Australian National University

Crawford School of Public Policy

TTPI

Tax and Transfer Policy Institute

Nudging businesses to pay their taxes: Does timing matter?

TTPI - Working Paper 13/2018
June 2018

Christian Gillitzer
School of Economics, University of Sydney

Mathias G. Sinning
Tax and Transfer Policy Institute, Crawford School of Public Policy, Australian National University, RWI and IZA

Abstract

This paper provides theoretical and empirical evidence on the implications of the timing of reminders by studying the effect of varying the timing of reminder letters to taxpayers on their payment behavior. The collection of unpaid tax debts constitutes a considerable challenge for tax authorities. We show that varying the timing of a reminder letter has a theoretically ambiguous effect on tax payments. We study the payment behaviour of business taxpayers in a field experiment in Australia and find that a simple reminder letter increases the probability of payment by about 25 percentage points relative to a control group that does not receive a letter from the tax authority. However, variation over a three-week period in the timing of the reminder letter has no effect on the probability of payment within seven weeks of the due date. Our findings indicate that sending reminders early results in faster payment of debts with no effect on the ultimate probability of payment.

JEL Codes: C93, H25, H26.
Keywords: Tax compliance, business taxation, natural field experiment, behavioral insights

∗We thank Robert Breunig, Uwe Dulleck, Kristen Sobeck and participants of the 2018 Asia Pacific Economic Science Association (APESA) Conference, the 13th International Conference on Tax Administration and the 2018 Public Economics Research Workshop at Victoria University Wellington for helpful comments and gratefully acknowledge the financial support from the Australian Research Council (LP160100810). *All correspondence to Mathias Sinning, Crawford School of Public Policy, College of Asia and the Pacific, JG Crawford Building #132, Lennox Crossing, The Australian National University, Canberra ACT 2601, Tel: +61 2 6125 1284, E-mail: mathias.sinning@anu.edu.au.*

Tax and Transfer Policy Institute

Crawford School of Public Policy

College of Asia and the Pacific

+61 2 6125 9318

tax.policy@anu.edu.au

The Australian National University

Canberra ACT 0200 Australia

www.anu.edu.au

The Tax and Transfer Policy Institute in the Crawford School of Public Policy has been established to carry out research on tax and transfer policy, law and implementation for public benefit in Australia. The research of TTPI focuses on key themes of economic prosperity, social equity and system resilience. Responding to the need to adapt Australia's tax and transfer system to meet contemporary challenges, TTPI delivers policy-relevant research and seeks to inform public knowledge and debate on tax and transfers in Australia, the region and the world. TTPI is committed to working with governments, other academic scholars and institutions, business and the community.

The Crawford School of Public Policy is the Australian National University's public policy school, serving and influencing Australia, Asia and the Pacific through advanced policy research, graduate and executive education, and policy impact.

1 Introduction

Timing is an important aspect of policy design that is often overlooked by policymakers. Prompting people at different times can have drastically different levels of success (BIT, 2014). In particular, policies that rely on people to take action at a certain point in time are affected by present bias and imperfect memory (Ericson, 2017). Reminders have been linked to improved individual behavior in various contexts, including savings (Karlan, McConnell, Mullainathan, and Zinman, 2016) and loan repayments (Cadena and Schoar, 2011; Karlan, Morten, and Zinman, 2015). Less is known about the extent to which the timing of reminders affects policy outcomes although the effectiveness of early and late reminders may differ considerably. While early reminders are more likely to be forgotten or may cause people to overestimate the frequency of reminders, late reminders may be less effective because they reduce the time available to take action.

The aim of this paper is to provide evidence on the implications of the timing of reminders by studying how varying the timing of reminder letters to taxpayers affect their tax payment behavior. There is now a large body of experimental research investigating how deterrence and non-deterrence methods affect taxpayers' income reports, but there is comparatively little research on the timely payment of tax debts (Hallsworth, 2014). We present results from a field experiment that was conducted in collaboration with the Australian Taxation Office (ATO) to learn about the payment behavior of small business taxpayers. Such an analysis is important because the volume of outstanding tax debts is non-trivial. For the United States, Internal Revenue Service (IRS) tax gap estimates for the 2008-2010 tax years show average underpayment of $39bn, which is about 10 percent of the gross tax gap (IRS, 2016). The bulk of unpaid debt is owed by individual taxpayers and unincorporated businesses. In Australia, 30 percent of small businesses did not pay their tax liabilities on time in the 2017 financial year and together owed around 67 percent of total collectible tax debt (ATO, 2017).

We construct a simple theoretical model to examine the channels through which the timing of reminders affect the payment behavior of taxpayers. We show that varying the time at which a reminder letter is sent to taxpayers has a theoretically ambiguous

effect on payment behavior. In our theoretical model, taxpayers trade off the benefit of paying their tax debt immediately with waiting until a time in the future when the opportunity cost of payment is lower. The disadvantages of delaying payment include interest penalties on the outstanding debt and the possibility that the debt is forgotten. If the debt is forgotten, it remains out of memory until a reminder is received from the tax authority. Sending reminder letters early alerts taxpayers who have forgotten about their debts. However, an early reminder may also cause taxpayers to believe they will receive frequent reminders from the tax authority, reducing the cost of delay to the taxpayer, and lowering the likelihood of payment. In this case, the probability of payment can be greater when the reminder letter is sent with some delay after the missed payment deadline.

While some taxpayers with overdue debts are willfully non-compliant, many have simply forgotten about their debt. The ATO seeks to resolve outstanding tax debts among compliant taxpayers by sending a reminder letter soon after the tax debt becomes overdue. Our field experiment is novel because it varies the time elapsed between the tax payment deadline and the reminder letter being sent. Deciding when to send reminders is an issue facing all debt collectors. Despite its importance, we provide the first scientific evidence on this choice in a large-scale real-world setting. The target population of taxpayers was restricted to business taxpayers with a history of compliant payment behavior who had missed their 26 May 2017 tax deadline. Debt cases were randomly allocated to receive a reminder letter either one, two, or three weeks following their missed tax debt due date; a control group did not receive a letter for the seven week duration of the trial.

The results from the field experiment reveal a large effect of a reminder letter on payment behavior. The probability of an overdue debt being paid by the end of the seven week trial was approximately 25 percentage points greater for cases receiving a reminder letter relative to cases in the control group, which did not receive a reminder letter. However, irrespective of the date at which reminder letters were received, overdue debts were paid at the same rate in each of the treatment groups. Earlier receipt of a reminder letter resulted in debts being paid sooner, but the share of debts paid in each group that received a reminder letter was the same at the end of the seven week trial

period. Accordingly, we find no benefit from delaying the date at which the reminder letter is sent. The only meaningful source of heterogeneity in payment probability is related to the amount of outstanding debt. Receipt of a reminder letter increased the probability of payment for debts up to about AUS$7,500, but had no discernible effect for debts above AUS$7,500.[1] Even though reminder letters did not increase the probability of payment for high value debts, the probability of payment was already substantially greater for large than small debt cases.

Our results contribute to several related literatures, which we discuss in the next section. Section 3 outlines a model of tax debt payment, showing that the time at which a reminder letter is sent has a theoretically ambiguous effect on the probability of payment. Section 4 describes the field experiment, our empirical strategy and the data used. Section 5 presents the results and Section 6 concludes.

2 Related Literature

Based on the seminal work of Thaler and Sunstein (2008), a recent strand of the behavioral economics literature focuses on the design of cost-effective interventions that "nudge" people to make better decisions without limiting their choices to improve their health, wealth and happiness. Nudging aims to target the psychological roots of human behavior to address cognitive biases. Important examples include present bias (O'Donoghue and Rabin, 1999), loss aversion (Kahneman and Tversky, 1979; Gächter, Orzen, Renner, and Starmer, 2009), framing (Kahneman and Tversky, 1979; Levin, Schneider, and Gaeth, 1998), anchoring (Tversky and Kahneman, 1974; Wansink, Kent, and Hoch, 1998; Scott and Lizieri, 2012) and social norms (Ariely, 2008; Cialdini, 2008; Allcott, 2011). The work in this field has made extensive use of randomized controlled trials (RCTs) to detect cognitive biases and to nudge people to make better decisions.

Our paper adds to a growing literature that employs four design principles proposed by the UK's Behavioural Insights Team based on their own work and the literature: "(...) make it Easy, Attractive, Social and Timely (EAST)" (BIT, 2014, p. 4). We focus on

[1] AUS$=Australian dollar. One Australian dollar is equal to 0.80 US dollars (21 January 2018).

studying the role of making nudges timely. Moreover, by exploring how varying the timing of reminders to taxpayers affects their tax payment behavior, we contribute directly to the literature on tax compliance. For individual taxpayers, Slemrod, Blumenthal, and Christian (2001) and Kleven, Knudsen, Kreiner, Pedersen, and Saez (2011) provide evidence in favor of the deterrence model of compliance, showing that audit threat letters increase reported income. For business taxpayers, Hasseldine, Hite, James, and Toumi (2007), Ortega and Sanguinetti (2013) and Harju, Kosonen, and Ropponen (2014) also find evidence that an increased threat of audit increases reported income.

Our research differs from much of the tax compliance literature in studying the payment of a tax liability, rather than an initial declaration of income. Notable exceptions are Del Carpio (2013) and Castro and Scartascini (2015), who study the effect of audit threat letters and appeals to social norms on property tax payments in Peru and Argentina, respectively; Dwenger, Kleven, Rasul, and Rincke (2016), who investigate the effect of enforcement, social norm and letter simplification treatments on payments of a church tax in Germany; and Pomeranz (2015), who shows that firms in Chile increased VAT payments following receipt of an audit threat letter. In Australia, Wenzel (2006) finds that reminder letters sent to business taxpayers who had not filed their tax declaration on-time increased compliance, with larger effects on compliance evident if the reminder letter included text assuring taxpayers they were not suspected of being dishonest and expressed understanding.

Our experimental trial is most closely related to Hallsworth, List, Metcalfe, and Vlaev (2017), who study the effect of reminder letters on payments of overdue income tax for a large sample of UK taxpayers. They find small but significant effects on payment rates when reminder letters include appeals to social norms. There are three important differences between our study and Hallsworth, List, Metcalfe, and Vlaev (2017). First, we study business rather than individual income taxpayers. Second, we investigate the effect on payment rates using variation from the timing at which the reminder letter is sent. Third, our study includes a control group that did not receive a reminder letter for the duration of the trial. In the experimental trial studied by Hallsworth, List, Metcalfe, and Vlaev (2017) all taxpayers with an overdue debt were sent a reminder letter. While

variation in the date at which reminder letters were sent in the first week of the trial enables Hallsworth, List, Metcalfe, and Vlaev (2017) to estimate the effect of a generic reminder letter on payments at the end of the first week, this estimate provides only a lower bound because additional payments are likely to be made after the first week. See Hallsworth (2014) and Slemrod (2017) for a comprehensive review of the literature using RCTs to study tax compliance.

Reminder letters have been found to be effective in changing behavior in other settings. Karlan, McConnell, Mullainathan, and Zinman (2016) show experimentally that a reminder letter can increase saving, while Cadena and Schoar (2011) and Karlan, Morten, and Zinman (2015) find that reminders increase the rate at which microloans are repaid in developing countries. Like us, Karlan, Morten, and Zinman (2015) investigates the effect of variation in the timing of a reminder letter, comparing payment rates between groups sent an SMS reminder two days before the due date, one day before the due date, and on the due date. They find no difference in the timing of the reminder on payment rates. However, they only study up to a two day variation in timing and the confidence intervals are large.

Our work is also related to a literature studying task completion when memory is imperfect. Taubinsky (2014) shows experimentally that longer deadlines can reduce the probability of task completion in the absence of reminders, but that reminders reduce the dampening effect of longer deadlines on task completion. Holman and Zaidi (2010) also show, theoretically, that longer deadlines can reduce the probability of task completion when people are overconfident about their memory. Ericson (2017) studies the optimal timing of one-shot reminders in the presence of limited memory. In the following section we outline a simple model based on Ericson (2017) that illustrates the theoretical considerations affecting the optimal timing of a reminder letter for an overdue debt. Our results contribute to the task completion literature by providing experimental evidence in a real-world setting involving large payment amounts.

3 Model

We outline a model of tax debt payment to motivate our research question and to provide a lens through which to interpret our empirical findings. The model shows that varying the time at which a reminder letter is sent has a theoretically ambiguous effect on debt payment rates. The model draws closely on Ericson (2017), but differs in a number of ways.

3.1 The taxpayer's problem

Consider a business taxpayer deciding when to pay an outstanding tax debt. If the debt is paid today the taxpayer incurs a cost of action c_t plus the cost of the outstanding tax debt d. The cost of action is measured in dollars and includes all costs incurred in addition to the value of the outstanding tax debt, such as the value of lost time, hassle costs and the cost of reduced cash flow to the business.[2] For simplicity, c_t is assumed to be independently drawn each period from a continuous distribution F with density f. If the taxpayer does not pay the debt today an interest charge is added and the debt grows to gd dollars next period, where $g > 1$.

Taxpayers remember their outstanding debt with probability ρ each period and forget about their debt with probability $(1 - \rho)$. If taxpayers forget about their debt, they do not become aware of it again unless they receive a reminder from the tax authority. We assume that taxpayers believe they will receive a reminder from the tax authority about an overdue tax debt each period with probability $\hat{\delta}$. This belief may differ from the actual probability of receiving a reminder letter δ.

The perceived value function for a taxpayer who has an unpaid tax debt d in memory is given by

$$V\left(d, c, \hat{\delta}\right) = max\left\{-\left(d + c\right), \frac{\rho}{R} EV\left(gd, c, \hat{\delta}\right) + \frac{(1-\rho)}{R} EW\left(gd, c, \hat{\delta}\right)\right\}, \qquad (1)$$

[2] We model the cost of action c as a fixed cost, not varying in proportion to the value of the outstanding tax debt. This captures aspects of tax debt payment such as hassle cost that do not vary with the size of the debt. If proportional costs are important, our theoretical results should be thought of as applying to tax debts of the same value.

where $R > 1$ is the taxpayer's discount rate, E denotes an expectation taken over next period's cost and

$$W\left(d, c, \hat{\delta}\right) = \hat{\delta} V\left(d, c, \hat{\delta}\right) + \left(1 - \hat{\delta}\right) EW\left(gd, c, \hat{\delta}\right) \tag{2}$$

is the perceived value function for a forgotten tax debt. The perceived value functions differ from the actual value functions whenever $\hat{\delta} \neq \delta$. The perceived value functions govern the taxpayer's behavior.

Each period the taxpayer experiences a cost realization c_t. If the debt is in memory then the taxpayer follows a threshold rule and pays the debt today if $c_t < \bar{c}$. The threshold value $\bar{c}$ equates the value of paying today with the value of waiting. Using Equation (1),

$$\bar{c} = -d - \frac{\rho}{R} EV\left(gd, c, \hat{\delta}\right) - \frac{(1-\rho)}{R} EW\left(gd, c, \hat{\delta}\right). \tag{3}$$

If the debt is in memory the debt is paid with probability $F(\bar{c})$.

We can now examine how changes in beliefs about the perceived likelihood of receiving a reminder affect the cost threshold $\bar{c}$. Forgetting about the outstanding tax debt is costly to the taxpayer because the debt accrues interest during the period it is out of mind. Paying early reduces the likelihood of forgetting about the tax debt but means the taxpayer forgoes the option value of waiting for more favorable cost draws in the future. An increase in the perceived frequency of reminders from the tax authority reduces the cost of forgetting about the tax debt and raises the option value of waiting for favorable cost draws in the future. Hence, the threshold $\bar{c}$ declines as $\hat{\delta}$ increases. This discussion is summarized in Proposition 1 below.

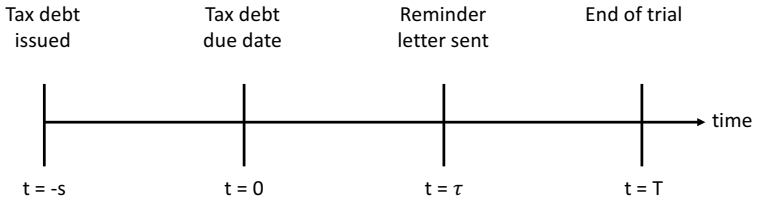
Proposition 1 (Effect of reminder frequency on probability of action): *An increase in the perceived probability of receiving a reminder $\hat{\delta}$ lowers the cost threshold $\bar{c}$ and reduces the probability the debt is paid today if it is in memory.* Proof: See Appendix A.

Proposition 1 has practical relevance because varying the timing of the first reminder letter sent to taxpayers may affect beliefs. Sending a reminder letter soon after the due date may cause taxpayers to believe that they will receive frequent reminders from the

tax authority, raising $\hat{\delta}$. Delaying a reminder letter may cause taxpayers to revise their beliefs in such a way that the cost threshold declines. This would increase the probability of payment at each point in time.

3.2 Experimental setup

Taxpayers are given s days to pay their tax debt. We study payment behavior of taxpayers who had an unpaid debt at the due date $t = 0$. Taxpayers with an overdue debt are sent a reminder letter at a time τ, which we vary experimentally. Cases are observed until T days after the due date. No other contact within taxpayers is initiated by the tax authority prior to time T. A control group does not receive a reminder letter before time T.



3.3 The effect of a reminder letter on payment behavior

In this section we consider the effect of a reminder letter on payment behavior. We begin by making two definitions, following Ericson (2016). First, we define a tax debt to be *active* if it is unpaid and in memory. A debt stays active if it remains in memory and unpaid.[3] Second, we say a reminder letter is *useful* if a debt is unpaid and forgotten.

The probability that a tax debt is paid in period t depends on the cost realization for period t and the probability the debt is active:

$$p_t = F\left(\bar{c}_t\right) Pr\left(active_t\right). \tag{4}$$

[3]The debt remains in memory between periods with probability ρ and remains unpaid between periods $t-1$ and t with probability $(1 - F\left(\bar{c}_{t-1}\right))$. Hence, $Pr\left(active_t\right) = \rho\left(1 - F\left(\bar{c}_{t-1}\right)\right) Pr\left(active_{t-1}\right)$.

A debt is more likely to be paid the higher the cost threshold $\bar{c}_t$ and the higher the probability the debt is active. This expression highlights the main channels through which a reminder letter affects payment behavior. A reminder letter makes any forgotten debt active, and so raises the probability of payment. However, the reminder letter may affect the cost threshold, as described in Proposition 1. These effects can be offsetting. This occurs if the reminder letter increases the probability the debt is active but causes the taxpayer to reduce the cost threshold, so that $F(\bar{c}_t)$ declines.

Now consider the effect of a reminder letter sent at date τ. The reminder letter makes all forgotten debts active, which occurs with probability $Pr(useful_\tau)$, and raises the probability the debt is paid by time T by the amount

$$Pr(useful_\tau) \sum_{j=\tau}^{T} p_j | Pr(active_\tau) = 1. \tag{5}$$

Next, consider the effect of delaying the date that the reminder is sent by one day, to $\tau+1$. A reminder at date $\tau+1$ raises the probability that a debt overdue at time τ is paid by period T by the amount

$$\underbrace{[Pr(useful_\tau) + (1-\rho)(1-F(\bar{c}_\tau))\, Pr(active_\tau)]}_{Pr(useful_{\tau+1})} \sum_{j=\tau+1}^{T} p_j | Pr(active_{\tau+1}) = 1. \tag{6}$$

Comparison of Equations (5) and (6) reveals three ways in which varying the timing of the reminder letter can affect payment behavior.

1. Delaying the date at which the reminder letter is sent leaves fewer periods for the taxpayer to receive a favorable cost draw and pay their debt, reducing the probability of payment by time T. This can be seen by comparing the number of periods in the summation signs in Equations (5) and (6).

2. The time at which the reminder letter is received may cause the taxpayer to revise beliefs about the frequency of reminders. If delaying the date at which a reminder is received lowers the perceived frequency of reminders then this lowers the cost threshold and increases the probability of payment in each period, as described by

Proposition 1. Thus, the summation term may be larger in Equation (6) than in Equation (5) even though there are fewer periods.[4]

3. The probability a reminder letter is useful is greater at time $\tau + 1$ than at time τ. This is because some people with an unpaid debt in memory at time τ may not pay their debt at time τ but forget about their debt by time $\tau + 1$. The probability of this occurring is given by the second term in brackets in Equation (6). (A letter is useful in both periods for people who had forgotten about their debt by time τ.) This consideration alone implies that delaying the date a reminder letter is sent raises the probability of payment.

The net effect is theoretically ambiguous, as summarized in Proposition 2.

Proposition 2 (Variation in timing of reminder letter): *Delaying the date at which a reminder letter is sent may increase, decrease or have no effect on the probability an unpaid debt is paid by the end of the trial.* Proof: See Appendix A.

Figure 1 shows hypothetical payment rates. The line labeled $P_{\tau_1,T}$ illustrates the cumulative payment probability when a reminder is sent at τ_1, assuming memory is imperfect. For the reasons just outlined, the probability an overdue debt is paid by time T may be greater or smaller when a reminder is sent at $\tau_2 > \tau_1$ rather than τ_1. The lines labeled $P^A_{\tau_2,T}$, $P^B_{\tau_2,T}$ and $P^C_{\tau_2,T}$ illustrate scenarios where a reminder sent at τ_2 is more effective, the same, and less effective than a reminder sent at τ_1.

[Figure 1 about here.]

4 Trial Design, Empirical Strategy and Data

The ATO sends a reminder letter to business taxpayers who have missed their tax debt due date. The trial was designed to test whether and how the timing of a reminder letter affects payment behavior. We did not vary the design or content of the letter. The target population of the trial was restricted to business taxpayers with a history of compliant

[4]Furthermore, any change in the cost threshold affects the probability of payment for debts that were in memory but unpaid at time τ.

payment behavior over the last three years. This section provides an overview of the trial design, our empirical strategy and the data provided by the ATO.[5]

4.1 Trial Design

The trial targets businesses that the ATO considers as low-risk clients (who belong to one of two "risk clusters" according to an internal analytics model) although they have missed the 26 May 2017 due date. A total of 4,787 unpaid debt cases were quarantined from the usual ATO treatment pathways and randomly allocated to receive a reminder letter either 12, 19 or 27 days following the due date. A control group did not receive a letter for the duration of the trial. About the same number of quarantined cases was randomly assigned to each of the treatment groups and to the control group.

De-identified baseline data were provided by the ATO after the researchers received human ethics approval from the Australian National University.[6] Cases were grouped into strata with similar baseline characteristics to achieve stratified randomization. Within each stratum, each case was assigned at random to one of the treatment groups or to the control group. This procedure ensured that the cases were evenly distributed across groups with regard to baseline characteristics. A complete list of baseline characteristics is provided in Appendix B. Randomization was based on a random variable generator in STATA®, using a random choice of the underlying seed. The user-written command `randtreat` version 1.4 (5 April 2017), available from the `ssc` library, was used for stratified randomization.

The random assignment led to the following allocation of cases: Treatment Group 1: 1,199 cases, Treatment Group 2: 1,200 cases, Treatment Group 3: 1,186 cases and Control Group: 1,202 cases. On 7 June 2017, the ATO sent 1,054 letters to Treatment Group 1 (145 debts had already been paid in the meantime); 926 letters were sent to Treatment Group 2 on 14 June (274 cases had already been paid by that time); Treatment Group 3 received 768 letters that were sent out on 22 June (418 cases had already been paid).

[5]The trial was registered in the RCT Registry of the American Economic Association (AEARCTR-0003059, `http://www.socialscienceregistry.org/trials/3059`).

[6]Human ethics protocol number 2017/454, title: *Testing the Effect of the Timing of Reminder Letters on the Payment Behavior of Business Taxpayers.*

De-identified data were made available by the ATO at the end of the data collection period on 14 July 2017.

4.2 Empirical Strategy

4.2.1 Survival Analysis

We estimate Kaplan-Meier survivor functions to study differences in tax debt payments between the treatment and control groups over time. By definition, the survivor function $S(t)$ tells us the probability that a tax debt remains outstanding past time t. We observe a set of "failure times", $\tau_1, \tau_2, \ldots, \tau_J$, where J is the number of distinct uncensored failure times in our data. Kaplan and Meier (1958) propose a nonparametric estimate of the survivor function,

$$\widehat{S}(t) = \prod_{j|\tau_j \leq t} \left(\frac{n_j - d_j}{n_j} \right),$$

where n_j is the number of individuals "at risk" (of paying their taxes) at time τ_j and d_j is the number of "failures" (tax payments) at time τ_j. Following Kalbfleisch and Prentice (2002), we calculate confidence intervals using the asymptotic variance of $\ln(-\ln(\widehat{S}(t)))$,

$$\sigma^2(t) = \frac{\sum_{j|\tau_j \leq t} \frac{d_j}{n_j(n_j - d_j)}}{(\sum_{j|\tau_j \leq t} \ln(\frac{n_j - d_j}{n_j}))^2},$$

to ensure that the confidence intervals are bounded between 0 and 1. The confidence intervals are given by $\left[[\widehat{S}(t)]^{\exp(z_{\alpha/2}\widehat{\sigma}^2)}, [\widehat{S}(t)]^{\exp(-z_{\alpha/2}\widehat{\sigma}^2)} \right]$, where $z_{\alpha/2}$ is the $(1 - \alpha/2)$th quantile of the standard normal distribution. To simplify the interpretation of our results, our discussion will focus on failure functions, which can be estimated by $\widehat{F}(t) = 1 - \widehat{S}(t)$. Failure functions allow us to consider the probability of paying taxes ("failing") at a given point in time, which appears more natural in the context of our analysis than studying the probability of not paying taxes ("surviving"). The failure function is the empirical analogue to the probability of payment p_t in the theoretical model.

4.2.2 Treatment Effects Estimation

Our analysis of treatment effects is based on estimating separate regression models to compare the outcome measures of members of each of the treatment groups to those of the control group. We use the following model to estimate the effect of a reminder letter on an outcome measure of interest:

$$Y_i = \beta_0 + \beta_1 D_i + X_i \beta_2 + \varepsilon_i,$$

where Y_i refers to one of the outcome measures of taxpayer i, D_i is the treatment indicator for the comparison of one of the treatment groups to the control group, X_i is a set of observed taxpayer characteristics that are used as control variables to balance out potential differences between treatment and control group, and ε_i is the model error term. A complete list of control variables is provided in Appendix B. Our parameter of interest is β_1, the average treatment effect on the treated.

Our analysis focuses on two outcome measures: a 0/1-variable indicating whether or not payments were made by the end of the trial and a continuous variable including the amount (in AUS$) paid by the end of the trial. We use separate regression models excluding and including control variables to estimate unconditional and conditional treatment effects on the treated, respectively. The regression results are presented in Section 5. We estimate a linear probability model to obtain the effect of each of the treatments on the probability of payment by the end of the trial. We compare these estimates to the marginal effects of a binary Probit model to account for the nonlinear nature of the outcome variable. A linear regression model is used to estimate the effect of each of the treatments on the amount paid by the end of the trial. Finally, we perform a range of robustness checks to examine the validity of our results.

4.3 Data

Table 1 includes summary statistics of the control variables used in our analysis. We also present the p-values that refer to the comparison of sample means between each

treatment group and the control group. We observe that the average total business income varies from about AUS$730,000 to AUS$970,000 across groups. However, due to the large variation in business income within each of the groups, these differences are not statistically significant (the p-values of the comparison of sample means range from 0.42 to 0.96). In our analysis, we will use income quartiles as control variables to be consistent with our stratified randomization.

Table 1 also reports the distribution of businesses across three broad debt levels used by the ATO to categorize tax debts: Debt Level 1: AUS$0 – AUS$2,499, Debt Level 2: AUS$2,500 – AUS$7,499, Debt Level 3: AUS$7,500+. Most businesses (almost 60%) have a relatively low initial tax debt of less than AUS$2,500. Only about 15% of business owe AUS$7,500 or more at the beginning of the trial. Around 7-9% of businesses experience an increase in their outstanding tax debt during the trial period. We perform robustness checks to investigate the impact of including these businesses in our analysis.

[Table 1 about here.]

More than 90% of the businesses in our sample are "micro enterprises" with an annual turnover of less than AUS$2 million and almost half (around 45%) of the businesses are individual/sole traders. The ATO classifies businesses into "risk clusters" based on an internal analytics model. Our analysis sample consists of two risk clusters comprised of businesses that the ATO considers as low-risk clients. Most businesses lodge their taxes through automated and electronic lodgment channels and about one quarter uses business and tax agent portals.

The vast majority of businesses in our sample (more than 90%) have a tax agent. We do not observe the number of employees for a large fraction of businesses in our data but most businesses appear to have a relatively small number of employees. There is considerable heterogeneity with regard to industries and the geographic distribution of businesses across states. A relatively large fraction of businesses belong to the construction sector (about 13%), financial and insurance services (about 14%), rental, hiring and real estate services (about 11%) and professional, scientific and technical services (about 11%). More than 70% of businesses are located in New South Wales, Victoria or

Queensland.

In the following analysis, we will use the variables reported in Table 1 as control variables to balance out potential differences between observed characteristics when estimating treatment effects. We will also study heterogenous treatment effects for the most important control variables. Section 5.3 includes a summary of the main findings of our analysis of heterogenous treatment effects.

5 Results

5.1 Payment Rates and Share of Debt Paid

Figure 2 shows the Kaplan-Meier failure function for the control group and each of the treatment groups over the duration of the trial. Each line depicts the share of cases resolved by group and by day since the beginning of the trial. Figure 2 is the empirical analogue to the hypothetical payment rates implied by the model and shown in Figure 1. The solid line in Figure 2 reveals that the share of resolved cases in the control group remains relatively low over the entire study period. Almost 50% of the cases in the control group remain unresolved 52 days after the due date. In contrast, more than 75% of the cases in the three treatment groups could be resolved within 52 days (less than 25% of the cases remain unresolved). The difference between the treatment groups and the control group constitutes the causal effect of the reminder letter. Differences between the three treatment groups and the control group are statistically significant.

[Figure 2 about here.]

Among the treatment groups, we observe that the early reminder letters could resolve outstanding debts earlier than the reminder letters that were sent out later. This is because early reminder letters cause forgotten debts to become *active* sooner. Critically, the three treatment groups converge to the same proportion of cases resolved by the end of the trial period. This indicates that early reminder letters cause debts to be resolved more quickly without affecting the cumulative probability of payment by date T. This

is important because our model shows that the effect of reminder letter timing on the cumulative payment probability is theoretically ambiguous.

To explore the mechanism through which the timing of reminder letters affects payment behavior we test whether the *rate* at which cases are being resolved differs across the three treatment groups. We do this by estimating the payment profiles for each treatment group using the sent date (instead of the due date) as "day 0". The resulting estimates, which are presented in Figure 3, reveal that the profiles do not differ significantly between the three treatment groups, indicating that the rate at which the cases could be resolved did not depend on whether the reminder letter was sent out earlier or later.

In relation to the model, we can deduce from Figure 3 that varying timing of the reminder letter has no significant effect on the taxpayer's payment cost threshold c_t. Using Equation (4), and the fact that all debts are active at "day 0", the probability of payment at day zero is $p_0 = F(\bar{c}_0)$. The payment probability at "day 0" depends only on $F(\bar{c}_0)$. Because there is no significant difference in payment rates we can deduce that $\bar{c}_0$ is the same for taxpayers in each treatment group. Iterating Equation (4) forward to the next period, the payment probability for period $t+1$ is $p_1 = F(\bar{c}_1) Pr(active_1) = \rho F(\bar{c}_1)(1 - F(\bar{c}_0))$. We again observe no significant difference in payment rates at "day 1" and so deduce that $\bar{c}_1$ is the same for each treatment group. More generally, the probability of payment at "day j" since the letter send date is given by

$$p_j = F(\bar{c}_j) Pr(active_j) = \rho^j F(\bar{c}_j)(1 - F(\bar{c}_{j-1})) \cdots (1 - F(\bar{c}_0)). \tag{7}$$

Because the payment probability p_j does not significantly differ across the three treatment groups at each point in time (see Figure 3) we deduce that $\bar{c}_0, \ldots, \bar{c}_j$ is the same for each treatment group. We can infer that varying the timing of reminder letters did not affect taxpayer's perceived frequency of receiving a reminder letter, $\hat{\delta}$.

[Figure 3 about here.]

So far, we have focused on the share of cases that could be resolved. Figure 4 provides information about the share of debt that was paid over time. We observe that taxpayers

in the control group repaid about 75% of their debt by the end of the trial period. In contrast, taxpayers in the three treatment groups repaid close to 90% of their debt. The share of debt paid in each group is larger than the share of cases resolved (see Figure 2) because high value debts are more likely to be repaid than low value debts.

[Figure 4 about here.]

While the difference between the treatment groups and the control group are considerable towards the end of the trial period, the three treatment groups converge to about the same share of debt paid over time. Moreover, we observe that taxpayers who receive their reminder letter earlier also repay their debt earlier than taxpayers who receive their reminder letter later.

5.2 Treatment Effects

The treatment effects on the outcome variable indicating whether payments were made by the end of the trial are presented in Table 2. Our estimates of the unconditional treatment effects obtained from a linear probability model (Panel A) indicate that the reminder letters increased the likelihood of tax debt payment by about 24 percentage points by the end of the trial period, regardless of the exact point in time at which the letters were sent out. We also observe considerable heterogeneity in the treatment effects when initial debt levels are considered. While the reminder letters increased the payment rates of businesses with an initial tax debt of less than AUS$7,500 by about 28 percentage points, businesses with an initial debt of AUS$7,500 or more did not change their behavior as a result of receiving a reminder letter. The treatment effect estimates presented in Panel A of Table 2 are remarkably stable and do not change much when we control for business characteristics (Panel B). We also find that the estimates obtained from a binary Probit model (Panel C) are about the same as those of the linear probability model.

[Table 2 about here.]

Table 3 includes the OLS estimates of the treatment effects on the amount paid by the end of the trial. The numbers in Panel A of Table 3 indicate that the overall treatment

effects are not statistically significant. However, we observe significant treatment effects when we estimate separate regressions by initial debt level. While businesses with an initial debt of below AUS$7,500 increase their tax debt payments by about AUS$400 if they receive a reminder letter, we find no significant effect of receiving a reminder letter on tax debt payments of businesses with a tax debt of AUS$7,500 or more. Our findings do not change qualitatively if we add control variables to our model (Panel B).

[Table 3 about here.]

Taken together, the results in Tables 2 and 3 indicate that the reminder letters could increase both payment rates and the amount of payments but that the effects are driven entirely by relatively low (below AUS$7,500) initial debt levels. This finding suggests that reminder letters are ineffective if initial debt levels are too high. To determine the "tipping point" beyond which the reminder letters are no longer effective, we examine the effect of receiving a letter (ie. the effect of being in one of the three treatment groups) on debt payments by the initial debt level of the taxpayer. Figure 5 shows the difference between businesses that do and do not receive a reminder letter within each decile of the initial debt level. We find that the letters were highly effective for initial debt levels of about AUS$8,000 or less. Beyond that threshold, the effect of the letter on debt payments is not significant, suggesting that reminder letters are ineffective if the initial amount of debt is larger than AUS$8,000. However, it is worth noting that high value debt cases not receiving a reminder letter resolved at a similar rate to low value debt cases that did receive a reminder letter.

[Figure 5 about here.]

5.3 Robustness Checks

We perform a number of robustness checks to test the validity of the results presented in Section 5.2. Firstly, the conditional models in Tables 2 and 3 include a large set of control variables that may be correlated and may therefore offset each other. To address this concern, we re-estimate the models presented in Tables 2 and 3 but instead of including

all control variables, we only include single (groups of) control variables (consistent with the grouping of variables in Table 1). We find that the inclusion of single (groups of) control variables does not affect our findings qualitatively.

Secondly, Tables 2 and 3 report heterogenous treatment effects by initial debt level but we ignore heterogeneity with regard to other factors, such as total business income or number of employees. Therefore, we estimate heterogenous treatment effects for all (groups of) control variables presented in Table 1. We only find heterogeneity when we estimate separate treatment effects for cases that did or did not experience an increase in their outstanding debt over the trial period. We observe that the reminder letters did not lead to a significant increase in payment probabilities if businesses experienced an increase in outstanding debt. The treatment effects observed for businesses that did not experience an increase in outstanding debt are about the same as those presented in Table 2. We do not find heterogeneity when we estimate the corresponding treatment effects on the amount paid by the end of the trial. We study the implications of excluding cases that experienced an increase in outstanding debt over the trial period from our sample and find that their exclusion does not affect the results presented in Tables 2 and 3 qualitatively. Our treatment effects are even a bit (although not significantly) larger when we exclude these cases from our sample.

Thirdly, the estimates presented in Tables 2 and 3 include cases in which businesses have only made partial payments. We interpret partial payments as cases that could be resolved over the trial period, which may affect our estimates in Table 2. We also consider full or partial payments when we study the amount paid by the end of the trial, which may have implications for the interpretation of the estimates in Table 3. To address these issues, we drop cases in which partial payments were made from our analysis sample. We find that the resulting treatment effects are somewhat larger but not significantly different from those presented in Tables 2 and 3.

Finally, the ATO provided us with additional data on payment rates beyond the end of the trial period. The share of debts paid in each treatment group remained almost identical beyond the end of the trial period. Strikingly though, the share of debts paid in the control group remained below that of the treatment groups until about 150 days after

the end of the trial period. However, caution is needed in interpreting the data after the end of the trial period because unresolved debt cases were subject to business-as-usual processes and thus no longer selected at random for treatment. For that reason, we do not present any results based on data that were collected after the end of the trial period.

5.4 Cost-benefit analysis

It is interesting to compare the revenue implications of varying the letter send date. For each day a tax debt is outstanding the ATO levies interest penalties at the rate of 8 percent per annum, compounded daily. Thus, delaying the date at which a debt is paid raises more revenue from penalties. Delaying the reminder letter send date also reduces cost, because some debts will be paid in the intervening period and fewer letters need to be sent. However, compared with interest penalties the cost of sending the reminder letters is low, at about AUS$1.25 per letter, including postage. Table 4 summarizes these costs and benefits for each group.

[Table 4 about here.]

A private debt collector would prefer sending letters in week three, rather than week one or week two, because this maximizes net revenue and has no cost in terms of the share or amount of debt paid by the end of the trial. However, net revenue is only around AUS$4,200 higher when the letters are sent in week three rather than week one. For comparison, around AUS$1m of debt was outstanding in each experimental group at the beginning of the trial. From a social welfare perspective, exploiting taxpayer's imperfect memory to raise revenue seems problematic. One the one hand, there is no behavioral response available to taxpayers to reduce the amount of tax owed and penalties raise lump-sum revenue. However, if taxpayers were to become aware of the fact the tax authority was deliberately not alerting taxpayers about overdue debts to raise revenue, such a policy could adversely affect taxpayer behavior in the future. We discussed this trade-off with staff at the ATO and they were of the view that sending reminder letters early was best from a taxpayer compliance and engagement perspective.

6 Conclusions

This paper provides evidence on the relevance of the timing of nudges by studying how varying the timing of reminder letters to taxpayers affects their tax payment behavior. All debt collectors face a choice over the timing of when to send a reminder letter. Despite this, there is little rigorous empirical evidence on the effect of the timing of reminders on payment behavior. Theoretically, variation in the timing of a reminder has an ambiguous effect on the ultimate probability of payment. We test this proposition in a large-scale field experiment with business taxpayers in Australia. Small businesses were randomly chosen to receive a reminder letter either one, two or three weeks following their missed tax debt due date; a control group received no contact from the tax authority for the duration of the seven week field experiment.

We find that the probability of payment at the end of the seven week field experiment was 25 percentage points greater for each group that received a reminder letter relative to the control group. However, there was no difference in the probability of payment between treatment groups at the end of the seven week trial period, regardless of whether the reminder letter was sent one, two or three weeks after the due date. Measured relative to the date at which the reminder letter was sent, the probability of payment evolved almost identically across the three groups receiving a reminder letter.

Our results imply that sending reminder letters early accelerates the collection of tax debts and has no effect on the ultimate probability of payment. While delaying the timing of the reminder letters increases revenue collected through interest penalties, the amount of additional revenue collected relative to debt outstanding is modest. Furthermore, although penalties levied on debt already incurred raises lump-sum revenue, deliberately not alerting taxpayers about their overdue debts is likely to be counter-productive in the long-term.

The only meaningful heterogeneity in payment behavior is related to the size of debts. Reminder letters did not increase the probability of payment for high value debts (>AUS$7,500). This could indicate that inability to pay is a more important barrier to payment than imperfect memory for taxpayers with high value debts.

Figures and Tables

FIGURE 1: Hypothetical Payment Rates

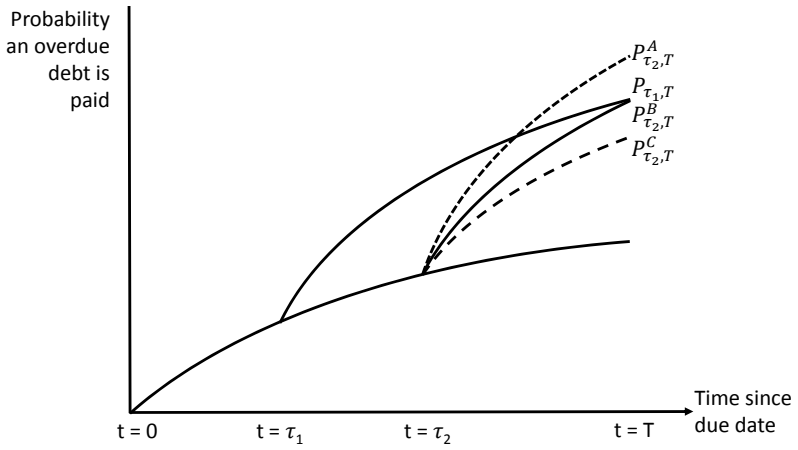


Table 1: Baseline Characteristics

	Control		Treatment 1			Treatment 2			Treatment 3		
	Mean	N	Mean	N	p-value	Mean	N	p-value	Mean	N	p-value
Total Business Income	733,688	1,186	968,881	1,184	0.423	898,547	1,186	0.606	746,371	1,172	0.960
Initial Debt Level											
\$0 - \$2,499	0.577	1,202	0.580	1,199	0.877	0.583	1,200	0.799	0.586	1,186	0.669
\$2,500 - \$7,499	0.268	1,202	0.269	1,199	0.970	0.265	1,200	0.873	0.265	1,186	0.863
\$7,500+	0.155	1,202	0.151	1,199	0.797	0.152	1,200	0.879	0.149	1,186	0.708
Increase in Outstanding Debt	0.077	1,202	0.067	1,199	0.313	0.080	1,200	0.811	0.086	1,186	0.441
Business Market Segment											
Micro enterprise	0.911	1,186	0.919	1,184	0.470	0.906	1,186	0.670	0.910	1,172	0.928
Small/Medium enterprise	0.041	1,186	0.039	1,184	0.760	0.046	1,186	0.615	0.047	1,172	0.507
Not for profit enterprise	0.048	1,186	0.042	1,184	0.494	0.049	1,186	0.924	0.044	1,172	0.598
Client Type											
Australian Private Company	0.230	1,202	0.229	1,199	0.949	0.227	1,200	0.863	0.228	1,186	0.909
Individual/Sole Trader	0.452	1,202	0.452	1,199	0.988	0.452	1,200	0.997	0.453	1,186	0.959
Other	0.319	1,202	0.319	1,199	0.967	0.322	1,200	0.874	0.320	1,186	0.961
Risk Cluster											
Risk Cluster 2	0.667	1,202	0.666	1,199	0.965	0.671	1,200	0.851	0.670	1,186	0.872
Risk Cluster 7	0.333	1,202	0.334	1,199	0.965	0.329	1,200	0.851	0.330	1,186	0.872
Lodgement Channel											
ATO Online	0.053	1,175	0.067	1,161	0.142	0.055	1,178	0.796	0.051	1,158	0.843
Auto Finalised	0.328	1,175	0.309	1,161	0.339	0.312	1,178	0.427	0.328	1,158	0.980
Agent Portal	0.017	1,175	0.036	1,161	0.004	0.025	1,178	0.155	0.022	1,158	0.346
Business Portal	0.130	1,175	0.134	1,161	0.767	0.111	1,178	0.157	0.133	1,158	0.843
Corporate Data Capture	0.060	1,175	0.065	1,161	0.557	0.070	1,178	0.284	0.070	1,158	0.309
Electronic Lodgement	0.220	1,175	0.218	1,161	0.883	0.215	1,178	0.740	0.216	1,158	0.791
Tax Agent Portal	0.134	1,175	0.132	1,161	0.896	0.159	1,178	0.084	0.117	1,158	0.214
Web Services	0.049	1,175	0.029	1,161	0.013	0.041	1,178	0.314	0.050	1,158	0.936
Other	0.009	1,175	0.009	1,161	0.848	0.011	1,178	0.686	0.013	1,158	0.409

Continued on next page...

TABLE 1 (CONTINUED)

	Control		Treatment 1			Treatment 2			Treatment 3		
	Mean	N	Mean	N	p-value	Mean	N	p-value	Mean	N	p-value
Tax Agent	0.937	1,202	0.932	1,199	0.610	0.932	1,200	0.672	0.946	1,186	0.335
Number of Employees											
1	0.097	1,202	0.093	1,199	0.796	0.112	1,200	0.224	0.094	1,186	0.863
2-5	0.106	1,202	0.118	1,199	0.388	0.116	1,200	0.466	0.113	1,186	0.612
6-19	0.052	1,202	0.053	1,199	0.989	0.052	1,200	0.934	0.051	1,186	0.914
20+	0.012	1,202	0.018	1,199	0.243	0.019	1,200	0.189	0.018	1,186	0.295
Missing	0.732	1,202	0.718	1,199	0.442	0.702	1,200	0.098	0.723	1,186	0.634
Industry											
Agriculture, Forestry, Fishing	0.071	1,186	0.068	1,184	0.755	0.063	1,186	0.460	0.072	1,172	0.936
Manufacturing	0.028	1,186	0.025	1,184	0.707	0.039	1,186	0.137	0.029	1,172	0.863
Construction	0.138	1,186	0.141	1,184	0.846	0.131	1,186	0.588	0.128	1,172	0.462
Wholesale Trade	0.022	1,186	0.024	1,184	0.778	0.024	1,186	0.682	0.027	1,172	0.399
Retail Trade	0.048	1,186	0.036	1,184	0.155	0.038	1,186	0.225	0.038	1,172	0.207
Accommodation and Food Services	0.033	1,186	0.034	1,184	0.903	0.025	1,186	0.272	0.024	1,172	0.189
Transport, Postal, Warehousing	0.049	1,186	0.046	1,184	0.705	0.053	1,186	0.641	0.061	1,172	0.183
Financial and Insurance Services	0.142	1,186	0.149	1,184	0.630	0.152	1,186	0.524	0.144	1,172	0.906
Rental, Hiring, Real Estate Services	0.107	1,186	0.120	1,184	0.324	0.116	1,186	0.514	0.109	1,172	0.868
Professional, Scientific, Technical Services	0.109	1,186	0.118	1,184	0.467	0.108	1,186	0.947	0.115	1,172	0.621
Administrative and Support Services	0.030	1,186	0.045	1,184	0.049	0.026	1,186	0.618	0.041	1,172	0.132
Health Care and Social Assistance	0.053	1,186	0.046	1,184	0.456	0.052	1,186	0.927	0.049	1,172	0.690
Miscellaneous	0.170	1,186	0.148	1,184	0.134	0.173	1,186	0.870	0.162	1,172	0.593
State											
New South Wales	0.345	1,186	0.326	1,184	0.331	0.361	1,186	0.414	0.363	1,172	0.345
Queensland	0.218	1,186	0.231	1,184	0.447	0.209	1,186	0.616	0.219	1,172	0.918
South Australia	0.054	1,186	0.057	1,184	0.780	0.056	1,186	0.857	0.047	1,172	0.435
Tasmania, ACT, NT[†]	0.030	1,186	0.037	1,184	0.359	0.030	1,186	0.904	0.030	1,172	0.944
Victoria	0.262	1,186	0.249	1,184	0.466	0.245	1,186	0.345	0.256	1,172	0.729
Western Australia	0.091	1,186	0.101	1,184	0.435	0.099	1,186	0.484	0.084	1,172	0.572

Note: p-values refer to the comparison of means between treatment and control groups.
[†] ACT: Australian Capital Territory, NT: Northern Territory.

FIGURE 2: Actual Payment Rates: Kaplan-Meier Failure Estimates

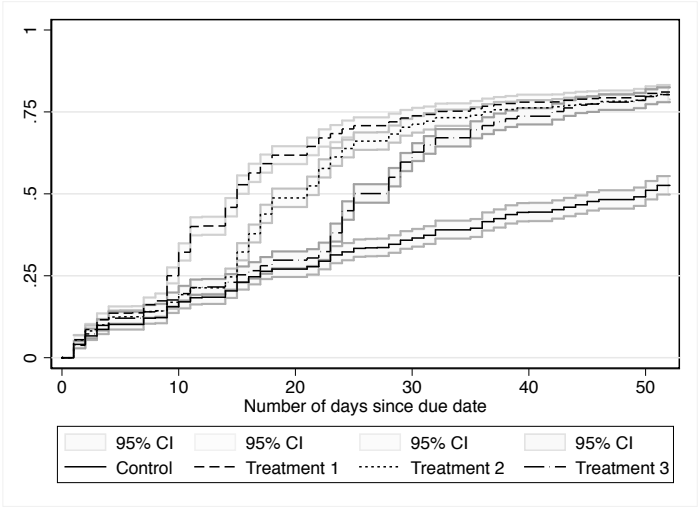


FIGURE 3: Comparison of Payment Profiles

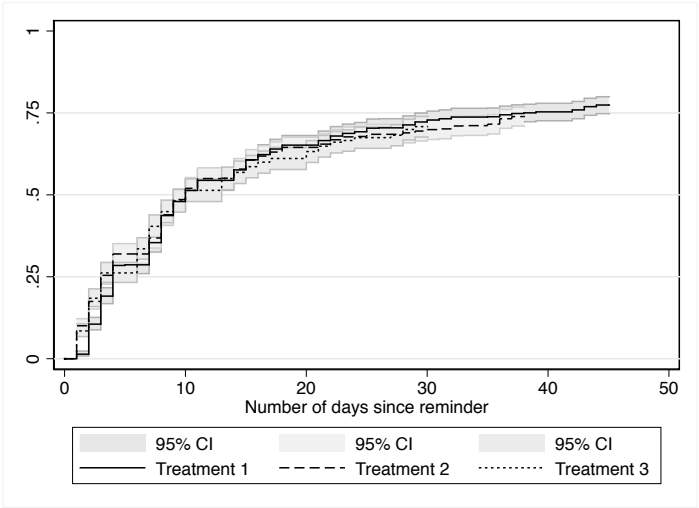


FIGURE 4: Share of Debt Paid

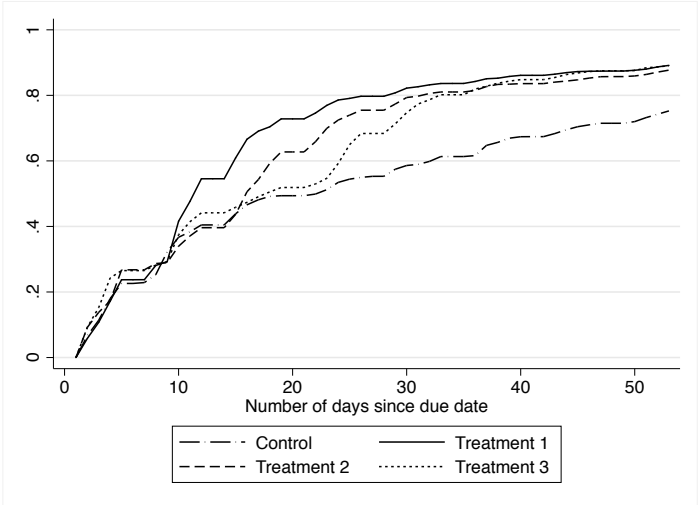


Table 2: Treatment Effects on Payment Made by End of Trial

	Treatment 1	Treatment 2	Treatment 3
Panel A: Unconditional linear probability model			
Payment Made by End of Trial	0.248**	0.238**	0.234**
	(0.017)	(0.017)	(0.017)
	[2,401]	[2,402]	[2,388]
By Initial Debt Level			
$0 - $7,499	0.289**	0.279**	0.282**
	(0.019)	(0.019)	(0.019)
	[2,034]	[2,033]	[2,025]
$7,500+	0.025	0.015	-0.028
	(0.029)	(0.030)	(0.033)
	[367]	[369]	[363]
Panel B: Conditional linear probability model			
Payment Made by End of Trial	0.248**	0.235**	0.229**
	(0.017)	(0.017)	(0.017)
	[2,305]	[2,323]	[2,303]
By Initial Debt Level			
$0 - $7,499	0.290**	0.278**	0.278**
	(0.019)	(0.019)	(0.019)
	[1,947]	[1,959]	[1,949]
$7,500+	0.009	0.000	-0.028
	(0.030)	(0.030)	(0.033)
	[358]	[364]	[354]
Panel C: Conditional Probit model (marginal effects)			
Payment Made by End of Trial	0.250**	0.235**	0.232**
	(0.017)	(0.017)	(0.017)
	[2,305]	[2,323]	[2,303]
By Initial Debt Level			
$0 - $7,499	0.296**	0.283**	0.284**
	(0.019)	(0.019)	(0.019)
	[1,947]	[1,959]	[1,949]
$7,500+	0.021	-0.002	-0.035
	(0.028)	(0.019)	(0.027)
	[260]	[325]	[298]

Note: Robust standard errors in parentheses. Number of observations in brackets.
* $p < 0.05$, ** $p < 0.01$.

Table 3: Treatment Effects on Amount Paid by End of Trial

	Treatment 1	Treatment 2	Treatment 3
Panel A: Unconditional linear regression model			
Amount Paid by End of Trial	590.94	252.64	634.77
	(762.23)	(530.19)	(587.46)
	[2,401]	[2,402]	[2,388]
By Initial Debt Level			
$0 - $7,499	463.81**	389.48**	440.74**
	(70.44)	(79.93)	(81.02)
	[2,401]	[2,402]	[2,388]
$7,500+	120.71	-185.18	157.06
	(768.00)	(537.66)	(594.92)
	[2,401]	[2,402]	[2,388]
Panel B: Conditional linear regression model			
Amount Paid by End of Trial	797.05	135.41	614.75
	(802.71)	(449.77)	(515.95)
	[2,305]	[2,323]	[2,303]
By Initial Debt Level			
$0 - $7,499	470.50**	392.78**	458.77**
	(52.67)	(66.56)	(65.16)
	[2,305]	[2,323]	[2,303]
$7,500+	320.98	-305.79	120.14
	(800.99)	(446.61)	(513.36)
	[2,305]	[2,323]	[2,303]

Note: Robust standard errors in parentheses. Number of observations in brackets.
* $p < 0.05$, ** $p < 0.01$.

FIGURE 5: Treatment Effect by Initial Debt Level

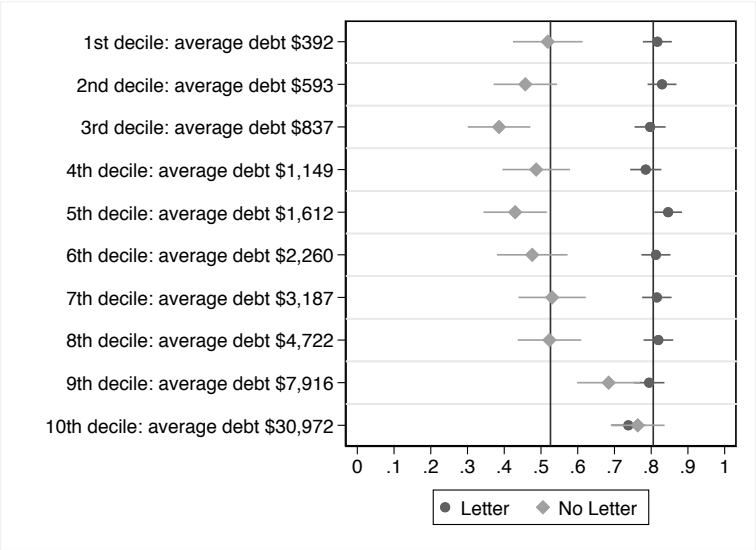


TABLE 4: COST CALCULATIONS

Trial group	Total interest penalties by day 52	Number of letters sent	Cost of letters (at $1.25 per letter)	Interest penalties less cost of letters	Share cases paid by day 52
No letter	$23,742	0	$0	$23,742	0.53
Week 1	$14,532	1,054	$1,318	$13,214	0.81
Week 2	$16,561	926	$1,158	$15,403	0.80
Week 3	$18,414	768	$960	$17,454	0.80

References

Allcott, H. (2011): "Social Norms and Energy Conservation," *Journal of Public Economics*, 95(5), 1982–2095.

Ariely, D. (2008): *Predictably Irrational*. New York: Harper Collins.

ATO (2017): "Commisioner of Taxation Annual Report 2016-17," Australian Taxation Office (ATO), Australian Government, Commonwealth of Australia, Canberra.

BIT (2014): "EAST - Four Simple Ways to Apply Behavioural Insights," Report, Behavioural Insights Team (BIT), UK.

Cadena, X., and A. Schoar (2011): "Remembering to Pay? Reminders vs. Financial Incentives for Loan Payments," NBER Working Paper Series 17020, National Bureau of Economic Research (NBER), Cambridge, MA.

Castro, L., and C. Scartascini (2015): "Tax Compliance and Enforcement in the Pampas: Evidence from a Field Experiment," *Journal of Economic Behaviour and Organization*, 116, 65–82.

Cialdini, R. B. (2008): *Influence: Science and Practice*. Boston: Pearson.

Del Carpio, L. (2013): "Are the Neighbors Cheating? Evidence from a Social Norm Experiment on Property Taxes in Peru," Unpublished Manuscript, Princeton University.

Dwenger, N., H. Kleven, I. Rasul, and J. Rincke (2016): "Extrinsic and Intrinsic Motivations for Tax Compliance: Evidence from a Field Experiment in Germany," *American Economic Journal: Economic Policy*, 8(3), 203–232.

Ericson, K. M. (2017): "On the Interaction of Memory and Procrastination: Implications for Reminders, Deadlines, and Empirical Estimation," *Journal of the European Economic Association*, 15(3), 692–719.

Gächter, S., H. Orzen, E. Renner, and C. Starmer (2009): "Are Experimental Economists Prone to Framing Effects? A Natural Field Experiment," *Journal of Economic Behavior and Organization*, 70(3), 443–446.

Hallsworth, M. (2014): "The Use of Field Experiments to Increase Tax Compliance," *Oxford Review of Economic Policy*, 30(4), 658–679.

Hallsworth, M., J. A. List, R. D. Metcalfe, and I. Vlaev (2017): "The Behavioralist as Tax Collector: Using Natural Field Experiments to Enhance Tax Compliance," *Journal of Public Economics*, 148, 14–31.

Harju, J., T. Kosonen, and O. Ropponen (2014): "Do Honest Hairdressers Get a Haircut?," Working paper, Government Institute for Economic Research (VATT).

Hasseldine, J., P. Hite, S. James, and M. Toumi (2007): "Persuasive Communications: Tax Compliance Enforcement Strategies for Sole Proprietors," *Contemporary Accounting Research*, 24(1), 171–194.

Holman, J., and F. Zaidi (2010): "The Economics of Prospective Memory," Working paper, Working Paper, Available at SSRN: http://dx.doi.org/10.2139/ssrn.1662183.

IRS (2016): "Tax Gap Estimates for Tax Years 2008-2010," Available at: https://www.irs.gov/newsroom/the-tax-gap (Accessed 18 January 2017), US Department of the Treasury, Internal Revenue Service (IRS).

Kahneman, D., and A. Tversky (1979): "Prospect Theory: An Analysis of Decision Under Risk," *Econometrica*, 47(2), 263–291.

Kalbfleisch, J. D., and R. L. Prentice (2002): *The Statistical Analysis of Failure Time Data, 2nd edition*. New York: Wiley.

Kaplan, E. L., and P. Meier (1958): "Nonparametric Estimation from Incomplete Observations," *Journal of the American Statistical Association*, 53(282), 457–481.

Karlan, D., M. McConnell, S. Mullainathan, and J. Zinman (2016): "Getting to the Top of Mind: How Reminders Increase Saving," *Management Science*, 62(12), 3393–3411.

Karlan, D., M. Morten, and J. Zinman (2015): "A Personal Touch in Text Messaging Can Improve Microloan Payments," *Behavioral Science and Policy*, 2, 25–32.

Kleven, H. J., M. B. Knudsen, C. T. Kreiner, S. Pedersen, and E. Saez (2011): "Unwilling or Unable to Cheat? Evidence from a Tax Audit Experiment in Denmark," *Econometrica*, 79(3), 651–692.

Levin, I. P., S. L. Schneider, and G. J. Gaeth (1998): "All Frames are Not Created Equal: A Typology and Critical Analysis of Framing Effects," *Organizational Behavior and Human Decision Processes*, 76(2), 149–188.

O'Donoghue, T., and M. Rabin (1999): "Doing it Now or Later," *American Economic Review*, 89(1), 103–124.

Ortega, D. E., and P. Sanguinetti (2013): "Deterrence and Reciprocity Effects on Tax Compliance: Experimental Evidence from Venezuela," Working paper, CAF Working paper 2013/08.

Pomeranz, D. (2015): "No Taxation Without Information: Deterrence and Self-Enforcement in the Value Added Tax," *American Economic Review*, 105(8), 2539–2569.

Scott, P. J., and C. Lizieri (2012): "Consumer House Price Judgments: New Evidence on Anchoring and Arbitrary Coherence," *Journal of Property Research*, 29(1), 49–68.

Slemrod, J. (2017): "Tax Compliance and Enforcement," Working paper, University of Michigan.

Slemrod, J., M. Blumenthal, and C. Christian (2001): "Taxpayer Response to an Increased Probability of Audit: Evidence from a Controlled Experiment in Minnesota," *Journal of Public Economics*, 79(3), 455–483.

Taubinsky, D. (2014): "From Inattentions to Actions: A Model and Experimental Evidence of Inattentive Choice," Working paper, UC Berkeley.

Thaler, R., and C. Sunstein (2008): *Nudge: Improving Decisions about Health, Wealth and Happiness*. New Haven: Yale University Press.

Tversky, A., and D. Kahneman (1974): "Judgement under Uncertainty: Heuristics and Biases," *Science (New Series)*, 185(4157), 1124–1131.

Wansink, B., R. J. Kent, and S. J. Hoch (1998): "An Anchoring and Adjustment Model of Purchase Quantity Decisions," *Journal of Marketing Research*, 35(1), 71–81.

Wenzel, M. (2006): "A Letter from the Tax Office: Compliance Effects of Informational and Interpersonal Justice," *Social Justice Research*, 19(3), 345–364.

Appendix A – Proofs of results in the main text

We begin by showing the following lemmas, which are used in the proof of Proposition 1.

Lemma A1: $EV\left(d,c,\hat{\delta}\right)-EW\left(d,c,\hat{\delta}\right)>0.$

Proof: If the debt is in memory and the taxpayer does not act then the payoff is the same as if the debt is not in memory. This implies $EV\left(d,c,\hat{\delta}\right)-EW\left(d,c,\hat{\delta}\right)\geq 0$**.** If $c<\bar{c}$ then it is optimal to act if the debt is in memory. This is only possible with probability $\delta<1$ if the debt is not in memory. Hence, $EV\left(d,c,\hat{\delta}\right)-EW\left(d,c,\hat{\delta}\right)>0.$

Lemma A2: *An increase in the perceived frequency of reminders from the tax authority weakly increases the perceived value of a tax debt in memory or forgotten:*

$$\partial EV\left(d,c,\hat{\delta}\right)/\partial\hat{\delta}\geqslant 0 \text{ and } \partial EW\left(d,c,\hat{\delta}\right)/\partial\hat{\delta}\geqslant 0.$$

Proof: Payoffs depend on the ability to act at each point in time. More frequent reminders do not restrict the perceived set of actions available and thus cannot reduce the perceived value of a tax debt in memory of forgotten.

Proof of Proposition 1:

We need to show that $\partial\bar{c}/\partial\hat{\delta}<0$. Using Equations (2) and (3),

$$\begin{aligned}
\frac{\partial\bar{c}}{\partial\hat{\delta}} &= -\frac{\rho}{R}\frac{\partial EV\left(gd,c,\hat{\delta}\right)}{\partial\hat{\delta}}-\frac{(1-\rho)}{R}\frac{\partial EW\left(gd,c,\hat{\delta}\right)}{\partial\hat{\delta}}\\
&= -\frac{\rho}{R}\underbrace{\frac{\partial EV\left(gd,c,\hat{\delta}\right)}{\partial\hat{\delta}}}_{\geqslant 0}-\frac{(1-\rho)}{R}\underbrace{\left[EV\left(gd,c,\hat{\delta}\right)-EW\left(g^2d,c,\hat{\delta}\right)\right]}_{>0}\\
&- \frac{\hat{\delta}(1-\rho)}{R}\underbrace{\frac{\partial EV\left(gd,c,\hat{\delta}\right)}{\partial\hat{\delta}}}_{\geqslant 0}-\frac{\left(1-\hat{\delta}\right)(1-\rho)}{R}\underbrace{\frac{\partial EW\left(g^2d,c,\hat{\delta}\right)}{\partial\hat{\delta}}}_{\geqslant 0}.
\end{aligned}$$

Each of the terms can be signed using Lemmas A1 and A2, and the result is proved.

Proof of Proposition 2:

The first and third channels are evident from comparison of Equations (5) and (6). These effects alone make the effect of reminder letter timing on payment probability theoretically ambiguous. To see that an increase in the cost threshold increases the probability of payment, re-write Equation (5) as follows:

$$F\left(\bar{c}_\tau\right) + \rho\left(1 - F\left(\bar{c}_\tau\right)\right) \sum_{j=\tau+1}^{T} p_j | Pr\left(active_{\tau+1} = 1\right).$$

Differentiation of this expression with respect to $\bar{c}_\tau$ yields

$$f\left(\bar{c}_\tau\right)\left[1 - \rho \sum_{j=\tau+1}^{T} p_j | Pr\left(active_{\tau+1} = 1\right)\right],$$

which is positive provided either memory is imperfect ($\rho < 1$) or the probability the debt is paid by time T is less than one. If the reminder letter changes beliefs such that $\bar{c}_\tau$ increases then $\bar{c}_{\tau+1} \cdots \bar{c}_T$ would also increase, further raising the probability of payment.

Appendix B – List of Variables

Outcome variables

- Payment in full (Yes/No)
- Amount of tax debt payment (in AUS$)

Control variables

- Total business income
- Initial debt level
- Increase in outstanding debt
- Business market segment (Micro, small/medium, not for profit)
- Client type (Australian private company, individual/sole trader, other)
- Risk cluster (based on internal ATO analytics model)
- Lodgment channel (ATO online, auto finalised, agent portal, business portal, corporate data capture, electronic lodgment, tax agent portal, web services, other)
- Tax agent (yes/no)
- Number of employees
- Industry (5 digit ANZSIC code)
- State/Territory

Appendix C – Treatment Letter

Australian Government
Australian Taxation Office

IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
<TITLE> <FIRST NAME> <MIDDLE NAME> <SURNAME>
<ORGANISATION>
<ADDRESS LINE 1>
<ADDRESS LINE 2>
<LOCALITY <STATE> <POSTCODE>
<COUNTRY>

Our reference: <Corres ID>
Phone: < >
<TFN<ABN>: <TFN><ABN>

<Issue date>

Total due now
<$Total amount>

You have a tax debt

> Have you missed a tax bill?
> You can choose from various payment methods

Dear <FIRST NAME><Sir/Madam>,

We haven't received your payment for your <tax type> bill yet. We can see you normally lodge and pay on time, so in case you can't find the details, here they are again.

Tax type	Amount owing
<Account type>	<$Total amount>

If you have paid in the last 7 days, thank you. No further action is required.

What you need to do

You need to pay your overdue debt by [14 days from issue date]<due date>. Each day your debt remains unpaid it increases. We currently charge interest at <GIC rate> a year, compounding daily, until the debt is paid in full.

If you can't pay

If you can't pay the total amount now contact us on < > between <8.00am> and <6.00pm>, <Monday to Friday> to see how we can help you.

Most people pay their tax on time and, in doing so, help pay for the essential services we all need and use. Thank you for your payment.

Yours <sincerely><faithfully>
<Deputy Commissioner's Name>
Deputy Commissioner of Taxation

PAY NOW

Your payment reference number (PRN) is: <PRN>

BPAY®

Biller code: < >

CREDIT CARD

Pay online with your credit card at **< >**
or phone **< >**.

A card payment fee applies.

For other payment options, visit **<ato.gov.au/howtopay>**

NEED HELP?

Visit us at **<ato.gov.au/contactus>**
Or
Contact us on **< >**
between <8:00am> and <6:00pm>, <Monday to Friday>.