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Progressive taxation in a tournament economy☆

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ABSTRACT

Not enough is known about the responsiveness of individuals, in particular those who work under different incentives, to changes in marginal tax rates. We ask whether changes in tax rates are less distortionary for workers engaged in a contest. To examine this potential rationale for a more progressive tax code, we first model the effort decisions of workers faced with progressive taxation under tournaments and piece rates. Because of the difficulty identifying any distortion that may be induced by the tax code in naturally occurring data, we then report on the results of a real-effort experiment based on this model. Consistent with a behavioral approach to public finance, we find that competitive tournament workers are less sensitive and hint, in our discussion, at the possible welfare benefits of progressive taxation in tournament economies.

1. Introduction

Renewed interest in the social and economic consequences of unequal income distribution has also stimulated new discussion about the costs and benefits of progressive taxation. In most but not all contributions to the literature, taxation is the means to income redistribution, the utilitarian benefits of which are weighed against various disincentive effects, the "leaks" in Okun's (1975) proverbial bucket. Diamond and Saez's (2011) much-cited recent case for high and rising marginal tax rates for high income earners is one of hundreds, if not thousands, of examples. A second, less common, approach emphasizes the provision of public goods in an unequal world, including, but not limited to, their redistributive properties, and derives the tax schedule as a solution to the "financing problem." In either case, however, the choice of schedule turns, in part, on the responsiveness of income earners to variations in marginal tax rates. Our purpose in this paper is to draw attention to an important lacuna in the characterization of this response.

A number of recent studies have found that wage earners are less "tax sensitive" than once believed. Goolsbee 's (2000) influential paper on executive compensation, for example, finds little or no evidence that taxable income decreases in the medium run, and identifies "compensation timing" as the source of almost all short term variation. Like other contributions to the "elasticities approach" (Piketty et al., 2014; Saez, 2001), however, these are reduced form estimates and so we know much more about the magnitude of the response than its explanation.

The surprise, perhaps, is how few structural models are available to empirical researchers. Keane's (2011) authoritative review of the literature explores the empirical implications of three distinct models (static, simple life-cycle and life-cycle with human capital accumulation) but in each of these, the representative worker sells "labor time" in return for a fixed wage or time rate. Lemieux et al. (2009), however, find that more than 40% of male household heads in their PSID sample received some sort of "performance pay," a number that does not include, among others, those on promotion

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ladders whose income at each "rung" is more or less fixed. Furthermore, performance is often measured not in times of hours or weeks, but effective effort. Corroborating this, Lazear and Shaw (2007) show that the use of performance pay is not just at a high level, it is increasing. From the late 1980s through the 1990s, the share of large firms using performance pay has grown from roughly a third to two-thirds. In other words, characterizing the response of workers to changes in the tax code is likely to be incomplete if the incentives encompassed by pay-for-performance schemes, like tournaments, are ignored.

Our emphasis on tournaments reflects two considerations. First, consistent with one of Lazear and Rosen's (1981) initial motivations for their model, tournaments are often used to characterize compensation schemes that rely on bonuses or other performance-related rewards. Second, as Lazear and Oyer (2004) remind us, tournaments also capture several characteristic features of internal labor markets, in which the prizes are promotions to higher levels. Viewed from this perspective, the scope of our work is much broader than workers seeking bonuses: as Osterman and Burton (2009) observe, internal labor markets remain an important feature of the economic landscape.

Our conjecture is that tournament workers are less sensitive to changes in marginal tax rates for at least two reasons. First, when marginal rates are high, differences in prizes are smaller, and further incremental changes in the tax code should have a smaller effect. Second, tournament workers are competitive, and often find additional motivation in the "joy of winning." This encourages hard work even when incentives are blunted and further mitigates the effects of tax code changes. We posit, in short, that standard theoretical predictions about the disincentive effects of progressive taxation overstate their practical consequences for workers preoccupied with tournaments.

A more complete understanding of the incentive effects of progressive taxation in this setting therefore requires models that incorporate three basic features: alternative compensation schemes, possible behavioral influences on tax responsiveness and, in some cases, variation in effort rather than hours. The model in the next section is a first step in this direction. Building on the recent work of Persson and Sandmo (2005), we focus on the effort choices of tournament workers under different tax regimes, compared to a piece rate benchmark, with some allowance for worker competitiveness.

Because of all the standard difficulties with making inferences from observational data (e.g., selection, measurement error and endogeneity) we then turn to the experimental lab to offer a first test of our conjecture. To increase the external validity of our data, however, we conduct a real effort experiment designed to explore some of the model's implications. We compare effort choices under two tax regimes, one more progressive than the other, and under two compensation schemes, a simple piece rate and a tournament. An incidental but important feature of our design is that tax revenues are neither redistributed nor assumed to vanish into some "fiscal black hole," as in the past but are instead used to fund a public good whose benefits are salient to workers. We also collect data on individual characteristics and beliefs, including gender, competitiveness and political views.

Our main result is that while the introduction of more progressive taxes causes some distortion (effort does fall) under both compensation schemes, the difference-in-differences is negative; that is, it falls much less (indeed, in a statistical sense, almost not at all) under the tournament. In short, we find that the response of tournament workers is almost inelastic, a provocative result with profound implications for public finance. For example, if the executives Goolsbee (2000) studied were competitive tournament workers, the observation that their labor incomes are tax insensitive comes as no surprise.

We are not the first, of course, to explore the effects of tax changes in an experimental setting. It is important to note, for example, that our piece rate experiment replicates to a great extent what others have found. This increases the internal validity of our results by suggesting there is nothing idiosyncratic about our design. Sutter and Weck-Hannemann (2003), for example, find that individual effort falls as tax rates increase, but that the reduction is smaller when tax decisions are made behind the veil of ignorance. Ottone and Ponzano (2007) also find significant effort reductions but, in their case, the effect is limited to high tax rates (70%, for example). Working with a much larger sample, Levy-Garboua et al. (2009)reach a similar conclusion, and provide some evidence that it owes as much to fairness norms as the traditional logic of labor/leisure tradeoffs. No less important for our work, there is also some experimental evidence that it isn't just the effective tax rate, but the progressivity of the entire tax code, that matters. Swenson (1988), for example, increased the tax rate and, as a consequence of a budget-balancing lump sum element of the code, its progressivity, and found a significant decline in effort. In a series of experiments, Sillamaa (1999a,b,c) replicated Swenson's results and showed that a more progressive code (implemented through the construction of a Hausman equivalent code as a control) also reduced effort.

Our own design, discussed in more detail in the third section, differs from the others in at least three important dimensions. First, consistent with the previous discussion, we considered both piece rates (linking our results to the existing literature) and tournaments, our focus. Second, our treatment of taxes is more expansive: the convention has been to treat taxation as either confiscation (Levy-Garboua et al., 2009; Sutter and Weck-Hannemann, 2003) or redistribution (Ottone and Ponzano, 2007; Sillamaa, 1999a,b,c; Swenson, 1988) but in our experiment (much like Ortona et al., 2011 or Ottone and Ponzano, 2011), revenues are used to fund a proper public good, one that is optimal to provide and vulnerable to free-riding. Third, we felt it important, if somewhat less transparent, for our participants to interact with the tax code itself, and not, as in almost all previous experiments, with a schedule of after-tax wages.

2. Progressive taxation and tournament incentives

To formalize our intuition that the distortionary effects of progressive taxation can be smaller when three workers vie for a prize (e.g., a bonus or promotion), we extend the recent model of Persson and Sandmo (2005) in several directions. Given the details of our design, however – we do not induce the cost of effort or "competitiveness weights," for example, nor do we observe the noise in effort – the model is intended to motivate the logic of observed behavior. With this in mind, consider a representative firm with three workers, each of whom produces output $x_i = e_i + \epsilon_i$, where e_i is normalized effort and ϵ_i is an independent draw from a symmetric (around zero) distribution H with continuous density h.

Each worker confronts the simplest possible progressive tax schedule, in which the total tax burden τ_i is equal to $tx_i - f$ where t denotes the marginal tax rate and f a lump-sum allowance. For given f, the average tax rate increases with income, consistent with standard notions of progressivity.[1] It follows that an increase in t is both an increase in the marginal tax rate and the progressivity of the entire tax code. In contrast to Persson and Sandmo (2005), workers in our model also receive public good benefits equal to a fraction $\alpha < \frac{1}{N}$ of total tax revenues $t\left(\sum_j x_j\right) - 3f$. Workers are also assumed to be risk neutral, and to exhibit a standard quadratic cost of effort schedule, $\frac{1}{2}ke_i^2$ where k determines the slope of the marginal cost function.

[1] More specifically, where workers are paid a unit piece rate, for example, the average tax rate is just $\frac{tx_i - f}{x_i}$, which is increasing in x_i.

Consider first a piece rate regime in which the price of output is normalized to one and the three workers receive the full market value for each unit produced. Because she is risk neutral, the first worker maximizes the expected value of her after-tax income, net of effort costs and public goods benefits, equivalent to the decision problem:

$$\max_{e_1} \quad e_1(1-t)+f-\frac{1}{2}ke_1^2+\alpha\left(t\left(e_1+e_2+e_3\right)-3f\right) \tag{1}$$

It is straightforward to show that her optimal effort level, and the optimal effort levels of the other two workers, are:

$$e_P^*=\frac{1-(1-\alpha)\,t}{k} \tag{2}$$

where "P" denotes piece rate. As expected, effort decreases as k, and therefore the marginal cost of effort, rises and increases with α, the rate of return on the public good, an important if sometimes overlooked response.[2] Most important, there is distortion — effort also decreases as the marginal tax rate t rises, although the magnitude of the response does not depend on whether f is adjusted to preserve tax revenue.[3]

The worker's decision problem under a tournament regime is more complicated. We depart from the conventional "fixed prize" specification, and assume that the winner receives a share s_1 of firm revenues, the expected value of which is $e_1+e_2+e_3$, while the second- and third-place workers receive s_2 and s_3, where $s_1>s_2>s_3$ and $\sum_k s_k=1$. In other words, we consider tournaments that "balance the budget," as the piece rate scheme does. Last, let $p_1=p_1\left(e_1,e_T^*\right)$ denote the likelihood that the first worker wins the tournament when she expends effort e_1 and the second and third workers each expend the optimal level of effort e_T^*; $p_2=p_2\left(e_1,e_T^*\right)$, the likelihood that she finishes in second place; and $p_3=p_3(e_1,e_T^*)$, the likelihood that she finishes last.

If the first worker is risk neutral and maximizes expected gains, she solves:

$$\begin{aligned}\max_{e_1}\; & p_1\left[(1-t)\,s_1\left(e_1+2e_T^*\right)+f\right]+p_2\left[(1-t)s_2\left(e_1+2e_T^*\right)+f\right]\\ & +p_3\left[(1-t)s_3\left(e_1+2e_T^*\right)+f\right]-\frac{1}{2}ke_1^2+\alpha\left[t\left(e_1+2e_T^*\right)-3f\right]\end{aligned} \tag{3}$$

Her optimal choice e_1^* satisfies the first order condition:

$$\begin{aligned}p_1(1-t)s_1+p_1'(1-t)s_1\left(e_1^*+2e_T^*\right)+p_2(1-t)s_2+p_2'(1-t)s_2\left(e_1^*+2e_T^*\right)\\ +p_3(1-t)s_3+p_3'(1-t)s_3\left(e_1^*+2e_T^*\right)-ke_1^*+\alpha t=0\end{aligned} \tag{4}$$

where $p_k{}'$ is the derivative of p_k with respect to e_1. Because $e_1^*=e_T^*$ and therefore $p_1=p_2=p_3=\frac{1}{3}$ in a symmetric pure strategy equilibrium, this reduces to:

$$\left(\frac{1}{3}\right)(1-t)+3(1-t)e_T^*\left[p_1's_1+p_2's_2+p_3's_3\right]-ke_1^*+\alpha t=0 \tag{5}$$

Krishna and Morgan (1998) show that for a three person tournament, $p_2{}'=0$ and $p_1'=-p_3'=\int_{-\infty}^{+\infty}h_1^{(2)}(\epsilon)h(\epsilon)d\epsilon$, where $h_1^{(2)}(\epsilon)=2H(\epsilon)h(\epsilon)$ is the density of the first order statistic for two realizations of the "noise" in individual production. For example, where the distribution is uniform over the interval $[-a,a]$, it is not difficult to show that $p_1'=-p_3'=\frac{1}{2a}$, and simplification of Eq. (4) produces:

$$e_T^*=\frac{(1/3)(1-t)+\alpha t}{k-(3/2a)\,(1-t)\,(s_1-s_3)} \tag{6}$$

The basic properties of the tournament effort function are intuitive. As with piece rates, an increase in the return on the public good or a decrease in the marginal cost of effort both cause effort to rise. Workers also respond to tournament incentives: effort in the pure strategy equilibrium increases in the difference between the first and last place shares, s_1-s_3. And while the existence of a tournament equilibrium requires "sufficient noise" – that is, $k>(3/2a)(1-t)(s_1-s_3)$– it also follows that the less precise the output signal, i.e., the larger the value of a, the less effort each worker expends. In other words, if promotion has more to do with luck than hard work, effort will be low.

It also comes as no surprise that tournament effort decreases as the marginal tax rate increases:

$$\frac{de_T^*}{dt}=-\left\{\frac{k((1/3)-\alpha)+(3/2a)\alpha(s_1-s_3)}{[k-(3/2a)(1-t)(s_1-s_3)]^2}\right\}<0 \tag{7}$$

The question, however, is how this distortion compares with that under piece rates. As Eq. (7) implies, the answer depends on the initial tax rate t. Whereas effort declines at a constant rate ($de_P^*/dt=-(1-\alpha)/k$) under the piece rate, the responsiveness of effort declines as the tax rate increases under the tournament. As the subsequent numerical example illustrates, there is, for reasonable parameter values, some critical tax rate at which tournament workers become less responsive. The challenge is that these are also the parameter values for which tournament workers are often less productive, an observation inconsistent with at least our own lab results.

We posit that the model, in its current form, overlooks an important characteristics of workers in both the lab and the field. Consistent with our motivation, consider a behavioral enhancement in which workers are more competitive than is typically modeled. In such an environment, managers might find it in their interests to implement a tournament, despite the tax consequences, to exploit such a characteristic.

The notion of "competitiveness" is now common in the behavioral literature and, in this context, it is often linked to a "joy of winning." Observations of competitiveness have manifested as both over-bidding in auctions (Astor et al., 2013; Cooper and Fang, 2008; Delgado et al., 2008; Dohmen et al., 2011) and over-working in contests and tournaments (Altmann et al., 2012; Amaldoss and Rapoport, 2009; Chen et al., 2011; Kraekel, 2008; Parco et al., 2005; Sheremeta, 2010) . To incorporate this, the representative tournament worker's decision problem is modified to:

$$\begin{aligned}\max_{e_1}\; & (1-c)\left\{p_1\left[(1-t)s_1(e_1+2e_C^*)+f\right]+p_2\left[(1-t)s_2(e_1+2e_C^*)+f\right]\right.\\ & \left.+p_3\left[(1-t)s_3\left(e_1+2e_C^*\right)+f\right]\right\}+cp_1J\\ & -\frac{1}{2}ke_1^2+\alpha\left[t(e_1+2e_C^*)-3f\right]\end{aligned} \tag{8}$$

where c is a measure of competitiveness between 0 and 1, J is the "joy" of winning and e_C^* is the competitive level of effort in a symmetric tournament equilibrium in pure strategies. That is, the "prize" is now a convex combination of the previous tournament reward and the joy of winning where, for the sake of convenience, it is assumed that neither the "runner up" nor the third place worker experience

[2] Further, the social optimal level of effort $\left(\frac{1-(1-3\alpha)t}{k}\right)$ illustrates that the underprovision problem persists with respect to the piece rate equilibrium.

[3] To the extent that our framework does not allow for income effects, the disincentive/substitution effects are underscored.

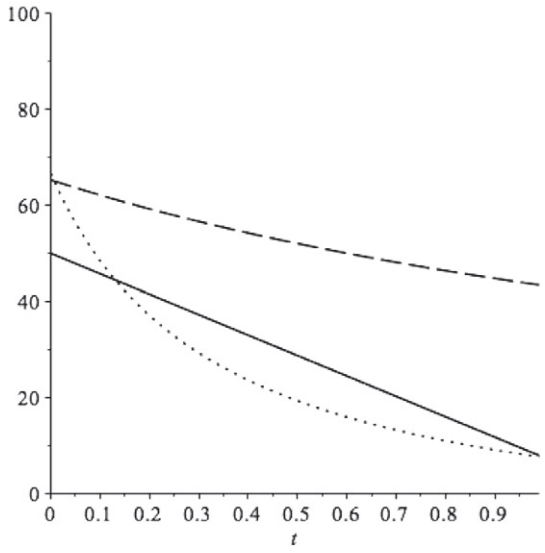

Fig. 1. Effort under three incentive regimes as a function of the marginal tax rate (Note: The solid line is for the piece rate condition, dotted is the basic tournament and dashed indicates the tournament with competitive workers).

this. It is then not difficult to show that in symmetric equilibrium in pure strategies:

$$e_C^* = \frac{(1-c)(1/3)(1-t) + \alpha t + c(1/2a)J}{[k-(1-c)(3/2a)(1-t)(s_1-s_3)]} \tag{9}$$

But will this make tournament workers less responsive to changes in the marginal tax rate? That is, while we know that standard tournament workers will be less responsive when marginal tax rates are high, what should we expect when workers see the tournament through the "red mist" of competition? With some simplification, the responsiveness of competitive tournament workers can be written as follows, an expression that is less responsive to the tax rate than under the piece rate regime.

$$\frac{de_C^*}{dt} = -\left\{\frac{k[(1/3)(1-c)-\alpha] + (1-c)(3/2a)(s_3-s_1)(\alpha + c(1/2a)J)}{[k-(1-c)(3/2a)(1-t)(s_1-s_3)]^2}\right\} < 0 \tag{10}$$

To illustrate the main features of our model, we plot equilibrium effort levels in all three cases (piece rate, tournament, competitive tournament) in Fig. 1.[4] It is obvious from Eq. (2), but Fig. 1 confirms that piece rate workers' response is linear and therefore independent of the initial tax rate. This is not the case in the tournaments, however. As the tax rate increases in Eqs. (6) and (9), workers' responses are nonlinear. The intuition for this is that with variable prizes, the differentials between first and last place also shrink as the effort of all workers falls with the increase in the tax rate. Furthermore, for reasonable J, the response of competitive tournament workers will be more muted because more weight is attached to an outcome (joy) whose value doesn't shrink with increased marginal tax rates. In short, *if workers are competitive enough, tournaments will be productive (that is, elicit more effort than piece rates) and exhibit less tax distortion.*

[4] The parameter values used to construct Fig. 1 reflect both the particulars of our experimental design and the results themselves: $s_1 = 0.6$, $s_3 = 0.10$, $\alpha = 0.15$, $k = 0.02$, $c = 0.55$ and, a uniform distribution of disturbances. When the marginal tax rate is 15%, for example, the expected outputs of piece rate and competitive tournament workers are, respectively, 44 and 60 units, similar, in both level and difference, to our experimental data discussed in the next section.

3. Evidence from a real effort experiment

The pursuit of credible estimates of the responsiveness of workers to changes in marginal tax rates, at both the intensive and extensive margins, remains a feature of the public finance literature. Not only are there obvious sources of endogeneity in naturally occurring data (Keane, 2011), the quality of the data presents another challenge. For example, it is often hard to distinguish the shift in compensation timing from permanent shifts in compensation and tax code changes tend to affect rates as well as brackets and the definition of taxable income, itself (Goolsbee, 2000).

Rather than struggle with these common empirical issues, we offer a first examination of the main hypothesis developed in Section 2 (that the tax responsiveness of workers depends on how they are incentivized) in a setting in which identification can be guaranteed. We conduct an experiment in which workers are hired and randomly assigned to an incentive structure and a tax code. This allows us to estimate the causal effect of the progressivity of the tax code on effort for different compensation schemes. As a result, we test whether the hypothesis holds when internal validity is guaranteed before examining the idea using naturally occurring data. That said, to enhance the external validity of our results, our experiment requires participants to put forth real effort. They actually work and their compensation depends on how hard they work. The details and results are explained below.

3.1. Experimental design

While theory offers a rich set of hypotheses, our experiment focuses, as a first step, on what we think is the central conjecture, consistent with Fig. 1. If one compares two outcomes, one that represents expected output under a less progressive tax system and another representing a more progressive system, we should observe that the effect on output is negative but more muted in a tournament. Furthermore, to a considerable extent, this result should reflect the competitive nature of workers. This is not to say, however, that a complete test of the entire theory would not also examine the expected linearity of the piece rate response and the curvature of the posited tournament response, but we postpone these as important topics for follow-up experiments. To concentrate on this central conjecture and compare points on the labor supply curves, we implemented a two-by-two factorial design. The design crosses compensation scheme differences with differences in the progressivity of the tax code (implemented as larger marginal tax rate increases between income brackets) to generate the required data.

Our participants completed a task similar to the ones used previously in this area of research (e.g., Levy-Garboua et al., 2009; Sillamaa, 1999a,b,c) They deciphered numbers (from 1 to 99) into letters using a decoding sheet. On the computer screen the participant was presented five numbers and an input box to type the corresponding letters.[5] After decoding a "set" of five numbers, the participant would click a button, the computer would check to see if the set had been decoded correctly, and, if it had, the participant would be given another five numbers to decode. An error message was displayed if the set was decoded incorrectly and the participant was given as many tries as necessary to get it right. There was no limit to the number of sets a participant could decode in the time provided. The task was chosen because ability was unlikely to be tied to demographics and the task had little intrinsic reward so there was likely to be substantial variation in the output data (and it would be unlikely for participants to run up against any "output ceiling").

In each session of the experiment, nine participants were randomly sorted into three "firms" that formed a small scale economy in

[5] The experiment was approved by the Middlebury College IRB and programmed in z-Tree, (Fischbacher, 2007).

which people worked, paid taxes and the taxes were used to provide a public good. We utilized two, simple, five-bracket tax codes. The first was relatively flat and the second was considerably more progressive, corresponding to values on the x-axis in Fig. 1. We chose to vary the progressivity of the tax code because it is the treatment of interest to us and because we worried that comparing a simple flat tax to a progressive one would be as much about the simplicity of the code as it is about the code's effect on effort.[6] The "less progressive" tax code was based, loosely, on the U.S. tax code during the Clinton administration, the brackets progressed from 15% to 35% in equal steps (i.e., 15%, 20%, 25%, 30%, 35%). The "more progressive" tax code resembled the U.S. code during the Great Depression. It started at just 5% but climbed to 64% at the highest bracket. Because the bracket earning intervals were fixed across codes to simplify them and we wanted to devise a more progressive code that would be incidence-neutral when compared to the less progressive code for the average participant, the more progressive rates of 5%, 17%, 32%, 47%, and 64% could not increase in fixed steps. Instead, the more progressive rates were calibrated to the performance of the average worker in three initial less progressive code sessions.[7] This process proved successful – the incidence, at the individual level, did not differ significantly by the tax code imposed (t-test, $p = 0.77$).[8]

We also employed two compensation schemes. As is common in this literature (e.g., Swenson, 1988), participants were paid a piece rate in the first scheme. For each set that they correctly decoded they earned ten cents of pre-tax earnings. The second compensation scheme was a rank-order tournament. Here each correctly decoded set generated ten cents of pre-tax earnings for the firm. The person who decoded the most sets was awarded 60% of firm earnings, the person who decoded the second most sets was given 30% of the earnings and the lowest producer earned the remaining 10%.[9]

The collected tax revenue was used to fund a public good. However, because we did not want participants to focus too much attention on this benefit, the returns were intentionally modest. For every dollar of tax revenue collected in the economy, each of the nine workers received fifteen cents. As discussed in Section 2, workers will under-provide effort in the symmetric piece rate equilibrium for all positive returns (less than one) but unlike the canonical public goods experiment, no lower bound is required to ensure that some level of the good will be provided.

Considering the protocol, we aimed to make efficient use of the time our participants provided while being mindful of the complexity of the experiment. This meant that we exposed the participants in each session to two of the four treatments. Specifically, we decided to vary the more straightforward aspect of the design, the incentive scheme, within subjects and vary the more complicated aspect, the tax code, between subjects. Hence, each session, regardless of treatment, had three work periods. The first lasted three minutes, was unpaid, and familiarized the participants with the software and the task. This was followed by two twelve-minute paid work periods. Again, to keep things as simple as possible, during each session the tax code was fixed for the two work periods but the compensation scheme changed between the first paid work period and the second. The order in which the compensation scheme changed (i.e., piece rate to tournament or tournament to piece rate) was determined randomly. Because the cryptography changed at the beginning of each period and the task was simple, we predicted experience would have little effect on productivity.[10]

We conducted twelve sessions, each lasting about 45 min, and therefore gathered 216 output observations from 108 participants. The average (take home) earnings of our participants was $14.84, including a $5 show-up payment. Weeks prior to participating, subjects answered a brief survey as part of the recruitment process. We decided to collect this data considerably before the experiment so that it would be extremely unlikely that the responses of the participants to the survey questions would directly affect their choices in the experiment, perhaps out of some sense of being consistent. Also, given the sample size and the questions asked, it should have been clear to the participants that none of the data we collected would allow us to personally identify anyone. From this data we learned that 43% of our participants were female, 77% considered themselves to be competitive, 17% classified themselves as politically conservative and 26% considered government to always be wasteful and inefficient."[11] Summary tests of equal proportions reported in Table A1 of the Appendix based on these survey results suggest that our recruitment was balanced. The one exception was that there were significantly more participants in the more progressive treatment that thought that government is wasteful. However, as the analysis described below suggests, these opinions do not have much effect on effort choices.

3.2. Effort choices

As is common in the real effort paradigm, our participants worked hard; however, there was variance in their efforts (e.g., van Dijk et al., 2001 or Bruggen and Strobel, 2007). The overall mean output per work period was 45.74 sets (or 3.81 per minute) but the outputs ranged from a low of 25 sets to a high of 70 sets. Across treatments, the taxes paid on the resulting earnings averaged $1.03 per work period which worked out to be an average effective tax rate of 19%. As mentioned above, our tax code calibration worked well in that the individual taxes paid between the two codes did not differ significantly.

We begin our analysis of any treatment differences visually using Fig. 2 which illustrates the distribution of output by condition. As one can see on the left side of the figure, we partially replicate previous results on the effort-reducing effects of piece rates. Replicating the related experimental literature on contests (summarized in Charness and Kuhn, 2011 and Dechenaux et al., 2012), we also see that the rank order tournament causes our participants to work a little harder, in this case, regardless of the tax code. Overall, the positive effect on effort of the tournament appears to be stronger and more consistent than the negative effect of progressive taxation.

To get a better sense of the treatment effects, consider Fig. 3, which we have drawn to facilitate comparisons with the main hypotheses illustrated in Fig. 1.[12] Indeed, as predicted, mean output under piece

[6] This seems to have been a reasonable fear. Abeler and Jaeger (2013) find, in a similar real effort setting, that the complexity of the tax code affects the extent to which workers respond to code changes.

[7] Specifically, we first observed worker productivity under the flatter code and then set the intermediate rates of the more progressive code so that workers who achieved the same (mean) output in the more progressive sessions would have roughly the same tax incidence.

[8] See the experimental instructions in the Appendix for the details of the bracket limits and how the codes were implemented.

[9] Consistent with the model described in Section 2, any output ties would have been settled at random. None were realized, however.

[10] In fact, the results presented in the Appendix (Table A3) confirm that there were no productivity gains in the second work period.

[11] The exact questions and possible responses were: *In general, how competitive do you think that you are?* ("avoid competition always", "generally not competitive", "neither competitive nor not competitive" "generally competitive" or "extremely competitive") Those choosing "generally" or "extremely competitive" were classified as competitive for the analysis. *Do you consider yourself a Republican, Democrat, or Independent?* ("strong democrat", "democrat", "independent lean democrat", "independent", "independent lean republican", "republican" or "strong republican") Those selecting "independent lean republican", "republican" or "strong republican" were labelled conservative for the analysis.*Select one response from the paired statements below. Even if neither statement is exactly right, choose the response that comes closest to your views.* ("Government is almost always wasteful and inefficient" or "Government often does a better job than people give it credit for")

[12] More details can be found in Table A2 in the appendix.

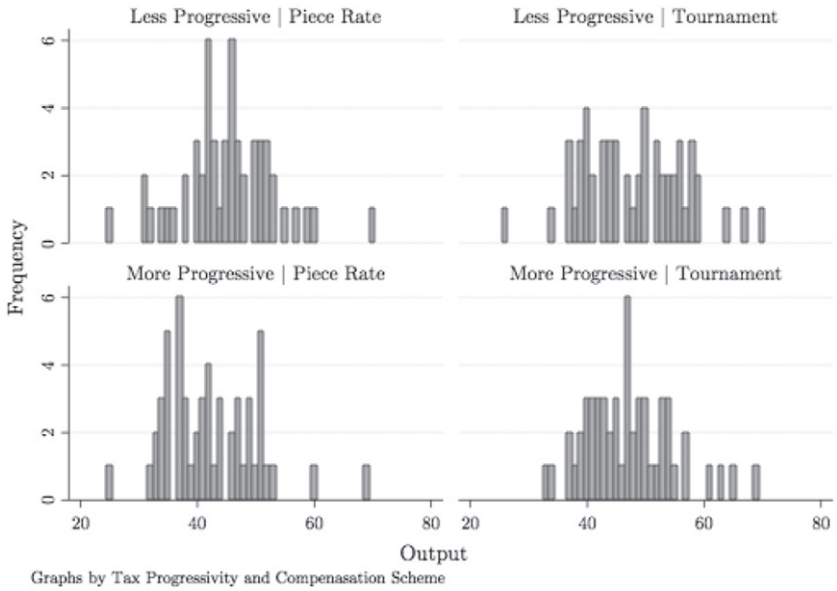

Fig. 2. Observed output (by treatment).

rates falls from 45.20 sets to 42.37 as the tax code becomes more progressive. This constitutes a 6%, marginally significant ($t = 1.85$; $p = 0.06$), reduction in output. Compared to previous results, discussed in the introduction, this reduction is modest but one plausible explanation is that our participants might have been less averse to taxes because the tax revenue provided a public good instead of being confiscated. Comparing compensation schemes, we confirm that the tournament had a more consistent effect on output. In the case of the less progressive code, output increased by 7% and in the case of the more progressive code, the increase was 11%. These differences are similar in magnitude to those found in previous tournament experiments (e.g., van Dijk et al., 2001) The most important comparison in Fig. 3, however, is embodied in the upper line, the (non)difference in output within the tournament. Here we see that the more progressive tax code did not cause a significant reduction in effort when tournament incentives were used. Although mean output falls from 48.19 to 47.22, the resulting 2% reduction is far from significant.[13]

To be more precise about our estimates, we report the average marginal effects of the treatments, controlling for both experiment order and the demographics collected in the recruiting survey, in Table 1. For simplicity we report only the effects of direct interest, but a full table of results can be found in the Appendix(i.e., Table A3).[14] In column (1) we control for the order of the experiment which has little effect on our estimates. We continue to find that more progressive taxation reduces output under piece rates by 6% ($AME = -2.87$, $p = 0.09$) and that the tournament increases output by 6.5% ($AME = 2.95$, $p = 0.07$) with the less progressive code and by 11% ($AME = 4.90$, $p < 0.01$) with the more progressive code. We also continue to find no significant reduction in output when taxes become more progressive and participants are competing in a rank-order tournament ($AME = -0.92$, $p = 0.58$). In column (2) of Table 1 we add the demographic covariates. This addition has modest effects on our estimates, the largest being that the drop due to tax progressivity in the piece rate treatment increases a bit (in magnitude and significance) to 8% ($p = 0.04$). In column (3) we see that our estimates of the average marginal effects are not affected by the inclusion of interactions between the treatments and the demographic covariates (though Table A3 in the Appendix suggests that some of the interactions are interesting). To summarize, our estimates of the treatment effects replicate a number of studies in the related experimental literatures which is comforting in that this suggests that our procedures are not unique, nor are they directly responsible for our results. The noteworthy finding of our experiment, however, is that tournaments not only attenuate, they appear to nullify, any disincentive effect of more progressive taxation.

3.3. The role of competitive workers

Our data is consistent with the theoretical predictions in Section 2: optimal effort ought to fall under both piece rates and

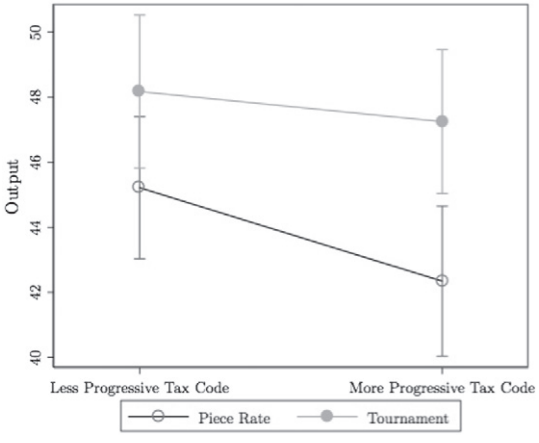

Fig. 3. Mean output (by tax code progressivity).

[13] One might worry that the lack of a significant difference between the two tournament treatments is caused by a "ceiling effect" driven by participants reaching their capacities in the less progressive tournament. There is no evidence of this, however. From Fig. 2, the reader can see that the distribution of outputs is symmetric around the mean in all treatments (i.e., there is no "pile up" at a ceiling in the less progressive tournament). Further, the maxima and variance in outputs is very similar across treatments.

[14] Because of the interaction terms, some addition is required to get from Table A3 to Table 1. For example, in column (2) of Table 1 the average marginal effect of the more progressive code in the tournament is the addition of the Table A3 coefficient on "More Progressive × Tournament" (2.32) and the one on "More Progressive Code" (−3.66) which yields, after some rounding, −1.35 — the figure in Table 1 . The other values can be found using a similar method. The last column (3) is more complicated because the estimates of the treatment interactions with the demographic controls are assessed at the population averages of the demographics.

Table 1
Average (estimated) marginal treatment effects.

	(1)	(2)	(3)
More progressive code (under piece rates)	−2.87*	−3.66**	−3.66**
	(1.71)	(1.78)	(1.73)
More progressive code (under tournament)	−0.92	−1.35	−1.38
	(1.67)	(1.70)	(1.63)
Tournament (under less progressive code)	2.95*	2.80*	2.86*
	(1.66)	(1.70)	(1.65)
Tournament (under more progressive code)	4.90***	5.12***	5.15***
	(1.76)	(1.73)	(1.67)
Controls for experiment order.	Yes	Yes	Yes
Controls for covariates.	No	Yes	Yes
Controls for interactions.	No	No	Yes
Observations	216	210	210
Adjusted R^2	0.05	0.06	0.12

Note: Dependent variable is individual output; OLS with robust (standard errors).
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

tournaments as the tax code becomes more progressive but, conditional on the presence of even limited competitiveness, optimal effort in tournaments should decrease less. Not only do we confirm these predictions with our data, the last result on the difference in progressivity differentials seems particularly strong. The natural follow-up question is whether we can show that these results do, indeed, hinge on the competitiveness of our workers. Is it the case that competitive participants in rank-order tournaments are less sensitive to changes in tax incidence? In behavioral terms, if one is focused on winning the tournament (see, for example, Sheremeta, 2010), does the tax code difference lose some salience (a la Chetty et al., 2009; Finkelstein, 2009)?

Our survey data, allow us to test this auxiliary hypothesis about the role of competitiveness directly. The results are summarized in Fig. 4. Using the same specification as at the heart of Table 1, we parse the average marginal effect of the more progressive tax code on participants in the tournament into the effects for competitive and non-competitive participants (see Table A4 in the Appendix for details). In other words, the graph illustrates one's effort response to the tax code becoming more progressive (the circle heights) and reports this difference for competitive and non-competitive participants in the two compensation treatments (illustrated by the two lines). The difference in the marginal effects is large and significant ($p < 0.05$) according to the regression analysis. Non-competitive tournament participants reduce their efforts by an average of 5.75 sets ($p < 0.05$) while the competitive participants seem to ignore the tax code. Their efforts actually increase slightly, though not significantly ($p = 0.77$). This confirms that competitive participants tend to ignore the tax code when participating in a tournament. As one can also see in Fig. 4 the blinding effects of competitiveness seem to extend past the tournament. The regressions suggest that competitive piece rate workers also only reduce their efforts 1.70 sets after the tax hike ($p = 0.39$) compared to the non-competitive workers who reduce their efforts much more, an average of 7.28 sets ($p < 0.01$).[15]

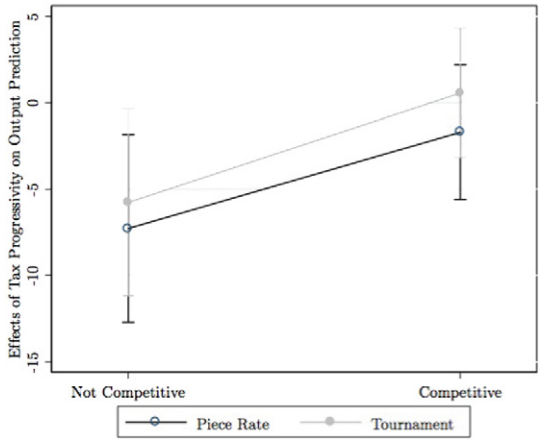

Fig. 4. Average marginal effects of tax progressivity by competitiveness (with 95% CIs).

In sum, our results are consistent with a behavioral public finance model in which workers maximize a traditional objective function augmented by a small "joy of winning." It is worth adding, however, that if more competitive workers sort into tournaments outside the lab, the effects of more progressive taxation could be even more diluted than what we find.

4. Discussion

It was our initial intuition that workers who are concerned, for both strategic and behavioral reasons, with their rank within internal labor markets would be less sensitive to variations in the tax code. If so, the usual disincentive effects of progressive taxation would be attenuated, with important welfare implications, more so when tax revenues are used to finance productive public goods.

We are able to write down a model that formalizes this logic, and find support for it in our real effort experimental data. As in the previous literature, we find that progressive taxation distorts incentives under piece rates. At the same time, with tournaments effort increases and is more or less inelastic with respect to the progressivity of the tax code.

Our results dovetail nicely with a number of studies focused on the broader topic of "tax perceptions" — the extent to which consumers and workers correctly assess and react to a given tax code (Arrazola et al., 2000; Koenig et al., 1995) . In some cases the complexity or framing of the code may affect perceptions (Abeler and Jaeger, 2013; Ackermann et al., 2013; Hayashi et al., 2012; Sausgruber and Tyran, 2005) or the ultimate use of the tax revenue itself can affect work effort (Keser et al., 2015). Alternatively, correctly perceiving the code may be affected by things as simple as the visibility of the code (Rupert and Wright, 1998), who collect/pays the tax (Sausgruber and Tyran, 2011; Weber and Schram, forthcoming) or one's experience being taxed (Fochmann and Weimann, 2013). At the same time not all tax misperceptions lead to cheating or inefficient distortions. Djanali and Sheehan-Connor (2012), for example, find that some people exhibit "tax affinity" and their pro-social nature makes them only too happy to pay their taxes. Given the lessons of this literature, one way to think about our results is that competitiveness and a venue in which to express this trait can easily force a wedge between one's perception of the tax code and reality. In our case, this trait causes workers to adjust their behavior less than non-competitive workers as the code becomes more progressive. In this way we reveal one of the many possible mechanisms through which tax "misperceptions" arise.

One open question concerns welfare and the prevalence of tournament incentives in the economy. In settings in which tax revenues fund public goods and competitive workers respond little to the

[15] There is considerable evidence from a variety of disciplines that suggests that "individualistic" personalities (i.e., those who tend to agree with statements like "Winning is everything" or "I feel good when I compete with others) do tend to see situations with benign incentives as competitions (Triandis, 1995). For example, the competitive nature of individualistic people has been shown to spoil work teams to a degree beyond simple, and rational, free-riding (Chow et al., 2001; Kim et al., 1994; Naranjo-Gil et al., 2012) .

steepness of the tax code, as more firms adopt tournament-based incentive schemes, does the optimal level of tax progressivity shift? With more tournaments, a more progressive code could generate greater tax revenues, resulting in more public goods being provided and, perhaps, higher welfare, all with minimal distortionary effects on labor supply. Given the contrast with the canonical textbook treatment of the distortionary effects of tax progressivity, more research is warranted, and we take some first tentative steps in this direction in an online Appendix.

Appendix A. Appendix (auxiliary empirics)

Table A1
Treatment balance.

	Less progressive	More progressive	*p*-Value
Female (I)	0.42 (0.50)	0.43 (0.50)	0.93
Competitive (I)	0.72 (0.45)	0.81 (0.39)	0.28
Government wasteful (I)	0.15 (0.36)	0.38 (0.49)	0.01
Conservative (I)	0.19 (0.39)	0.15 (0.36)	0.64

Note: means, (standard deviations) and tests of equal proportions.

Table A2
Mean effort (s.d.) and summary *t*-test results.

	Piece rate	Tournament	*p*-Value
Less progressive code	45.20 (7.91)	48.19 (8.79)	0.07
More progressive code	42.37 (7.82)	47.22, (7.58)	<0.01
p-Value	0.06	0.54	

Table A3
A full set of output determinants.

	(1)		(2)		(3)	
	No controls		Controls		Ctl + Inter	
More progressive tax code (I)	−2.87*	(1.71)	−3.66**	(1.78)	−10.69***	(2.44)
Tournament (I)	2.96*	(1.66)	2.80	(1.70)	−0.05	(2.36)
More progressive × Tournament (I)	1.95	(2.57)	2.32	(2.57)	2.28	(2.46)
Second work period (I)	0.08	(1.32)	0.23	(1.32)	0.49	(1.29)
Female (I)			0.53	(1.12)	−2.95	(1.89)
Competitive (I)			2.68**	(1.34)	−0.44	(1.99)
Government wasteful (I)			1.49	(1.09)	2.02	(1.85)
Conservative (I)			−2.45*	(1.32)	−6.45***	(2.10)
More progressive × Female (I)					7.16***	(2.16)
Tournament × Female (I)					0.14	(2.24)
More progressive × Competitive (I)					4.22*	(2.45)
Tournament × Competitive (I)					3.00	(2.56)
More progressive × Gov't wasteful (I)					−1.53	(2.18)
Tournament × Gov't wasteful (I)					0.33	(2.09)
More progressive × Conservative (I)					6.88***	(2.60)
Tournament × Conservative (I)					2.63	(2.62)
Constant	45.18***	(1.14)	43.29***	(1.50)	47.56***	(1.68)
Observations	216		210		210	
Adjusted R^2	0.05		0.06		0.12	

Note: Dependent variable is output; OLS with robust (standard errors).
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table A4
Output determinants and competitiveness.

	(1)		(2)	
More progressive tax code (I)	−1.91*	(1.11)	−7.28***	(2.77)
Tournament (I)	3.86***	(1.13)	0.37**	(0.88)
Competitive (I)	2.03*	(1.21)	−2.21	(1.88)
More progressive × Competitive (I)			5.58*	(3.24)
Tournament × Competitive (I)			3.39	(3.21)
More progressive × Tournament (I)			1.52	(4.04)
More prog. × Tourn. × Comp. (I)			0.75	(4.61)
Second work period (I)	−0.41	(1.13)	0.49	(1.32)
Constant	43.50***	(1.34)	46.63***	(1.29)
Observations	214		214	
Adjusted R^2	0.06		0.08	

Note: Dependent variable is output; OLS with robust (standard errors).
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jpubeco.2016.08.008.

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