 0$, then $w_2 = w_1 - \varepsilon$.

As in any screening mechanism, the jury adopts a straightforward decision rule. They select a threshold value of w, denoted w^*. If the signaled difference in wealth is greater than w^*, then the jury replaces L with C on the list of taxpayers. Alternatively, if $w_2 < w^*$, then L remains on the list. This threshold is selected by balancing the juror's assessed costs of type I and type II errors and their updated beliefs.[10] If a particular case is viewed as being more important, where the cost of a wrongfully assigning C to the list of taxpayers is great relative to an erroneous decision of leaving him off, for example, then w^* increases, *ceteris paribus*. The analysis here, though, focuses on the mechanism's accuracy holding fixed the payoff parameters and, therefore, does not explore these comparative statics.

Thus, the required analysis is to identify for a given magnitude of the tax burden, λ, wealth discrepancy, w_{true}, and initial signal, w_1, when C chooses to swap assets and when he proceeds to trial. Similarly, the analysis requires that, given λ, w_2, and C's decision making, which values of w^* can be supported as equilibrium.[11]

[10] A full development of the Bayesian Nash equilibrium would require identifying the set of w^* that satisfies the individual rationality and incentive compatibility requirements. See Bjerk (2007) or McCannon (2010a) for these derivations. To keep the analysis concise, I focus here on the payoffs and decision making of the parties to the dispute.

[11] Formally, the Perfect Bayesian equilibria will be derived. As stated in footnote 8, to simplify the analysis the strategy selection of the jury is not presented here. To summarize, though, there exists a range

Understanding C's decision making provides useful insight because, to appreciate the quality of the *antidosis* procedure at identifying who are the wealthiest citizens, one would like to identify when the exchange option (1) creates mistakes to the assignment of liturgies and (2) when previously made mistakes are corrected.

4 Analysis

Consider the decision problem facing C. His payoff function is comprised of two components: wealth possessed and taxes paid. If C chooses to proceed to trial, then he retains his wealth. For simplicity assume that the benefit from the wealth is equal to w_{true}. One can simply think of this as the surplus generated above the opportunity cost of exchanging assets with L (and that he is risk neutral). Since C must make the choice under imperfect information (he does not know for sure what signal the jury will see and, therefore, does not know the trial's outcome with certainty), the expected utility must be considered. Thus, the expected utility to proceeding to trial is

$$\mathrm{Eu}(T) = \mathrm{Prob}(w_2 \geq w*)[w_{true} - \lambda] + \mathrm{Prob}(w_2 < w*)[w_{true}]. \tag{2}$$

If the signal received by the jury exceeds their threshold, then the jury will decide in favor of L and require C to pay the liturgy, λ. Regardless of the jury's decision, the wealth is retained. Since C is the actor fully informed, then his payoff is driven by the true discrepancy in wealth.

A straightforward simplification of this payoff can be done. First, note that $\mathrm{Eu}(T) = w_{true} - \lambda\mathrm{Prob}(w_2 \geq w^*)$. Second, given that the signal w_1 is known, the probability w_2 will exceed w^* is simply the probability that a realization of ε greater than or equal to $w^* - w_1$ occurs, assuming $w_{true} > 0$. If $w_{true} < 0$, then this probability is the likelihood that ε is greater than $w_1 - w^*$. Define ε^+ as the former and ε^- as the latter. Hence, $\varepsilon^+ = -\varepsilon^-$. Thus, if $w_{true} > 0$ then $\mathrm{Eu}(T) = w_{true} - \lambda[1 - \mathrm{H}(\varepsilon^+)]$, while if $w_{true} < 0$ then $\mathrm{Eu}(T) = w_{true} - \lambda[1 - \mathrm{H}(\varepsilon^-)]$.

Alternatively, C may choose to exchange assets. In this case C receives $-w_{true}$ in wealth and L pays the liturgy. There is no uncertainty in C's payoff. Hence, the utility to swapping is

$$\mathrm{u}(S) = -w_{true}. \tag{3}$$

Consider, then, the choice to be made by C. Swapping assets is ideal when $-w_{true} \geq w_{true} - \lambda[1 - \mathrm{H}(\varepsilon^*)]$ where ε^* is either ε^+ or ε^-, which simplifies to

$$\mathrm{H}(\varepsilon^*) \leq [-2w_{true} + \lambda]/\lambda, \tag{4}$$

Footnote 11 continued
of values of w^* that can be supported as Perfect Bayesian Nash Equilibria. The screening mechanism improves the quality of the information available to the jury. A jury who cares about accuracy will shift this interval to the left, allowing for more modest wealth discrepancies.

This decision rule can be used to analyze the effectiveness of the *antidosis* procedure at identifying the correct tax-payer in Ancient Athens.[12] To do this, the analysis will be separated into the scenario where, initially, the correct *oikos* is performing the liturgy, but deceptively is attempting to shift the burden to one less able to do so, from the scenario where the responsibilities are initially incorrectly assigned and the procedure is used with the intention to fix the mistake.

4.1 Creating mistakes

Consider, first, the situation where $w_{true} < 0$ so that L is indeed wealthier, but has instigated the *antidosis* procedure to relieve himself from the financial responsibility. The ability to accuse C before a jury opens up the possibility of an error being created. Does the *antidosis* mechanism curtail the success of this attempt to create a mistake?

Applying the decision rule derived, when w_{true} is negative the right-hand-side of (4) is greater than one. Thus, the inequality must hold, regardless of the value of w_1 and λ. In other words, the *antidosis* procedure, by allowing the swapping of assets to be a choice of the citizen, results in the accused always selecting to exchange. This transfers the greater wealth to the citizen, yet leaves the tax-paying responsibility with the accuser who now has less money. This adverse incentive occurs regardless of the magnitude of the financial responsibility (λ) or the ex ante quality of the information available to the public (w_1, or rather, θ). Thus, given that the initiation of the procedure is the choice of L, one would expect the mechanism to deter frivolous lawsuits.

It is worth pointing out, though, that the theoretical model developed starts from the point in time where L has chosen to initiate the proceedings and that C has not conceded to the claim. These are taken as exogenously given. The theoretical model predicts that asset would be swapped. If this deterred frivolous lawsuits with probability one, then the jury's belief about disputes that reach them can be expected to assign a probability of one to wtrue > 0. Therefore, one might reasonably expect, in an extended framework such as this, that L would chose a mixed strategy, as is common in asymmetric information environments. In this case, entry would be less likely for frivolous lawsuits.

That the mechanism provides the opportunity for the less well-off party to express it, through the exchange. The *antidosis* avoids improper re-assignment of liturgical responsibilities. This is the first, important result of the analysis.

4.2 Avoiding mistakes

Alternatively, one may be concerned that imperfect information results in the wrong *oikos* performing the liturgy. Given that it is hard to accurately track wealth in Ancient Athens, it seems reasonable that a mechanism can be implemented to

[12] The theoretical model assumes implicitly that there is no cost to taking a case to trial. This assumption, while not affecting the main message of the work, is not inconsequential. Including a fixed cost would change the threshold value for the error term ε^*. Additionally, in the Perfect Bayesian Nash Equilibria one would expect, then, that J's willingness to convict will adjust. Therefore, the value of w^* changes.

improve upon the information problem. Does the *antidosis* procedure enhance or detract from a jury's ability to properly assign public financing responsibilities?

Considering the decision rule presented in (4), there are two cases to consider. Since H(ε) is a cumulative distribution function, for any value of ε it can only take on values greater than or equal to zero. Hence, one case to consider is when $w_{true} > \lambda/2$. In this case, the discrepancy in the wealth is more than 50% of the size of the liturgy payment to be made and the inequality in (4) fails to hold. Thus, the exchange of assets does not occur and, instead, the dispute goes to the jury. This arises because the liturgical contribution is sufficiently small so that the non-taxpaying citizen prefers to keep his (greater) wealth.

In the second case, $w_{true} < \lambda/2$. This arises when the parties to the dispute have similar levels of household wealth and the liturgy to be performed is relatively onerous. Now, the decision to proceed with the dispute depends on the likelihood that the arguments before the jurors will effectively convince them to replace L with C on the list of tax payers. Given the jury's threshold for doing so, w^*, if the initial information is greater ($w_1 > w^*$), then the jury will correctly make the replacement since the trial clarifies the information ($\varepsilon \geq 0$). If, unfortunately for L, the signal is sufficiently weak, or even if the evidence before the jury wrongfully suggests that L is, in fact, richer, then it is unlikely that the arguments before the jurors will succeed. In which case, C will elect to exchange assets with L. In this scenario, the citizen must forfeit his greater wealth, but avoids taxation. The greater wealth goes to L who performs the liturgy. Thus, the mechanism properly assigns tax liability.

Finally, suppose the evidence available suggests that C is, in fact, wealthier, but it is not certain that the jury will be convinced and choose to replace L on the roster, or rather, w_1 is close to but not greater than w^*. Here, C elects to hold on to his greater wealth and gamble that the jury will also not require him to perform the liturgy. With probability $H(\varepsilon^+)$ the tactic will work and the mistaken assignment of tax liability will persist, while with probability $1 - H(\varepsilon^+)$ it will be corrected. Thus, the existence of these parameter values illustrates that the *antidosis* procedure, incorporating the asymmetric information involved, is only quasi-separating and that it is possible to, still, inaccurately assign tax-paying responsibilities.

Does this mean that the *antidosis* procedure is ineffective at dealing with the public finance problem in Classical Athens? No. In fact, it is an improvement. When the information available to the public is convincing, a jury will be able to properly assign responsibility. When the evidence is lacking, the wealth moves into the hands of the *leitourgos* allowing for proper taxation of wealth. It is only in the case where there is some publicly-available information, but the persuasiveness at trial is uncertain, does the mechanism even allow for the possibility of inaccurate taxation. Even this inaccuracy occurs only when the discrepancy in the wealth levels is small. Thus, one can argue that the *antidosis* procedure is a rather effective mechanism.

Figure 2 graphically illustrates the choices made by C for the possible values of w_{true}.

Hence, the leftmost region represents the results from Sect. 4.1 avoiding mistakes. The middle region illustrates the possibility of improved assignment of tax-paying responsibilities as the greater assets are given to the party responsible for

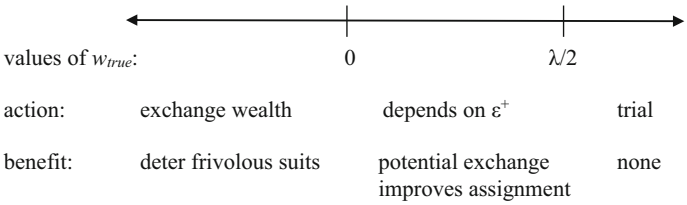


Fig. 2 Equilibrium responses of C

the liturgy, while no difference between the *antidosis* procedure and an un-screened trial arises in the rightmost region.

5 Conclusion

The *antidosis* procedure in Ancient Athens is an example of a novel mechanism developed to deal with the problem of accurately distributing tax-paying responsibilities in the community. Previous research has highlighted its ability to identify who, in fact, are the richest families. How well the mechanism functions under the asymmetric information that it is designed to deal with has not been previously explored.

Here, it is argued that, indeed, it is an effective mechanism. Its value is even greater, though, than previously argued. First, the ability of the challenged to exchange assets with the challenger effectively deters frivolous lawsuits. Second, if the lawsuit indeed has merit, either the parties to the dispute will exchange assets, to properly have the one with the greater wealth pay the tax, or the jury will be left to decide whether to switch the names on the list of tax-payers. When the parties do exchange wealth, it occurs when the challenged citizen is indeed wealthier. Thus, this represents an improvement in the assignment of public financing responsibilities.

The results provide another example of the controls put in place to deal with sykophants who use the legal system for personal gain. For example, in *dikai* it was common for a portion of the monetary fine to go to the plaintiff, while in *graphai* zealous prosecution could be motivated by factors such as revenge, as is suggested in the trial of Sokrates (McCannon 2010b). One mechanism developed was, if the party who initiated a trial was unable to obtain 20% of the jurors' votes, large monetary fines and disenfranchisement given to the one who initiated the trial. The *antidosis* provides another attempt to curb improper legal actions by allowing for wealth confiscation as a penalty.

The research illustrates the value of the formal analysis of historical institutions. The basic problem being addressed by the Athenians is one modern societies deal with. The institutions developed by them are unique and worthy of our consideration. Future work should continue on this path of exploring alternative institutions in Ancient Greece.

One can consider the application to modern democracies. Tax avoidance is a problem for many countries. The *antidosis* procedure uses knowledge dispersed in the society to improve upon the government's asymmetric information problem. The mechanism provides incentivizes for citizens to reveal their information. Implementing the insights from the Ancient Athenians to modern public finance should consider how to harness private information.

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