Taxing Cash to Fight Collaborative Tax Evasion?

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Abstract

We build a model of collaborative tax evasion where a buyer negotiates a price discount with a seller in exchange for not asking the receipt and paying cash, which eases tax evasion. Sellers and buyers are heterogeneous with respect to their honesty and to their cost of managing non cash payment instruments. We study the effect of two policy instruments, a tax rebate for the buyer that keeps the receipts and a tax on cash withdrawals (TCW). We find that a mix of these two instruments can reduce tax evasion while increasing revenue and welfare. The TCW is effective only if sufficiently high, and it must be higher the higher the tax evasion in the country and the bigger the mass of individuals that typically pays in cash. We discuss the implementation problems of the TCW and we suggest how to partially overcome them.

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1 Introduction

The first economic model of tax evasion by Allingham and Sandmo (1972) explains evasion as a result of a cost benefit analysis by perfectly rational individuals. They choose to evade if the expected cost of the sanction, given the auditing probability, is lower than the tax payments. A great deal of economic literature followed their pioneering work, adding many elements to their baseline framework (Sirinvasan 1973; Yitzhaki 1974; Baldry 1979; Marrelli 1984; Reinganum and Wilde 1985; Usher 1986; Marrelli and Martina 1988; Andreoni 1992). What is in general missing in this literature, besides few exceptions, is the role of the buyer: asking for a receipt of the transaction makes tax evasion more difficult, while paying cash without asking for a receipt facilitates it. Since the buyers have the power to ease or impede tax evasion, it is plausible that some sellers will try to induce a cooperative behavior from them, for instance offering a price discount. When the two parties reach an agreement, a form of "collaborative tax evasion" takes place.

Our goal is to study how to curb this collaborative tax evasion with two policy instruments: a tax deduction for the buyers who keep the receipt of the transaction and a tax on cash withdrawals (TCW henceforth) that imposes a cost on the buyers that pay cash.

The tax deduction, or tax credit, is a standard instrument, embedded in many tax codes around the world, sometimes very creatively: in Taiwan, China, Puerto Rico and in the city of Sao Paulo, for instance, the receipt of the transaction can be used to claim a lottery ticket (Marchese 2009, Fabbri 2013). The purpose of this tax deductions is to reduce evasion by rewarding honest taxpayers, rather than punishing dishonest ones, and many experimental studies suggest that this strategy can be effective (among others, Alm et al. 1992 and Berhan and Jerkins 2005). The TCW, conversely, is a rather unexplored instrument, although the idea of taxing currency is hardly new in the economic literature (Gesell 1916, Buiter and Panigirtzoglou 2003, Buiter 2009, Mankiw 2009). Similarly to the tax rebates, its purpose is to reduce the incentives of the buyer to cooperate with the seller: since evasion is facilitated, if not allowed, by the use of cash, then making cash more expensive should induce less cooperation and less evasion. We are aware of only two countries that implemented this tax, Pakistan in 2001 and India from 2005 to 2009 (the so called Banking Cash Transaction Tax or BCCT). In both cases, however, the official reason for the introduction of the tax was not to directly reduce tax evasion nor to increase tax revenues, but rather to provide information for the tax enforcing authorities to better guide the audits[1].

We build a model where price taking sellers enter in a bargaining round with their customers, offering a price discount in exchange for not asking the receipt of the transaction. We assume that the transaction must be completed in cash if the parties reach a deal, since credit cards, debit cards, bank transfers, checks and other non cash payment instruments leave a trace, impeding tax evasion. If there is no deal, then there is no discount for the customer, the seller issues a receipt but the buyer is not constrained to use cash. We model heterogenous sellers with respect to their honesty or tax morale and heterogeneous buyers with respect to their tax morale but also with respect to their cost of managing non cash payment instruments. Prior to the bargaining game, the government commits to a policy that consists of an income tax, a sale (or value added) tax, a tax rebate and a TCW.

If buyers and sellers as risk neutral, and if their individual characteristics are public information, we have an analytical solution for the model equilibrium, which allows us to understand the effects of the policy instruments on tax evasion, government revenue and welfare. However, since some of the net effects of the policies are ambiguous, we also consider the numerical solution of a calibrated version of the model to gain further insights. We calibrate the model to a fictitious "prototype economy" that features empirically plausible values for parameters and calibration targets but that is not representative of a real world country. We choose this approach because we want to highlight the principles that should guide the anti-evasion policy in general, for a large set of countries, instead of focusing attention on a single country. Indeed, we also make an effort to study the robustness of our results to a wide range of alternative parameterizations and calibrations, which allows us to generalize our results.

We show that a small tax deduction is effective at both reducing tax evasion and increasing government revenue and welfare. Moreover, the deduction must be higher the higher the rate of tax evasion and the higher the statutory tax rate. The reason is that a tax rebate is a transfer from the government to the (already) honest taxpayers, which means that the cost of using the rebate to fight tax evasion is higher the smaller the tax evasion rate. In other words, it is not optimal to fight small levels of tax evasion using a tax rebate.

[1] In fact, consistently with this view, the tax was abolished in India in 2009 on the grounds of its irrelevance after the adoption of more sophisticated IT technologies to track down evaders.

As for the TCW, we find that its introduction can actually increase evasion, especially in economies where the use of cash is widespread. The reason is that the individuals with high costs of using non cash payment instruments prefer to use cash even if they do not allow tax evasion. Not only the TCW does not impose an extra cost, it actually makes cooperation more attractive: a collaborative buyer pays the TCW on the price of the good net of the discount, while a non collaborative buyer pays it on the full price. Nevertheless, the higher the TCW, the smaller the percentage of those individuals that prefer to use cash. We show that the first effect prevails for a small rate of the TCW, while the second for high rates. We conclude that taxing cash is effective at reducing evasion and increasing revenue only if its rate is high enough. Moreover, the TCW must be higher the larger the mass of individuals with high costs of using non cash payment instruments and the higher the tax evasion rate. The gain in government revenue that the TCW allows is also higher the higher the prevailing evasion rate in the country and the higher the percentage of individuals with high costs of using non cash paying instruments. Aggregate welfare, on the other hand, is always decreasing in the TCW.

We show that our results are robust if we relax one of the main simplifying assumption, risk neutrality. Specifically, we found very similar result assuming a CRRA utility function and an empirically plausible risk aversion parameter, although only through a numerical analysis.

For the calibrated version of the model, we can also isolate numerically the optimal policies. We consider two different policy objectives: the first is maximization of total welfare conditional on raising a given amount of government revenue; the second is the maximization of government revenue conditional on reducing tax evasion below a certain threshold. Overall, the main result from this exercise is that, with an appropriate policy mix, it is possible to curb tax evasion and, at the same time, to raise additional tax revenue and to increase aggregate welfare.

The main problem with our policy instruments is the implementation of the TCW. First, the TCW can foster the emergence of a parallel cash economy: firms and consumers can use whatever cash they have for the transactions, bypassing the banking system (Morse et al. 2005). Second, there is the possibility of a bank run at the moment of the announcement of the tax and before its introduction. Third, since the banks typically charge a fee for non cash payment instruments to both sellers and buyers, there can be a profit loss for the sellers and a purchasing power loss for the buyers. Fourth, the TCW should be ideally implemented in all the countries of a currency area and, to avoid arbitrage, the rate should be equal or, at least, not very different. We propose a thoroughly discussion of these issues, suggesting how to (partially) overcome them.

The rest of the paper is organized as follows. Section 2 briefly summarizes the related economic literature. Section 3 describes the model and the analytical results. Section 4 illustrates the numerical results. In Section 5 we discuss the implementation problems of the TCW. Section 6 offers some concluding remarks. In Appendix A we provide the proofs of our analytical results. Appendix B discusses the optimal policy including an example for Italy.

2 Related literature

The paper follows the quite abundant economic literature on tax evasion. Instead of discussing all the works in this area, which have already been extensively reviewed (Andreoni, Erard and Feinstein 1998, Slemrod and Yitzhaki 2002, Cowell 2004, Marchese 2004, Sandmo 2005, Slemrod 2007 and Franzoni 2008), we limit ourselves to a brief account of the few works that specifically tackle collaborative tax evasion.

First, Gordon (1990) suggests that under-the-counter cash sales at a discount price, on which the seller evades taxes, can be used as a price discrimination tool. Namely, the receipt of the transactions is the basis on which all the after sale services are based, including the possibility of returning a defective item and the possibility of suing the seller. Customers who are not interested in this insurance, for various reasons, are willing to pay a lower price. A second work on collaborative tax evasion is Boadway, Marceau and Mongrain (2002), who model evasion as collusion between a buyer and a seller. They assume that cooperative tax evasion efforts can reduce the detection probability more than individual efforts, which gives an incentive to cooperate. They also show that tax evasion might increase after an increase in sanctions, since it increases the gain from cooperation. Finally, Chang and Lai (2004) model collaborative tax evasion as a bargaining game between a seller and a buyer and they study how social norms shape the incentives of the agents: evading taxes induces psychological costs, associated to the feelings of guilt and shame, but these costs are higher the higher the social sanction of evasion, that is, the lower the tax evasion rate. They also show that, contrary to the standard tax evasion model, if the economy is in a bad equilibrium with widespread evasion, a tighter enforcement can actually increase evasion, sice it increases the gains from trade. Differently from these previous works on collaborative tax evasion, in this paper we focus on policy instruments different from enforcement and fines, the tax rebate and the TCW.[2]

The idea of a tax on currency first appeared in Gesell (1916) and it has been discussed by Goodfriend (2000), Buiter and Panigirtzoglou (2003), Buiter (2009), Mankiw (2009) and Rogoff (2014). The main focus of all this works, however, is how to overcome the zero bound on interest rates faced by the central bank, which is actually a consequence of the existence of paper currency: if only bank deposits and electronic means of payments were available, there would be the possibility of charging negative interest rates, which is akin to taxing currency. Goodfriend (2000) and Buiter and Panigirtzoglou (2003), in particular, carefully explain how to implement this Gesell (1916) "carry tax "on currency by setting a nominal interest rate on base money below the the interest rate on non monetary instruments. The possibility of a negative nominal interest rate, in turn, allows a better monetary policy response to deflationary shocks and it can also be used to reduce deflation expectations. In this work we consider a sightly different currency tax which applies to bank teller or ATM cash withdrawals and whose objective is to limit the customers' incentive to pay cash rather then improving monetary policy.

The paper is also related to the literature on the inflation tax (Friedman 1969; Phelps 1973; Chamley 1985; Woodford 1990, among others). Like the inflation tax, the TCW reduces the purchasing power of the consumers. Unlike the inflation tax, however, it is selective, in the sense that it reduces the purchasing power only if the goods or services are paid in cash. Therefore its incidence is lower if the use of non cash payment instruments is high.[3] Nicolini (1998) and Koreshkova (2006) already discussed the role of the inflation tax as a way to raise revenue from tax evaders and from the businesses that operate in the underground sector. With respect to their work, in this paper we take a different perspective and study how to increase the tax revenue by reducing evasion, rather then how to extract revenue from the evaders.

[2]See Santoro (2006), for an argument against the effectiveness of policy instruments meant to reduce the incentives to cooperate on tax evasion.

[3]In addition, the introduction of the TCW, by reducing the number of transactions in cash, will most likely reduce the seigniorage revenue. Although this source of revenue is only of limited importance for low inflation, advanced, economies, it can be important for developing economies, which are not able to manage a tax collection system or that have high rates of irregular activity.

3 The Model

The economy is composed by price taking, risk neutral sellers, risk neutral buyers and by the government. The government imposes an income tax on the seller and a sale tax on the buyer and enforces them with random audits and fines for those who are caught evading. We assume that the buyer has a legal right to ask for a receipt and, for simplicity, that taxes can be evaded only if the seller does not issue a receipt. In this setting, which is indeed similar to what happens in many real world situations (doctors, contractors, plumbers, etc.), a negotiation between the seller and the buyer is likely: the seller might offer a price discount to the buyer in exchange for not issuing the receipt, allowing tax evasion. This situation has been called, in the economic literature, "collaborative tax evasion" to stress that the buyer's cooperation is essential to evasion. If the buyer cooperates, we assume that the good or service is paid in cash, since non cash payments leave a trace of the transaction that impairs or precludes evasion. Instead, if there is no cooperation, the buyer chooses to pay cash or not depending on their costs.

Sellers are heterogeneous with respect to their honesty or tax morale (Gordon 1989; Andreoni, Erard and Feinstein 1998; Feld and Frey 2002): honest sellers will always issue the receipt, while less honest sellers will bargain with the buyers. The buyers are heterogenous along two dimensions. The first is tax morale, as for the sellers: honest buyers will always ask for a receipt, preventing tax evasion, while less honest buyers will bargain[4]. The second is the cost of managing non cash payment instruments, like credit cards, debit cards, bank transfers cheques etc: some individuals might find it easy to manage these instruments, while others, like the elderly (Humphrey et al. 2003) or the less financially educated, might find it cumbersome. Moreover, some consumers are uncomfortable with the idea that their purchases will be tracked and are ready to pay a price for an anonymous payment (Garcia Swartz et al. 2006).

The Government announces and commits to a policy $\mathcal{P} = \{t_s, t_b, \tau, \vartheta\}$, that consists of an income tax for the seller t_s, a sale tax for the buyer t_b, a tax on cash withdrawals (TCW) ϑ and a tax deduction for the buyers that keep the receipt of the transaction τ. The government objectives

[4] According to Gordon (1990), there is also another reason, beyond honesty, for which the buyers need a receipt: to have a formal guarantee on the product, so that, for instance, they can return a defective item. In what follows, we will ignore this feature, mainly because, as narrative evidence suggests, the sellers typically offer the same kind of customer service even when the fail to provide the receipt (in fact this is part of the argument they use to convince the buyers to go without receipt).

are the reduction of tax evasion, the maximization of social welfare for given revenue and the maximization of revenue.

After observing the policy $\mathcal{P}$, one buyer and one seller are randomly matched for a single transaction and they bargain over the the price discount. We assume complete information and we use the Nash bargaining solution.

3.1 Sellers and Buyers

We assume that the parties of the transaction can either evade the full amount or nothing.[5] The seller's utility in case of tax evasion, which requires cooperation from the buyer, is the following:

$$\begin{aligned} v_s^1 &= (1-\pi)\left[p(1-t_s)+pt_s-d-\upsilon\right]+\pi[p(1-t_s)-d-pt_sf_s-\upsilon] \\ &= p(1-t_s)+pt_s\left[1-\pi\left(1+f_s\right)\right]-d-\upsilon \end{aligned} \tag{1}$$

where p is the price of the good or service (taken as given by the seller), t_s is the income tax for the seller, d is the discount bargained with the buyer, π is the audit probability, f_s is the fine and υ is the individual cost of tax evasion, which reflects differences in honesty between sellers. In case of no audit, with probability $1-\pi$, the seller earns the evaded amount pt_s. In case of audit, the seller is forced to pay the full amount of taxes plus a fine, which is computed on the evaded amount pt_sf_s.[6] The cost of tax evasion, which is higher the higher is tax morale, is distributed according to the cdf G_υ, whose pdf is g_υ. If the buyer and the seller do not reach a deal the utility is simply equal to $v_s^0 = p(1-t_s)$. Comparing v_s^0 with v_s^1, we notice that the cost of cheating is $d+\upsilon$ while the benefit is the evaded amount minus the expected sanction. To make the analysis interesting, we assume that $1-\pi\left(1+f_s\right)>0$, so that a trade off exist. This assumption implies that there must be an upper bound to the audit probability π and to the fine f_s, which is reasonable. The utility of a buyer, in case of collaborative tax evasion, is the following:

$$v_b^1 = u-(p-d)(1+\vartheta)-\pi pt_b\left(1+f_b\right)-s \tag{2}$$

[5]This assumption is without loss of generality for the risk neutral case.

[6]We follow Yitzhaki (1974) and set a penalty on the evaded amount rather than on the evaded tax as in Allingham and Sandmo (1972).

where u is the utility from purchasing the good or service, t_b is the tax paid by the buyer, ϑ is the TCW, f_b is the fine and s is the cost of tax evasion or tax morale. The tax paid by the buyer can be interpreted as a sale tax or, if the seller does not buy any intermediate goods from other suppliers, as a value added tax (VAT)[7]. We assume that s is distributed according to the cdf G_s, whose pdf is g_s[8]. Since, in order to evade, the transaction must be paid in cash, the buyer must pay ϑ on the negotiated effective amount of the transaction $(p - d)$. In case of audit, the buyer is forced to pay the tax plus a fine computed on the evaded amount $pt_b(1 + f_b)$. If the buyer does not cooperate, he must still choose whether to use cash or an alternative payment instrument, such as a credit or debit card. In the former case, the utility of the buyer is

$$v_b^0(cash) = u - p[1 + t_b - \tau + (1 + t_b)\vartheta]. \tag{3}$$

Instead, if he chooses a non cash payment instrument, the utility becomes

$$v_b^0(card) = u - p(1 + t_b - \tau) - c \tag{4}$$

where τ is the tax rebate and c is the cost associated with non cash payment instruments. For simplicity, we normalize the cost of using cash to zero while, in practice, it is not, since it must be withdrawn from ATM machines, stored and protected from theft, not to mention its loss in value due to inflation. We also disregard individuals who benefit from the use of non cash payment instruments (negative c), since their behavior is identical to that of individuals with zero cost. We denote the cdf of the distribution of the cost c by G_c and the associated pdf by g_c. We also assume that the distributions of c and s are independent. If the buyer chooses not to cooperate with the seller and asks for a receipt, he receives a tax rebate on the full amount of the transaction p. In this case, since he is free to choose among different payment instruments, he will choose the

[7]In case there are intermediate producers, it is more complicated to model the VAT tax scheme, since the seller is itself a buyer that pays the VAT only on the difference in value. In addition, if there is an intermediate producer the negotiation between the final producer and the buyer depends also on the decision to evade or not at the intermediate stage, which in turn might be the result of a negotiation. We chose to abstract from these complications to keep the model tractable.

[8]We assume that the enforcement probability for the buyer is the same as the enforcement probability for the seller or, in other words, that the enforcement is on the transaction. This is a shortcut since, in practice, the authorities can also audit the accounts of the sellers, which is obviously not possible for the buyers. We make this assumption for simplicity and because the auditing probability has only a modest effect on the conclusions of the analysis.

one with the lower cost. More formally, cash is preferred to non cash instruments if and only if $c \geq p(1+t_b)\vartheta$. From now on we define $\Upsilon = p(1+t_b)\vartheta$. Then, the utility of a non cooperating buyer is

$$v_b^0 = u - p(1 + t_b - \tau) - \min\{\Upsilon, c\}. \tag{5}$$

The tax rebate and the TCW affect the buyer's incentive to cooperate rather than the terms of the gamble faced by the tax evader. However, both instruments indirectly affect the behavior of the seller through the bargained discount.

3.2 Bargaining

We assume that the individual characteristics of sellers and buyers are public information and we model the negotiation as a Nash bargaining. The solution is defined by

$$\begin{aligned} d^* &= \arg\max_d \left(v_s^1 - v_s^0\right)^\beta \left(v_b^1 - v_b^0\right)^{1-\beta} \\ &s.t. \quad v_s^1 \geq v_s^0\,,\ v_b^1 \geq v_b^0 \end{aligned} \tag{6}$$

where β is the bargaining power of the seller. The solution for the discount is

$$d^*(\upsilon, s, c) = \beta \frac{p(\tau + \vartheta - t_b) + \pi p t_b\,(1 + f_b) + s - \min\{\Upsilon, c\}}{1 + \vartheta} + (1 - \beta)\{p t_s[1 - \pi\,(1 + f_s)] - \upsilon\} \tag{7}$$

for all υ such that $v_s^1 \geq v_s^0$, and for all the couples s and c such that $v_b^1 \geq v_b^0$, i.e.

$$\upsilon \leq p t_s[1 - \pi\,(1 + f_s)] - d^*(\upsilon, s, c) \tag{8}$$

$$s \leq d^*(\upsilon, s, c)(1 + \vartheta) - p(\tau + \vartheta - t_b) - \pi p t_b\,(1 + f_b) + \min\{\Upsilon, c\}. \tag{9}$$

Conversely, there is no evasion and the optimal discount is zero in case conditions (8) and (9) do not hold. By plugging the optimal discount (equation 7) into (9) we find

$$s \leq (1+\vartheta)\left\{pt_s[1-\pi(1+f_s)] - \upsilon - \frac{p(\tau+\vartheta-t_b)+\pi pt_b(1+f_b)-\min\{\Upsilon, c\}}{1+\vartheta}\right\}. \tag{10}$$

3.3 Tax evasion

We use condition (10) to compute the equilibrium level of tax evasion. First, we consider the buyers with $c \leq \Upsilon$ to obtain a threshold value $\tilde{s}_1(\upsilon, c)$ such that all the buyers of type $c < \Upsilon$, with an honesty lower than $\tilde{s}_1(\upsilon, c)$, cooperate. Next, we define the level of seller honesty $\tilde{\upsilon}_1$ that makes no buyer willing to cooperate, that is such that $\tilde{s}_1(\tilde{\upsilon}_1, c) = 0$. Doing the same for $c \geq \Upsilon$, we obtain a second threshold $\tilde{s}_2(\upsilon)$ (which does not depend on c), such that all the buyers of type $c \geq \Upsilon$, with honesty lower than $\tilde{s}_2(\upsilon)$, collaborate. We also define $\tilde{\upsilon}_2$ so that $\tilde{s}_2(\tilde{\upsilon}_2) = 0$. We get the following expression for total tax evasion E : [9]

$$E = \int_0^{\Upsilon} E_c(c) g_c dc + [1 - G_c(\Upsilon)]\, E^c \tag{11}$$

where $E_c(c) = \int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)} g_s ds) g_\upsilon d\upsilon$ is the mass of evaders with low c, while $E^c = \int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)} g_s ds) g_\upsilon d\upsilon$ is the mass of evaders with high c. We are interested in the effect of the government policy $\mathcal{P} = \{t_s, t_b, \tau, \vartheta\}$ on the total amount of tax evasion E.

The simplest way to have zero tax evasion is, obviously, to have no taxation at all. However, a government needs a minimum amount of resources to function and, therefore, it needs tax revenue. But imposing taxes has the consequence of generating tax evasion, of an amount that is increasing in the tax rates t_s and t_b. This result is different from the original Allingham and Sandmo model, where an increase in the tax rate would reduce evasion, but perfectly in line with most of the empirical literature (Clotfelter 1983; Crane and Nourzad 1992; Alm 2012). The difference between our result and Allingham and Sandmo comes from the fact that, because of risk neutrality, we have a corner solution with full evasion, so that we essentially look at the decision to evade or not (extensive margin) and the higher the tax rate the higher the mass of evaders. Conversely, in the Allingham and Sandmo model, there is an intensive margin effect with the evaded amount that is a decreasing function of the tax rate. In Section 4.3 we show that, if we relax the hypothesis of

[9] By plugging the expression (7) into (8) instead of (9) we find exactly the same result.

risk neutrality, we have an interior solution for the optimal level of tax evasion, which is decreasing in the tax rate. This implies that the response of evasion to the tax rate is first increasing (the extensive margin prevails) and then decreasing (the intensive margin prevails).

As for the effect of the tax deduction, it actually reduces the buyers' incentives to collaborate, decreasing tax evasion. The effect of the TCW ϑ on evasion is instead ambiguous, as shown by the next derivative:

$$\frac{\partial E}{\partial \vartheta} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial \vartheta} g_c dc + [1 - G_c(\Upsilon)] \frac{\partial E^c}{\partial \vartheta}, \tag{12}$$

since

$$\frac{\partial E_c(c)}{\partial \vartheta} = \int_0^{\tilde{\upsilon}_1} g_s(\tilde{s}_1(\upsilon, c)) \big\{ pt_s[1 - \pi(1 + f_s)] - \upsilon - p \big\} g_\upsilon d\upsilon < 0 \tag{13}$$

while

$$\frac{\partial E^c}{\partial \vartheta} = \int_0^{\tilde{\upsilon}_2} g_s(\tilde{s}_2(\upsilon)) \big\{ pt_s[1 - \pi(1 + f_s)] - \upsilon + pt_b \big\} g_\upsilon d\upsilon > 0. \tag{14}$$

The threshold $\tilde{s}_1(\upsilon, c)$, such that all the buyers of type $c \leq \Upsilon$ with tax morale lower than $\tilde{s}_1(\upsilon, c)$, collaborate, is decreasing in ϑ. Instead, the threshold $\tilde{s}_2(\upsilon)$, for types $c \geq \Upsilon$ is increasing. The reason is that, if the buyer does not collaborate, he must still choose whether to use cash or not and cash is better if and only if $c \geq \Upsilon$. For high c, buyers prefer to use cash even if they do not want to cooperate with the seller, in order to avoid the cost of non cash payments. This implies that the TCW does not impose an extra cost for cooperation, making cooperation more attractive: a collaborative buyer pays ϑ over the cash needed for the transaction, $p-d$, while a non collaborative buyer pays ϑ on the full price p. For low levels of c, the buyers who do not intend to collaborate with the seller prefer to bear the cost c and use non cash payment instruments. Thus, an increase in the TCW rate makes cooperation relatively more costly. Since the derivative of tax evasion with respect to the TCW is positive for low values of ϑ and negative for high values, an increase in ϑ is more likely to decrease tax evasion the larger is ϑ. In other words, a tax on cash withdrawals is an effective tool to fight tax evasion only if it is set sufficiently high[10]. We summarize the previous analysis with the following proposition:

[10]Notice that for $\vartheta = 0$ $\frac{\partial E}{\partial \vartheta} = \int_0^{\tilde{\upsilon}_2} g_s(\tilde{s}_2(\upsilon)) \frac{\partial \tilde{s}_2(\upsilon)}{\partial \vartheta} g_\upsilon \, d\upsilon > 0$ while for $\vartheta = 1$ $\frac{\partial E}{\partial \vartheta} = \int_0^1 \left(\int_0^{\tilde{\upsilon}_1} g_s(\tilde{s}_1(\upsilon, c)) \frac{\partial \tilde{s}_1(\upsilon, c)}{\partial \vartheta} g_\upsilon \, d\upsilon \right) g_c dc < 0$.

Proposition 1. *Tax evasion is increasing in the tax rates t_s and t_b and decreasing in the tax rebate τ. The TCW ϑ is an effective tool to fight tax evasion only if set sufficiently high.*

Importantly, a decrease in c has the same effect as an increase in ϑ. Thus an alternative policy to reduce tax evasion entails decreasing the cost to manage non cash payment instruments. However, while the TCW increases the government revenue, decreasing c is costly and, therefore, infeasible for financially constrained governments. There is also a further difference between the two policies, since the cost c cannot be compressed for all individuals, even in case of high government expenditures: some of the costs included in c are fees charged by banks, that can be simply compensated with a subsidy, but some of them are psychological (loss of privacy) and cognitive costs (financial literacy), which are difficult, if not impossible, to reduce or eliminate.

3.4 Welfare

We are also interested in studying the effect of the government policy $\mathcal{P} = \{t_s, t_b, \tau, \vartheta\}$ on the total welfare, which is given by the following expression:

$$\begin{aligned} W \quad = \quad & \int_0^{\Upsilon} \left\{ (v_s^0 + v_b^0)(1 - E_c(c)) + \int_0^{\tilde{\upsilon}_1} \int_0^{\tilde{s}_1(\upsilon, c)} (v_s^1 + v_b^1) g_s ds g_\upsilon d\upsilon \right\} g_c dc + \\ & [1 - G_c(\Upsilon)] \left\{ (v_s^0 + v_b^0)(1 - E^c) + \int_0^{\tilde{\upsilon}_2} \int_0^{\tilde{s}_2(\upsilon)} (v_s^1 + v_b^1) g_s ds g_\upsilon d\upsilon \right\}. \end{aligned} \tag{15}$$

The first line is the utility of sellers and buyers with low c: the first term is the utility of non evaders while the second term is the utility of sellers and buyers who collaborate to evade taxes. The second line is the utility of sellers and buyers with high c and again the first term refers to non evaders while the second to evaders.

In the rest of this paragraph we discuss the comparative statics of total welfare to policy changes (all the derivations are derived in Appendix A). In the numerical part of the paper, however, we will consider both this measure of total welfare that includes evading and non evading individuals, and an alternative measure that includes honest buyers and sellers only. The problem is if the government or, broadly speaking, society, should care also about the welfare of evaders when designing the optimal policy and we chose to remain agnostic, because any answer depends on ideological priors: on the one hand the evaders are breaking the law and should be punished but, on the other, they are citizens and there is a limit to the cost that it is reasonable to impose on them.

We start with the effect of an increase in the income tax t_s, shown in the next derivative:

$$\frac{\partial W}{\partial t_s} = -p + p(1-\pi(1+f_s))E + \vartheta(1-\beta)p(1-\pi\,(1+f_s))E. \tag{16}$$

An increase in the income tax t_s decreases the utility of non evaders (first term) and increases the utility of evaders (second term), but the negative effect prevails. Moreover, an increase in the income tax increases the discount, decreasing in turn the amount $(p-d)$ that collaborative buyers pay cash. This implies that the utility of collaborative buyers increases, since the TCW paid to finalize the illegal transaction $(p-d)\vartheta$ decreases (last term). The effect of an increase in the sale tax t_b on welfare is very similar to the increase in t_s, as summarized by the next derivative:

$$\frac{\partial W}{\partial t_b} = -p(1+(1-G_c(\Upsilon))\vartheta)+p(1-\pi(1+f_b))E-\frac{\vartheta\beta p}{1+\vartheta}((1-\pi\,(1+f_s))E+(1-G_c(\Upsilon))\vartheta E^c). \tag{17}$$

The main difference with respect to the income tax is that the sale tax decreases the discount, lowering the utility of cooperating buyers (last term).

As for the tax deduction, it increases the utility of non evaders (first term) and decreases the utility of dishonest buyers and sellers (second term), but the positive effect prevails. Moreover, an increase in the rebate increases the discount and the utility of collaborative buyers (last term). The analytical expression of the derivative is

$$\frac{\partial W}{\partial \tau} = p - pE + \frac{\vartheta\beta p}{1+\vartheta}E. \tag{18}$$

In contrast to the previous results, the effect of the TCW ϑ on welfare is in general ambiguous. We summarize the previous analysis with the following proposition:

Proposition 2. *i) Total welfare is decreasing in the sale tax t_b and increasing in the tax rebate τ. ii) For low levels of the TCW, total welfare is decreasing in the income tax t_s. iii) The effect of the TCW on total welfare is ambiguous.*

3.5 Net Government Revenue

We conclude this section investigating the effect of the policy $\mathcal{P} = \{t_s, t_b, \tau, \vartheta\}$ on government revenue, which is

$$
\begin{aligned}
G \;=\; & \int_0^{\Upsilon} \{[p\pi(t_s(1+f_s)+t_b(1+f_b)) + (p-d^*(\upsilon,s,c))\vartheta]E_c(c) + p(t_s+t_b-\tau)(1-E_c(c))\}\, g_c dc + \\
& [1-G_c(\Upsilon)]\{[p\pi(t_s(1+f_s)+t_b(1+f_b)) + (p-d^*(\upsilon,s))\vartheta]E^c + (p(t_s+t_b-\tau)+\Upsilon)(1-E^c)\}\,.
\end{aligned}
\tag{19}
$$

The first line is the revenue from transactions associated to low c buyers. These buyers are either matched with evading sellers (first term) or not (second term). In case of tax evasion and audit, seller and buyer are forced to pay the full amount of the tax plus a fine, computed on the evaded amount $p\pi[t_s(1+f_s)+t_b(1+f_b)]$. Moreover, since there must be a cash payment, the buyer also pays the TCW, which amounts to ϑ times the negotiated amount of the transaction $(p-d)$. When the matching does not lead to tax evasion, the revenue amounts to the taxes net of the rebate for the buyer, $p(t_s+t_b-\tau)$.

The second line is the revenue from transactions associated to high c buyers. In case of tax evasion, the government cashes in exactly the same amount as in the case of low c. Conversely, when the matching does not lead to tax evasion, the revenue is $p(t_s+t_b-\tau)+\Upsilon$, since the government collects the TCW also from the non collaborative buyers who prefer to use cash because of their high cost of non cash payment instruments. Indeed, the TCW levied on those individuals is a pure transfer to the Government and should be reimbursed to leave their purchasing power unchanged.

Introducing the TCW imposes the cost c also on those non collaborative buyers (those with $c \leq \Upsilon$) who opt for non cash payments. This cost is not a transfer, but a loss for society as a whole, and it is equal to

$$\int_0^{\Upsilon} c(1-E_c(c))g_c dc. \tag{20}$$

Since c is measured in monetary equivalents[11], it is possible to subtract it from the government revenue to obtain what we call the "Net Government Revenue", denoted G_n. Since we abstract from other positive effects determined by the switch to a cashless society (see Humprey et al., 2003

[11]Notice that our results do not change if we include a mass of buyers with negative costs of using non cash payment instruments, since they would have chosen those alternative means of payment irrespectively of the policy.

and Garcia-Swartz et al., 2006), we actually underestimate the gains realized with any policy that reduces the use of cash.

An increase in the income tax t_s increases the mass of evaders (extensive margin) and the revenue both from evaders and non evaders (intensive margin). Moreover, there is a decrease in revenue from the TCW, since an increase in t_s increases the equilibrium discount. In addition, also the cost imposed on the non collaborative buyers who pay cash decreases. If $\tau = \vartheta = t_b = 0$, only the first two effects are left. Moreover, when t_s is low, the first negative effect is small, while the positive one is large: in this case, an increase in t_s increases the revenue. The opposite happens if t_s is high. In other words, we have a standard Laffer curve type of result.

An increase in the sale tax t_b has a similar effect on the net government revenue. The main difference is that the tax on the seller decreases the equilibrium discount.

An increase in tax rebate τ decreases the mass of evaders with an ambiguous effect on revenue unless t_s and t_b are sufficiently high, in which case the effect is positive. There is no effect of an increase in τ on revenue from evaders and a negative effect for the revenue from non evaders. Moreover, an increase in τ decreases the revenue from the TCW, as a consequence of a higher equilibrium discount, and increases the cost imposed on non collaborative buyers who opt for non cash payments. Summarizing, low statutory taxes, a large mass of honest individuals $(1 - E)$ and an high TCW are all factors that can make a tax rebate undesirable.

The comparative statics with respect to ϑ is quite complicated. An increase in ϑ increases the mass of evaders with high c and decreases the mass of evaders with low c. Moreover, it increases the revenue at the intensive margin, both from evaders and non-evaders, and it increases the discount for evaders with high c and decreases the discount for evaders with low c. In general the effect of the policy is ambiguous.

We summarize the previous analysis with the following proposition:

Proposition 3. *i)If $\tau = \vartheta = t_b = 0$ there is a Laffer curve for the response of government revenue to t_s; i)If $\tau = \vartheta = t_s = 0$ there is a Laffer curve for the response of government revenue to t_b; iii) The tax rebate τ can decrease the government revenue in case of low tax rates or in case there are many honest individuals; iv) The effect of the TCW on Government revenue is ambiguous.*

4 Numerical Analysis

We now consider the numerical solution of a calibrated version of the model with empirically plausible distributions for tax morale and for the cost of managing non cash payment instruments. The first goal is to complete the comparative statics exercises, by pinning down the sign of the effects for which we have ambiguous analytical results. In addition, we also study the robustness of the results to the inclusion of risk aversion, for which we don't have an analytical solution, and we compute the optimal policy numerically.

We proceed as follows. In the next section (4.1) we define what we call a "Prototype Economy"and in Section 4.2 we illustrate the comparative static results for this fictitious economy. We have two reasons to focus our attention on a prototype economy rather then calibrate the model to a real world country. First, and foremost, we do not want to focus exclusively on a specific country, but rather to provide the widest possible perspective on these issues, making the analysis as general as possible. This is also the reason why we consider a wide range of parameters. Second, it is difficult to identify the exact value of some of the relevant empirical measures (e.g. the level of tax evasion) that we need to calibrate the model precisely, which also forces us to consider many different parameter values. In Section 4.3 we summarize all the robustness exercises. In Section 4.4 we briefly comment on the efficiency issues raised by the policies. To complete the analysis, in the appendix we identify the optimal policy (B) and we discuss an example for a real world country, Italy (B.2).

4.1 The Prototype Economy

We start the numerical analysis by choosing a set of parameters and calibration targets that define the baseline, fictitious, prototype economy. We fix the income tax rate t_s at 30% and the sale tax rate t_b at 10%. For the enforcement probability and the fine, we choose $\pi = 0.01$ and $f_s = f_b = 0.5$, respectively. We admittedly take a shortcut by assuming a constant probability that does not depend on the seller's characteristics and on the evaded amount. In practice, a big firm that evades 90% of its profits faces a higher audit probability than a small, less visible, business that seldom evades a small 10% (Yitzhaki 1987). We also abstract from congestion effects in law enforcement (Galbiati and Zanella 2012), which imply that, for a fixed amount of government resources devoted to enforcement, the individual audit probability decreases the higher the number of individuals that evade. This is the reason why we perform some robustness tests on the auditing probability: different probabilities reflect differences in the size and characteristics of the firms, with higher probabilities corresponding to bigger, more visible, businesses or to firms that evaded in the past. We do not consider the auditing probabilities as a policy instruments, since we do not have a cost of enforcement in the model and since there is no easy way of introducing one.[12]

In this baseline model, we set $\vartheta = \tau = 0$ and we normalize the cost of using cash to zero. For the distribution of c, we consider an economy in which many individuals have a cost of using non cash payment instruments equal to zero or very close to zero, but where a small mass of individuals has a high cost of using them (think about the elderly, for instance). Therefore we need a distribution with a probability mass at 0 and with a rapidly declining probability mass for bigger values of c. We chose the following mixture exponential:

$$g_c(x, \lambda) = \begin{cases} 0 & \text{Prob}\, \lambda \\ \lambda e^{-\lambda x} & \text{Prob}\, 1 - \lambda. \end{cases} \tag{21}$$

In the prototype economy, we set $\lambda = 0.2$, which entails assuming that, in the absence of the TCW, 20% of the population does not use cash for the transactions at the given price. We test the robustness of the model results to an alternative, higher, value of λ in Section 4.3.

We set $\beta = 0.5$, since we have no particular reason to assign a higher bargaining power to the buyer or to the seller, but we discuss the robustness of the model results in Section 4.3. As noticed in Section 4.4, if u is not sufficiently higher than the price p, a TCW might discourage the buyer from purchasing the good. In this baseline parametrization, we rule out this possibility by choosing a high value of u. Other than that, the values of p and u are just scalings, and do not affect the main findings. We set $p = 10$ and $u = 1.5\, p$. In practice, the number of individuals using alternative payment instruments increases with p. Ideally, we would need a model where the cost c is decreasing in p, but this is impractical from an empirical perspective, given that we do not have the detailed information needed to parameterize a whole function. Nevertheless, by considering different levels of λ, we can implicitly take into account this variability: a higher (lower) λ is more

[12]Reinganum and Wilde (1985) highlight the optimal auditing rule of the tax authority. Slemrod et al. (2001) and Kleven et al. (2011) study the effects of the threat of enforcement on reported income using field experiments.

likely in sectors with higher (lower) average transactions values. Therefore the robustness of the comparative static results to different values of λ must be interpreted also as a robustness across different sectors of the economy with different transaction values. Notice that, since the price p is just a scaling, we do not change it when we perform these robustness tests: changing it will only deliver different calibrated parameters but exactly the same results.

For the distribution of tax morale, we consider an extremely versatile distribution that assigns values in an interval, the Kumaraswamy distribution, which is essentially a Beta distribution with a different parametrization. The pdf is the following:

$$g(x; a, b, \bar{x}) = \frac{ab}{\bar{x}} \left(\frac{x}{\bar{x}}\right)^{a-1} \left[1 - \left(\frac{x}{\bar{x}}\right)^{a}\right]^{b-1} \qquad 0 < x < \bar{x} \tag{22}$$

Depending on the value of the parameters, we can have an increasing pdf with most of the probability mass corresponding to high values of tax morale, a decreasing pdf, where the opposite is true, or a peak corresponding to intermediate values. We consider the same distribution of tax morale for both the buyer and the seller ($\bar{s} = \bar{v}$), since there is no theoretical or empirical reason to believe that the sellers (for instance) are, a priori, more honest than the buyers. Obviously we can argue that the profession choice is also dictated by the different opportunities to evade taxes, so that less honest individuals, more prone to tax evasion because of moral considerations, typically choose to work where it is easier to evade taxes (Pestieau and Possen 1991). Nevertheless, since there is no robust empirical evidence that confirms these speculations (Parker 2003), we decided to abstract from these issues.

To choose the value of the parameters of the distribution, we use data from the World Value Survey (WVS henceforth). This survey is part of an ongoing Worldwide research project, whose goal is to compare several aspects of culture among different countries. Among the questions administered to a significant number of individuals in different countries, there is one specifically related to tax morale, namely "Do you consider justifiable cheating on taxes?" Respondents are asked to pick a number between 0 and 10, where 0 means always justifiable while 10 never justifiable. We consider the average frequencies of the responses to the question, where the average is with respect to all participating countries (not weighted). The shape of the empirical distribution of the answers is similar across countries: a big mass of individuals that never justifies evading and a rapidly declining probability mass.

The core of the calibration procedure entails choosing the parameters a, b, together with upper bound $\bar{s} = \bar{v}$, to match the empirical shape of the distribution of the answers and to match the observed level of tax evasion. We run a simple grid search procedure: for each upper bound of tax morale $\bar{s} = \bar{v}$ we divide the interval between 0 and $\bar{s} = \bar{v}$ into 9 equally spaced subintervals. We consider the threshold values of these intervals as corresponding to the 1-10 scale of the answers of the WWS. We then take couples of a and b and, for each couple, we compute the value of the model-based distribution at the threshold values. We then compute, for each couple, the sum of square distances between the model based distribution and the empirical distribution, which is equal to the observed average relative frequencies from the empirical answers to the questionnaire. We choose a, b and $\bar{s} = \bar{v}$ to minimize this sum of square residuals for the target calibrated level of tax evasion, so to have the closest possible match between the model and the data. For a target evasion level of 30%, we end up with $b = 1$,$a = 5.93$ and $\bar{s} = \bar{v} = 2.31$. To check for robustness, we also calibrated the model to deliver a higher and a lower tax evasion rate, respectively 50% and 15%.

4.2 Numerical Comparative Statics: the Prototype Economy

We start by describing the comparative statics of the four policy instruments in the baseline model specification. In all exercises we focus attention on one instrument at the time and we set the others to their baseline values. The numerical analysis confirms the analytical results, but also allows us to gain some further insights.

Figures 1 to 4 report the comparative statics of our four policy instruments for different calibration targets of the tax evasion level, 15%, 30% and 50%. In the upper left panel we report the tax evasion rate, in the upper right panel we report the normalized net government revenue, which is made equal to 100 in the benchmark model parametrization for each evasion level. This normalization implies that, subtracting 100 from the values of the net government revenue, we have their percentage variation with respect to the benchmark. A drawback of this normalization is that the three lines in the upper right panel are not expressed in the same unit and, therefore, they are not directly comparable. In the lower left panel we report the normalized total welfare, while in the lower right panel we report the normalized welfare of non evaders.

Figure 1 reports the effect of the income tax rate t_s. An increase in the tax rate determines an increase in tax evasion, with less individuals that pay taxes; however the non-evaders, who choose to pay taxes even at the higher tax rate, pay more. The numerical result confirms that the second effect prevails for low tax rates but, after a threshold, when the number of evaders is sufficiently high, the first effect prevails and the revenue is decreasing in the tax rate. So far, the numerical analysis confirms the analytical comparative statics. In addition, the picture also shows a new result: the threshold, which is also the tax rate that maximizes revenue, is smaller the higher the starting level of tax evasion. The intuition is that the second effect described above, that is the increase in revenue from non-evaders resulting from the tax increase, is smaller the higher the prevailing tax evasion level. By contrast, the first effect, the increase in tax evasion resulting from the tax increase, which is measured by the slope of the curve in the left panel, does not depend on the level of tax evasion. Finally, and consistently with Proposition 2, an increase in the tax rate has also the effect to decrease the welfare of both evaders and non-evaders.

Figure 2 reports the effect of the sale tax rate t_b, which is almost identical to an increase in t_s : evasion is increasing in the sale tax, there is again a Laffer curve for the government revenue and welfare is decreasing.

Figure 3 reports the effect of the tax rebate τ. Evasion decreases with τ, since a tax rebate reduces the incentives to cooperate for the buyer. There are two contrasting effects on the government revenue: on the one hand, the decreasing evasion increases revenue. On the other, the higher τ, the higher the transfer from the government to non-cooperating buyers. The right panel shows that there is a threshold level for the tax rebate such that, if the rebate is below the threshold, the first effect prevails and the revenue is increasing in the rebate; viceversa, if the rebate is above the threshold, the second effect prevails and the revenue is decreasing in the rebate. This analysis confirms the analytical results. The picture also shows that this threshold value, which is also the one that maximizes the government revenue, is higher the higher the prevailing tax evasion rate. For a calibrated tax evasion level of 30%, the optimal tax rebate is $\tau = 5\%$. For a 50% evasion, instead, the optimal τ is 7%, while it is only 3% in case of a 15% evasion rate. The reason is that, since an increase in the rebate is an increase in the total transfers from the government to the (already) honest taxpayers, the cost to fight tax evasion with the rebate is higher the smaller the tax evasion rate. The important consequence of this result is that it is not desirable to fight small levels of tax evasion using a tax rebate. Consistently with Proposition 2, τ increases aggregate welfare. Finally, it also increases the welfare of non evaders. This last result is due to the increase in the mass of honest individuals (decrease in evasion) and not to an increase in the utility of each individual, that is instead decreasing in τ(see Section 3.4).

Figure 4 reports the effect of the TCW ϑ. As previously stressed, for the individuals with high cost c (the cash users), increasing ϑ increases the incentive to cooperate, increasing tax evasion. For the individuals with low cost c (the non cash users), increasing ϑ decreases the incentive to cooperate, decreasing tax evasion. In addition, the number of non cash users increases with the TCW rate and the number of cash users decreases. The picture shows that evasion is first increasing in the TCW and then decreasing. In other words, there must be a sufficiently high number of non cash users for the second effect to prevail and, therefore, a sufficiently high TCW rate that increases such a number. This confirms the analytical result in Proposition 1. In addition, we also found that the higher the prevailing tax evasion rate, the smaller the rate of the TCW above which tax evasion is decreasing. This is because if the tax evasion is low, there is a big mass of non collaborative buyers who are cash users.

The effect of the TCW on the net government revenue is twofold: on the one hand an increase in the TCW rate affects the cooperation rate and, therefore, the level of tax evasion. On the other, it affects the total cost of non cash instruments use that must be subtracted from the gross revenue. For low levels of the TCW rate, cooperation and, therefore, evasion, is increasing, which translates in a decreasing gross revenue. However, since more individuals are using cash because they are evading taxes, there is a lower total cost of non cash instruments use. Thus the net revenue can be increasing even in case of an increase in tax evasion. Viceversa, for high values of the TCW, tax evasion is decreasing, but the net government revenue can be decreasing because the total non cash instruments use is high. Tax evasion is lower than the benchmark for a very high tax on cash, but the net government revenue might be lower or higher than the benchmark for such values. As shown in the upper right panel of Figure 4, the response of the net revenue to the TCW has an inverse u shape. Thus the numerical analysis solves the analytical ambiguity summarized in Proposition 2. In addition, we also found that the TCW that maximizes the net government revenue is higher the higher the baseline tax evasion. In particular, for the baseline

30% tax evasion, $\vartheta = 0.25$ maximizes the net revenue, while $\vartheta = 0.13$ maximizes revenue for the 15% calibrated evasion. The intuition, once again, is that for a high rate of tax evasion, there is a small mass of non collaborative cash users to compensate (most of them evade). Similarly to the tax rebate, there might be no gain at all from the introduction of the TCW if the starting evasion rate is sufficiently low.

Total welfare, on the other hand, is always decreasing in the TCW rate, although the welfare of non evaders might be increasing. This last result, as for the rebate, is due to the increase in the mass of honest individuals (decrease in evasion) and not to an increase of the utility of each individual, that is instead decreasing in the TCW rate.

Summing up, the numerical analysis confirmed the results in Propositions 1 to 3, but also highlighted some additional results, summarized in the following proposition:

Proposition 4. *The net government revenue is first increasing and then decreasing in the TCW rate. Total welfare is decreasing in the TCW rate. The higher the baseline tax evasion: i)The smaller the optimal tax rates that maximizes net government revenue; ii) The higher the optimal tax rebate that maximizes net government revenue; iii) The higher the TCW rate that maximizes net government revenue; and iv) The smaller the TCW rate above which tax evasion is decreasing.*

4.3 Numerical Comparative Statics: Robustness

We now consider the robustness of the results to alternative model parameterizations and calibrations. We start with a higher target value for the fraction of non cash users, $\lambda = 0.5$. In this scenario, tax evasion is always decreasing in ϑ and, for a 30% benchmark calibrated evasion rate, $\vartheta = 0.19$ maximizes the government revenue net of the cost. Since there is a higher mass of individuals with a small cost of using non cash payment instruments, the government requires a smaller tax on cash to prevent evasion. Reduced evasion, in turn, raises the tax revenues and decreases the collection of the TCW, but the first effect prevails, resulting in an increase in revenue. Importantly, since the use of cash is less common in sectors of the economy where the average transaction amount is higher, variations in λ describe also the differences in the effects of the TCW in different sectors (remember that the price p and the value u are just scalings in the model, so we would have exactly the same results if we redid the model parametrization and calibration for a different price level). The higher mass of non cash users also implies that the welfare of non evaders is increasing in the TCW also for the benchmark 30% evasion, since the extensive margin effect (increased number of non evaders for increasing TCW) prevails. Total welfare is still decreasing in the TCW, although the effect is quantitatively smaller.

Changing the bargaining power of the seller β results in a different distribution of the gains from evasion, but in a similar effect of the policies on the equilibrium quantities. As for the enforcement probability, we tried a rather extreme value, $\pi = 0.3$. In this scenario, the comparative static results are qualitatively similar, except that the optimal levels of τ and ϑ that maximize the net government revenue, everything else equal, are smaller. Therefore, we concluded that enforcement is a substitute for these two policies. However, since enforcement is costless in our model, we cannot really evaluate the impact of enforcement on the government revenue and, therefore, we cannot single out the optimal enforcement level. As for the effect on welfare, we found that enforcement worsen the evaders welfare but improves the non evaders welfare, with a negative, but quantitatively small, net effect. We also considered the comparative static results with respect to the fine f. Overall, a steeper fine results in a smaller level of tax evasion and in a higher government revenue, but the quantitative effect is very small. If $f = 3$, ten times bigger than the baseline value, evasion is only 1% lower than the benchmark and the revenue only 2.5% higher.

We also relaxed the assumption of risk neutrality, assuming a CRRA utility function with a risk aversion parameter $\eta = 3$ for both sellers and buyers. The main difference with the baseline model is that, with risk aversion, we do not have anymore a corner solution with full evasion for the seller. The optimal level of tax evasion for each seller is instead:

$$e^* = \frac{(1-k)[p(1-t_s) - d - v]}{t_s(k+f)} \tag{23}$$

where

$$k = \left[\frac{\pi f}{1-\pi}\right]^{\frac{1}{\eta}}. \tag{24}$$

This implies that the evaded amount is decreasing in the level of t_s. Following an increase in the income tax rate, there is now an intensive margin effect (decreased evasion amount) that goes in the opposite direction of the extensive margin one (increased number of evaders). The result is an inverse u shape relationship: evasion is increasing in the tax rate for low levels of the income taxes, but decreasing for high rates. Apart from this difference, all other results still hold: the net government revenue has an inverse u shape, similarly to the baseline model, and the comparative statics with respect to t_b, τ and ϑ are qualitatively unchanged.

The previous results are summarized in the following proposition:

Proposition 5. *i) The larger the mass of individuals with high cost of using payment instruments alternative to cash (the smaller λ), the higher the optimal TCW rate; ii) The tax rebate and the TCW are a substitute for enforcement; iii) Risk aversion affects the response of tax evasion to the tax rate, which has now an inverse u shape, but not the other results.*

4.4 Efficiency

One potential side effect of the TCW is the reduction in the volume of trade resulting from the increased transaction costs for the buyers. In this section we study how to set the TCW to avoid this efficiency loss.

First of all, if the seller does not engage in tax evasion, his utility is simply equal to $v_s^0 = p(1-t)$, which is always positive for any $t < 1$. Therefore we do not have to worry about the effect of our policy on the sellers' willingness to supply the good or service. Indeed, our policy will only decrease the seller utility from tax evasion v_s^1 through the discount, while still leaving the payoff from not engaging in tax evasion (v_s^0) unaffected.

Conversely, the policy does affect the buyer gains from trade, both in case of collaborative tax evasion (v_b^1) and, more importantly, in case he does not collaborate (v_b^0). To guarantee that the buyer has always an incentive to trade, we must have that $v_b^0 = u - p(1-\tau) - \min\{\Upsilon, c\} \geq 0$ for any possible cost c and for any policy $\{\tau, \vartheta\}$. A sufficient condition is that $u - p(1-\tau) - \Upsilon \geq 0$ for any policy $\{\tau, \vartheta\}$. We can rewrite the condition as:

$$u - p \geq p\vartheta(1 + t_b) - p\tau \text{ for any } \{\tau, \vartheta\}. \tag{25}$$

In words, the consumer surplus must be at least equal to the difference between what the buyer pays because of the TCW and what he gets from the tax rebate. Then, a sufficient condition for any level of consumer surplus ($u \geq p$) is

$$\vartheta(1+t_b) \leq \tau. \tag{26}$$

Among the numerical exercises that we perform in the appendix, we also look at the optimal policies that satisfy this constraint.

5 Cash Tax Implementation

In this section, we discuss some challenges to the implementation of the TCW and we propose solutions to (partially) overcome them. Since the TCW is a tax on withdrawals from a bank account, either a checking or a saving account, it can be naturally implemented by banks. The bank can collect the tax from the public and then transfer the proceedings to the tax administration.

Our TCW scheme is different from the carry tax on currency described by Buiter and Panigirtzoglou (2003) and originally proposed by Gesell (1916), which consists in a lower interest rate on base money with respect to other monetary instruments. It is also different from the solution proposed by Mankiw (2009) to tax cash, which consists in a lottery based on the serial numbers of the banknotes that makes the "winners" worthless (Rogoff 2014). In what follows we focus specifically on the implementation problems strictly related to our TCW and we abstract from the problems relates to this alternative means of taxing cash.

The first, and foremost, challenge to the implementation of the TCW is the possible emergence of a parallel cash economy: the buyers might start using whatever cash they already have and the sellers might start hoarding it to pay the suppliers and the employees, which will further use the cash for their purchases and so on. To credibly implement the TCW, the government must find a way to stifle this cash economy.

A first possibility to downsize the parallel cash economy is to fix a small TCW rate, which will not justify the high costs of operating a cash economy. As already shown, even with this constraint, it is still possible to reduce tax evasion and raise additional tax revenue, although less than in the unconstrained case. A second possibility is the contemporaneous introduction of a tax on cash deposits, a ban on cash purchases of financial instruments (treasury bonds, corporate bonds or stocks) and a sanction for the individuals caught exchanging cash above a certain amount. This will lower the incentives of the sellers to accept cash because it will make more difficult to use it. Consider, for instance, a small shopkeeper that starts hoarding cash. As already mentioned, he can use it to pay the suppliers and the employees, fostering the cash economy. But he can also accumulate it and use it later, say to buy a car or for the down payment of a house, or perhaps to improve the shop in the future. The sanctions for cash transactions of big amounts are meant exactly to forbid the use of this accumulated savings. In addition, the tax on cash deposits and the ban on cash purchases of financial instruments are meant to reduce the possibility to accumulate savings, reducing their rate of return (Morse et al. 2009).

A second, related, challenge concerns the dynamic of the introduction of the tax. If the tax is announced and then implemented, it is likely that a bank run will take place, with individuals withdrawing cash to avoid paying the tax in the future. The probability associated with these scenario is higher the higher the TCW. In fact, it is unlikely that a massive bank run will take place as a consequence of a small TCW, since the cost of managing all the payments in cash will most likely be higher than the cost imposed by the tax. In addition, operating exclusively in the cash economy hampers or precludes the possibility of obtaining mortgages or even short term financing for the sellers, imposing a very high cost on them (Straub 2005, Antunes and Cavalcanti 2007, Gordon and Li 2009, Capasso and Jappelli 2013). Also, some credit card issuers already charge a small fee for ATM withdrawals, but many individuals use them anyway.

A third problem is finding a way to compensate honest taxpayers. This is a crucial element since proper compensation will boost the acceptability of the TCW. If the policy was perceived as unfair, on the other hand, it would most likely be ineffective, since it will strengthen a social norm against it (Bordignon 1993, Falkinger 1995, Torgler 2003, Slemrod 2003). We think that it is particularly challenging to design the compensations for those who have a cost of using non cash payment instruments other from banking fees, say because of psychological or cognitive conditions. A possibility would be to link a monetary compensation to observable characteristics such as old age, disability and low education.

A fourth implementation problem is specific to currency areas: to avoid arbitrage, the TCW rate should be the same in all countries or, at a minimum, not very different. The problem is that this will hamper the possibility of tailoring the policy to the specific needs of a country. One plausible argument against this objection is that the arbitrage possibilities are limited. For instance, for the individuals that typically live and work in one country only, there is not really the possibility to open a bank account in another country, or to travel across borders just to withdraw cash. Most likely, the cost of these operations, which includes travel expenses and banking fees, will reduce the gain from arbitrage, at least for a small TCW. However there still is a problem for the individuals that live close to a border, which is difficult to deal with.

6 Conclusion

We presented a model of collaborative tax evasion where a buyer negotiates a price discount with a seller in exchange for not asking the receipt and paying in cash, facilitating tax evasion. We studied how a tax rebate for the buyer and a tax on cash withdrawals affect tax evasion, government revenue and welfare. A small tax deduction can reduce tax evasion, increase government revenue and welfare and its rate must be higher the higher the tax evasion rate and the higher the statutory tax rate. The TCW is effective at reducing evasion and increasing revenue only if set sufficiently high, and its rate must be higher the higher the tax evasion rate and the larger the mass of individuals using cash. We found that an appropriate mix of tax rebates and TCW can curb tax evasion while, at the same time, raising additional revenue and increasing aggregate welfare. However, there is a limit to the additional amount of revenue that can be raised without a welfare or efficiency loss. The additional revenue generated by this policy can be partly used to subsidize the use of non cash payment instruments, to avoid imposing individual costs to buyers and sellers and, therefore, fostering public support. To avoid the emergence of a parallel cash economy, we proposed to select a mix of tax rebates and TCW with a low rate of the latter, which entails a lower revenue with respect to the optimal unconstrained policy, but that can still reduce tax evasion.

In other words an abrupt and forced move towards a cashless economy, realized also with a tax on cash withdrawals, seems an effective way to increase revenue and fight tax evasion.

Alternatively, one could also enforce a ban on cash transactions to reduce the use of cash, as suggested in Buiter (2009), perhaps establishing a very low threshold value below which it is permitted to use cash. However, this alternative has many drawbacks: first, because it would be costly to enforce the ban; second, it would entail a generalized loss of privacy; third, imposing the use of credit cards, cheques or bank transfers, even for transactions of small amount, can be too cumbersome and might reduce the number of transactions. In this perspective, the TCW can be seen as putting a price on privacy and transaction ease: it allows to use non-traceable payment instruments to ensure privacy or to speed up the transaction, but transfers to the users the costs of these benefits.

A less obvious possibility consists in supporting an explicit cost-based pricing of payment instruments. Van Hove (2004) argues that, under current pricing schemes, the use of cash is not discouraged, since the fees charged to consumers for making cash withdrawals do not cover the full cost, which is recovered through cross-subsidization. "In this way, infrequent cash-users *de facto* subsidize those who make heavy use of cash (including those active in the underground economy) Van Hove, 2004, p.80". We consider the remedy proposed by Van Hove, that is the substitution of fees per account with fees per transaction, as a tool to reduce evasion complementary to a TCW.

Buiter (2009) proposes an alternative way to reduce the use of currency: the introduction of two different currencies, one that has the numeraire function and another that has the medium of exchange function, with a variable exchange rate between the two. However this alternative solution, although theoretically appealing, is extremely difficult to implement, because it is cumbersome to quote prices in a different currency from the one currently used for transactions.

The substitution of paper currency with electronic currency, which is one of the potential effects of the introduction of our TCW, beside the benefits of a reduced tax evasion and of a potentially more effective monetary policy, has also several costs, as discussed in Rogoff (2014): a potential decline in the demand for debt, more volatile inflation expectations and a system of payments more vulnerable to cyber attacks, power blackouts etc. In this respect our analysis is incomplete, since we considered just a limited sets of costs and benefits of the introduction of the TCW.

Appendices not for publication

A Proofs

Proof of Proposition 1: The amount of tax evasion is increasing in the tax t_s:

$$\frac{\partial E}{\partial t_s} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial t_s} g_c dc + (1 - G_c(\Upsilon)) \frac{\partial E^c}{\partial t_s} > 0 \tag{27}$$

since

$$\frac{\partial E_c(c)}{\partial t_s} = \int_0^{\tilde{\upsilon}_1} g_s(\tilde{s}_1(\upsilon, c))p(1 - \pi(1 + f_s))(1 + \vartheta)g_\upsilon d\upsilon \tag{28}$$

and

$$\frac{\partial E^c}{\partial t_s} = \int_0^{\tilde{\upsilon}_2} g_s(\tilde{s}_2(\upsilon))p(1 - \pi(1 + f_s))(1 + \vartheta)g_\upsilon d\upsilon. \tag{29}$$

are both positive. The same is true for an increase in the sale tax t_b:

$$\frac{\partial E}{\partial t_b} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial t_b} g_c dc + (1 - G_c(\Upsilon))\frac{\partial E^c}{\partial t_b} > 0 \tag{30}$$

since

$$\frac{\partial E_c(c)}{\partial t_b} = \int_0^{\tilde{\upsilon}_1} g_s(\tilde{s}_1(\upsilon, c))p(1 - \pi(1 + f_b))g_\upsilon d\upsilon \tag{31}$$

and

$$\frac{\partial E^c}{\partial t_b} = \int_0^{\tilde{\upsilon}_2} g_s(\tilde{s}_2(\upsilon))p[1 - \pi(1 + f_b)]g_\upsilon d\upsilon \tag{32}$$

are both positive. For the effect of the tax deduction on evasion, we have:

$$\frac{\partial E}{\partial \tau} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial \tau} g_c dc + (1 - G_c(\Upsilon))\frac{\partial E^c}{\partial \tau} < 0 \tag{33}$$

since

$$\frac{\partial E_c(c)}{\partial \tau} = -\int_0^{\tilde{\upsilon}_1} p g_s(\tilde{s}_1(\upsilon, c))g_\upsilon \, d\upsilon \tag{34}$$

and

$$\frac{\partial E^c}{\partial \tau} = -\int_0^{\tilde{\upsilon}_2} p g_s(\tilde{s}_2(\upsilon))g_\upsilon \, d\upsilon \tag{35}$$

are both negative. The effect of the TCW ϑ on the total amount of evasion was studied in the main text.

Proof of Proposition 2: We rewrite (15) as:

$$W = \int_0^{\Upsilon}((v_s^0+v_b^0)+\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}((v_s^1-v_s^0)+(v_b^1-v_b^0))g_s ds)g_\upsilon d\upsilon)g_c dc + \tag{36}$$
$$(1-G_c(\Upsilon))((v_s^0+v_b^0)+\int_0^{\tilde{\upsilon}_2}\int_0^{\tilde{s}_2(\upsilon)}((v_s^1-v_s^0)+(v_b^1-v_b^0))g_s ds g_\upsilon d\upsilon).$$

Define with $R_{hc} = v_s^0 + v_b^0$ the total utility of those non evaders agents who have a low c and with $R_h^c = v_s^0 + v_b^0$ the same utility but for agents with high c. Moreover, define with $\Delta R_{dc} = (v_s^1 - v_s^0) + (v_b^1 - v_b^0)$ the increase in utility from evading taxes both for sellers and buyers with low c and with $\Delta R_d^c = (v_s^1 - v_s^0) + (v_b^1 - v_b^0)$ the same increase in utility for agents with high c. Then, the derivative of total welfare with respect to t_s is:

$$\int_0^{\Upsilon}(-p+\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\frac{\partial \Delta R_{dc}}{\partial t_s}g_s ds + \Delta R_{dc}(\tilde{s}_1(\upsilon,c))g_s(\tilde{s}_1(\upsilon,c))\frac{\partial \tilde{s}_1(\upsilon,c)}{\partial t_s})g_\upsilon d\upsilon)g_c dc + \tag{37}$$
$$(1-G_c(\Upsilon))(-p+\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\frac{\partial \Delta R_d^c}{\partial t_s}g_s ds + \Delta R_d^c(\tilde{s}_2(\upsilon))g_s(\tilde{s}_2(\upsilon))\frac{\partial \tilde{s}_2(\upsilon)}{\partial t_s})g_\upsilon d\upsilon) +$$
$$(1-\beta)p(1-\pi(1+f_s))\vartheta E.$$

Notice that $\frac{\partial \Delta R_{dc}}{\partial t_s} = \frac{\partial \Delta R_d^c}{\partial t_s} = p(1-\pi(1+f_s))$ and $\Delta R_{dc}(\tilde{s}_1(\upsilon,c)) = \Delta R_d^c(\tilde{s}_2(\upsilon)) = 0$. The latter is true since by definition $\tilde{s}_1(\upsilon,c)$ is such that all the buyers of type $c \leq \Upsilon$, with a tax morale lower than $\tilde{s}_1(\upsilon,c)$, cooperate and $v_b^1 = v_b^0(\tilde{s}_1(\upsilon,c))$. Then, $\Delta R_{dc}(\tilde{s}_1(\upsilon,c)) = v_s^1 - v_s^0 = pt_s(\pi(1+f_s)-1) - d^*(\upsilon,s,c) - \upsilon$. By substituting $d^*(\upsilon,s,c)$ from (7) it is easy to check that $\Delta R_{dc}(\tilde{s}_1(\upsilon,c)) = 0$. A similar reasoning proves that $\Delta R_d^c(\tilde{s}_2(\upsilon)) = 0$. Then, expression (37) can be rewritten as:

$$\frac{\partial W}{\partial t_s} = -p + p(1-\pi(1+f_s))E + \vartheta(1-\beta)p(1-\pi(1+f_s))E, \tag{38}$$

which is negative for $\vartheta = 0$. Similarly, the derivative of total welfare with respect to t_b is:

$$\int_0^{\Upsilon}(-p+\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\frac{\partial\Delta R_{dc}}{\partial t_b}g_s ds+\Delta R_{dc}(\tilde{s}_1(\upsilon,c))g_s(\tilde{s}_1(\upsilon,c))\frac{\partial\tilde{s}_1(\upsilon,c)}{\partial t_b})g_\upsilon d\upsilon)g_c dc+ \quad (39)$$
$$(1-G_c(\Upsilon))(-p-p\vartheta+\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\frac{\partial\Delta R_d^c}{\partial t_b}g_s ds+\Delta R_d^c(\tilde{s}_2(\upsilon))g_s(\tilde{s}_2(\upsilon))\frac{\partial\tilde{s}_2(\upsilon)}{\partial t_b})g_\upsilon d\upsilon)+$$
$$g_c(\Upsilon)p\vartheta(u-p(t_s+t_b-\tau)+\Upsilon+\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\Delta R_{dc}(p(1+t_b)\vartheta)g_s ds)g_\upsilon d\upsilon)+$$
$$-g_c(\Upsilon)p\vartheta(u-p(t_s+t_b-\tau+\Upsilon+\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\Delta R_d^c g_s ds)g_\upsilon d\upsilon)+$$
$$-\frac{\vartheta\beta p}{1+\vartheta}((1-\pi\,(1+f_s))E+(1-G_c(\Upsilon))\vartheta E^c).$$

Notice that: $\frac{\partial\Delta R_{dc}}{\partial t_b}=\frac{\partial\Delta R_d^c}{\partial t_b}=p(1-\pi\,(1+f_b))$ and evaluated at $c=\Upsilon$ we have that $\Delta R_{dc}(\Upsilon)=\Delta R_d^c$. The latter also implies that $\tilde{s}_1(\upsilon,c)=\tilde{s}_2(\upsilon)$ and $\tilde{\upsilon}_1=\tilde{\upsilon}_2$. Then, expression (39) can be rewritten as:

$$\frac{\partial W}{\partial t_b}=-p(1+(1-G_c(\Upsilon))\vartheta)+p(1-\pi(1+f_b))E-\frac{\vartheta\beta p}{1+\vartheta}\left\{(1-\pi\,(1+f_s))E+(1-G_c(\Upsilon))\vartheta E^c\right\}, \quad (40)$$

which is negative for $\vartheta=0$. For the rebate we have:

$$\int_0^{\Upsilon}(p+\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\frac{\partial\Delta R_{dc}}{\partial\tau}g_s ds+\Delta R_{dc}(\tilde{s}_1(\upsilon,c))g_s(\tilde{s}_1(\upsilon,c))\frac{\partial\tilde{s}_1(\upsilon,c)}{\partial t_s})g_\upsilon d\upsilon)g_c dc+ \quad (41)$$
$$(1-G_c(\Upsilon))(p+\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\frac{\partial\Delta R_d^c}{\partial\tau}g_s ds+\Delta R_d^c(\tilde{s}_2(\upsilon))g_s(\tilde{s}_2(\upsilon))\frac{\partial\tilde{s}_2(\upsilon)}{\partial t_s})g_\upsilon d\upsilon)+\frac{\vartheta\beta p}{1+\vartheta}E.$$

Noticing that $\frac{\partial\Delta R_{dc}}{\partial\tau}=\frac{\partial\Delta R_d^c}{\partial\tau}=-p$ we can rewrite (41) as:

$$\frac{\partial W}{\partial\tau}=p-pE+\frac{\vartheta\beta p}{1+\vartheta}E, \quad (42)$$

which is always positive. Finally, for the effect of the TCW on welfare we have:

$$
\begin{aligned}
&\int_0^{\Upsilon}(\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\frac{\partial\Delta R_{dc}}{\partial\vartheta}g_s ds+\Delta R_{dc}(\tilde{s}_1(\upsilon,c))g_s(\tilde{s}_1(\upsilon,c))\frac{\partial\tilde{s}_1(\upsilon,c)}{\partial t_b})g_\upsilon d\upsilon)g_c dc+ \\
&(1-G_c(\Upsilon))(-p(1+t_b)+\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\frac{\partial\Delta R_d^c}{\partial\vartheta}g_s ds+\Delta R_d^c(\tilde{s}_2(\upsilon))g_s(\tilde{s}_2(\upsilon))\frac{\partial\tilde{s}_2(\upsilon)}{\partial t_b})g_\upsilon d\upsilon)+ \\
&g_c(\Upsilon)p(1+t_b)(u-p(t_s+t_b-\tau)-\Upsilon+\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\Delta R_{dc}(p(1+t_b)\vartheta)g_s ds)g_\upsilon d\upsilon)+ \\
&-g_c(\Upsilon)p(1+t_b)(u-p(t_s+t_b-\tau)-\Upsilon+\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\Delta R_d^c g_s ds)g_\upsilon d\upsilon)+ \\
&\int_0^{\Upsilon}(\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\vartheta\frac{\partial d^*(v,s,c)}{\partial\vartheta}g_s ds)g_\upsilon d\upsilon)g_c dc+(1-G_c(\Upsilon))\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\vartheta\frac{\partial d^*(v,s)}{\partial\vartheta}g_s ds)g_\upsilon d\upsilon.
\end{aligned} \tag{43}
$$

where

$$\frac{\partial d^*(v,s)}{\partial\vartheta}=-\beta\frac{p\tau+\pi p t_b\,(1+f_b)+s}{(1+\vartheta)^2}<0 \tag{44}$$

and

$$\frac{\partial d^*(v,s,c)}{\partial\vartheta}=\beta\frac{p-p\tau+pt_b(1-\pi(1+f_b))-s+c}{(1+\vartheta)^2}>0 \tag{45}$$

since $s<p-p\tau+pt_b(1-\pi(1+f_b))+c$.[13] Moreover, $\frac{\partial\Delta R_{dc}}{\partial\vartheta}=-(p-d^*(v,s,c))$ while $\frac{\partial\Delta R_d^c}{\partial\vartheta}=-(p-d^*(v,s))+p(1+t_b)$. Summing up (43) can be rewritten as:

$$
\begin{aligned}
\frac{\partial W}{\partial\vartheta} \;=\; &-(1-G_c(\Upsilon))p(1+t_b)+ \\
&-\int_0^{\Upsilon}(\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}(p-d^*(v,s,c))g_s ds)g_\upsilon d\upsilon)g_c dc+ \\
&(1-G_c(\Upsilon)\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}(d^*(v,s)+pt_b)g_s ds)g_\upsilon d\upsilon+ \\
&\int_0^{\Upsilon}(\int_0^{\tilde{\upsilon}_1}(\int_0^{\tilde{s}_1(\upsilon,c)}\vartheta\frac{\partial d^*(v,s,c)}{\partial\vartheta}g_s ds)g_\upsilon d\upsilon)g_c dc+ \\
&(1-G_c(\Upsilon))\int_0^{\tilde{\upsilon}_2}(\int_0^{\tilde{s}_2(\upsilon)}\vartheta\frac{\partial d^*(v,s)}{\partial\vartheta}g_s ds)g_\upsilon d\upsilon,
\end{aligned} \tag{46}
$$

[13] From condition (9), we know that, in order to have tax evasion, s must be smaller than $d^*(v,s,c)(1+\vartheta)-p(\tau+\vartheta+t_b)-\pi pt_b(1+f_b)+\min\{\Upsilon,c\}$. Then, we can show that $p-p\tau+pt_b(1-\pi(1+f_b))+c$ is larger than $d^*(v,s,c)(1+\vartheta)-p(\tau+\vartheta+t_b)-\pi pt_b(1+f_b)+\min\{\Upsilon,c\}$ (which is larger than s) or equivalently that $d^*(v,s,c)(1+\vartheta)-p\vartheta+\min\{\Upsilon,c\}<p+c$. This is always true. Indeed, if $\min\{\Upsilon,c\}=c$ we have $d^*(v,s,c)(1+\vartheta)<p(1+\vartheta)$. If, instead, $\min\{\Upsilon,c\}=\Upsilon$ we have $d^*(v,s,c)(1+\vartheta)+\Upsilon<p(1+\vartheta)+c$.

whose sign is ambiguous.

Proof of Proposition 3: Define $R_c = pt_s(\pi(1+f_s)-1)+pt_b(\pi(1+f_b)-1)+(p-d^*(v,s,c))\vartheta+p\tau$ and $R^c = pt_s(\pi(1+f_s)-1)+pt_b(\pi(1+f_b)-1)+(p-d^*(v,s))\vartheta+p\tau-\Upsilon$. Then, the derivative of the net government revenue with respect to t_s is:

$$\begin{aligned}\frac{\partial G_n}{\partial t_s} &= \int_0^{\Upsilon} R_c \frac{\partial E_c(c)}{\partial t_s} g_c dc + (1-G_c(\Upsilon))R^c \frac{\partial E^c}{\partial t_s} + p\pi(1+f_s)E + \\ &\quad + p(1-E) - (1-\beta)p(1-\pi(1+f_s))\vartheta E + \int_0^{\Upsilon} c\frac{\partial E_c(c)}{\partial t_s} g_c dc.\end{aligned} \tag{47}$$

The first and second term (the extensive margin) show that a higher tax rate t_s increases the mass of evaders (28 and 29). This effect on revenue is ambiguous, except if $\tau = \vartheta = t_b = 0$, in which case the effect is negative, since $R_c = R^c = pt_s(\pi(1+f_s)-1) < 0$. The third and fourth term (the intensive margin) measure the increase in revenue due to the increase in the tax rate, both for evaders and non evaders. The fifth term is the decrease in revenue from the TCW, since an increase in t_s increases the equilibrium discount. The last term measures the decrease in the cost imposed on those non collaborative buyers who opt for non cash payments. If $\tau = \vartheta = t_b = 0$, only the first four effects are left. Moreover, when t_s is low, the first two negative terms are small, while the third and fourth terms are large; in this case, an increase in t_s increases the revenue. The opposite happens if t_s is high. We have a standard Laffer curve type of result.

Similarly the derivative of net government revenue with respect to t_b is:

$$\begin{aligned}\frac{\partial G_n}{\partial t_b} &= \int_0^{\Upsilon} R_c \frac{\partial E_c(c)}{\partial t_b} g_c dc + (1-G_c(\Upsilon))R^c \frac{\partial E^c}{\partial t_b} + p\pi(1+f_b)E + \\ &\quad \int_0^{\Upsilon} p(1-E_c(c))g_c dc + (1-G_c(\Upsilon))p(1+\vartheta)(1-E^c) + \\ &\quad \frac{\beta\vartheta p}{1+\vartheta}(1-\pi(1+f_b)) \int_0^{\Upsilon} E_c(c) g_c dc + \frac{\beta\vartheta p}{1+\vartheta}(1-\pi(1+f_b)+\vartheta)(1-G_c(\Upsilon))E^c + \\ &\quad \int_0^{\Upsilon} c\frac{\partial E_c(c)}{\partial t_b} g_c dc - \Upsilon(1-E_c(\Upsilon))g_c(\Upsilon)p\vartheta + \\ &\quad g_c(\Upsilon)p\vartheta(R_c(\Upsilon)E_c(\Upsilon) + p(t_s+t_b-\tau) - R^c E^c - p(t_s+t_b-\tau) - \Upsilon(1-E^c)).\end{aligned} \tag{48}$$

Again a higher tax rate t_b increases the mass of evaders (first and second term). This effect on revenue is ambiguous, except if $\tau = \vartheta = t_b = 0$, in which case the effect is negative, since

$R_c = R^c = pt_b(\pi(1+f_b)-1) < 0$. The third, fourth and fifth term (the intensive margin) measure the increase in revenue due to the increase in the tax rate, both for evaders (third) and non evaders (fourth and fifth). The sixth and seventh term measure the increase in revenue from the TCW: differently from the tax on the seller an increase in t_b decreases the equilibrium discount. The eighth and ninth term measure the change in the cost imposed on those non collaborative buyers who opt for non cash payments. Finally, since (in $c = \Upsilon$) $R_c(\Upsilon) = R^c$ and $E_c(\Upsilon) = E^c$,the last term, that measures the decrease in revenue from the TCW due to the decrease in the mass of non collaborative buyers using cash, simplifies to $-\Upsilon(1-E_c(\Upsilon))g_c(\Upsilon)p\vartheta$. If $\tau = \vartheta = t_s = 0$, only first, second, third and fifth term are left. Moreover, when t_b is low, the first two negative terms are small, while the third and fifth term are large; in this case, an increase in t_b increases the revenue. The opposite happens if t_b is high. Again we have a standard Laffer curve type of result.

For the rebate we have:

$$\begin{aligned}\frac{\partial G_n}{\partial \tau} &= \int_0^{\Upsilon} R_c \frac{\partial E_c(c)}{\partial \tau} g_c dc + (1-G_c(\Upsilon))R^c \frac{\partial E^c}{\partial \tau} + \\ & \quad 0 - p(1-E) - \frac{\beta p \vartheta}{1+\vartheta} E + \int_0^{\Upsilon} c \frac{\partial E_c(c)}{\partial \tau} g_c dc.\end{aligned} \tag{49}$$

An increase in τ decreases the mass of evaders (first and second term) with an ambiguous effect on revenue unless t_s and t_b are sufficiently high, in which case the effect is positive. There is no effect of an increase of τ on evaders (third term) and a negative effect on the revenue from non evaders (fourth term). Moreover, an increase in τ decreases the revenue from the TCW, as a consequence of a higher equilibrium discount (fifth term), and increases the cost imposed on non collaborative buyers who opt for non cash payments (last term). In other words, low statutory taxes, a large mass of honest individuals $(1-E)$ and an high TCW are all factors that can make a tax rebate undesirable. For the effect of the TCW on revenue we have:

$$\begin{aligned}
\frac{\partial G_n}{\partial \vartheta} \quad = \quad & \int_0^{\Upsilon} R_c \frac{\partial E_c(c)}{\partial \vartheta} g_c dc + (1 - G_c(\Upsilon)) R^c \frac{\partial E^c}{\partial \vartheta} + \\
& \int_0^{\Upsilon} (p - d^*(v, s, c)) E_c(c) g_c dc + (1 - G_c(\Upsilon))(p - d^*(v, s)) E^c + \\
& p(1 + t_b)(1 - G_c(\Upsilon))(1 - E^c) + \\
& -\vartheta \int_0^{\Upsilon} \frac{\partial d^*(v, s, c)}{\partial \vartheta} E_c(c) g_c dc - \vartheta (1 - G_c(\Upsilon)) \frac{\partial d^*(v, s)}{\partial \vartheta} E^c + \\
& \int_0^{\Upsilon} c \frac{\partial E_c(c)}{\partial \vartheta} g_c dc - \Upsilon (1 - E_c(\Upsilon)) g_c(\Upsilon) p(1 + t_b) + \\
& g_c(\Upsilon) p(1 + t_b)(R_c(\Upsilon) E_c(\Upsilon) + p(t_s + t_b - \tau) - R^c E^c - p(t_s + t_b - \tau) - \Upsilon (1 - E^c)).
\end{aligned} \tag{50}$$

The comparative statics with respect to ϑ is quite complicated since an increase in ϑ increases the mass of evaders with high c (14) and decreases the mass of evaders with low c (13). An increase in ϑ also increases the revenue at the intensive margin, both from evaders (third and fourth term) and non-evaders (fifth term). Moreover, it increases the discount for evaders with high c (sixth term see 45) and decreases the discount for evaders with low c (seventh term see 44). The eigth and ninth term measure the increase in the cost imposed on non collaborative buyers who opt for non cash payments. Finally, the last term, which simplifies to $-\Upsilon(1 - E_c(\Upsilon)) g_c(\Upsilon) p(1 + t_b)$, measures the decrease in revenue from the TCW due to the decrease in the mass of non collaborative buyers using cash. We conclude that the effect of the TCW on government revenue is ambiguous.

B Optimal Policy

In this section we look numerically at the optimal policy, considering two different policy objectives. Following the economic literature on optimal taxation, the first objective is the maximization of total welfare subject to keeping the government revenue above a certain level. In addition, since one of the main goals of fighting tax evasion is to increase the tax proceedings, we also consider the maximization of net government revenue. However, as noted by Slemrod and Yitzhaki (1987), the social benefit of a tax evasion reduction is not well measured by the tax revenue increases only. Additional benefits include, among others, reduced risk bearing, increased efficiency and better competition among businesses. Therefore we add a further constraint to this second objective: we consider the maximization of net government revenue conditional on keeping tax evasion below 1%. We call this policy objective maximin, since it entails a maximization of the net revenue and a simultaneous minimization of tax evasion.

For both policy exercises, we stress the gain in gross government revenue and welfare with respect to the corresponding benchmark with fixed tax rates, no tax rebates and no TCW. Notice that this gives an idea of the possibility of the government to compensate honest taxpayers for the side effects introduced by the TCW, which we discuss later. In what follows, we summarize the optimal policy for the benchmark prototype economy. In the next section we also propose an example of the optimal policy for a real world country, Italy. A caveat before proceeding to the exercises: here we pick some numbers, but we only think of them as suggestive of the optimal policy. In other words, we want to highlight the direction of the optimal policy (reduce the rates, keep them low etc.) rather then a very precise value of the policy variables that we suggest implementing.

In the next subsection we look at the optimal policy for the benchmark prototype economy. In subsection B.2 we look instead at a real world country, Italy.

B.1 Optimal Policy: the Prototype Economy

The welfare maximizing policy subject to keeping revenue at least as high as in the benchmark entails increasing the income tax rate, decreasing the sale tax rate, a high tax rebate and a small TCW rate, $t_s = 35\%$, $t_b = 7.5\%$, $\tau = 16\%$ and $\vartheta = 2\%$. The level of tax evasion corresponding to this policy is below one percent, total welfare is 9.5% bigger and the non evaders welfare 59% bigger. If we consider the welfare maximizing policy that increases the gross revenue by 20% above the benchmark, we end up with $t_s = 35\%$, $t_b = 5\%$, $\tau = 11\%$ and $\vartheta = 7\%$. In this case tax evasion is 1.5%, while total welfare is 4% bigger than the benchmark and non evaders welfare is 50% bigger. Thus it is possible to fight tax evasion and also raise an additional amount of government revenue while, at the same time, increasing total welfare.

The optimal policy to maximize net revenue conditional on keeping evasion below one percent entails lowering both tax rates, $t_s = 25\%$, $t_b = 5\%$, a small tax rebate $\tau = 2\%$ and a big TCW $\vartheta = 18\%$. For this policy the gross revenue is 38% bigger than the benchmark: tax evasion can be almost eliminated while generating an hefty amount of extra tax revenue. Total welfare, however, is 2.7% smaller than the benchmark, although non evaders welfare is 40% bigger: evaders will lose at this policy, while non evaders will gain substantially. We also consider the optimal maximin policy that entails no loss of efficiency, imposing condition (26). The result is $t_s = 30\%$, $t_b = 12.5\%$, $\tau = 16\%$, and $\vartheta = 14\%$. The gain in gross government revenue is 26%, total welfare is 1.8% bigger than the benchmark and non evaders welfare is 47% bigger. In this case is possible to both fight tax evasion and raise more than 25% more government revenue without any welfare cost and without any loss of efficiency. However, it is not possible to raise more than this amount without either an efficiency loss or an aggregate welfare loss.

We also look at the optimal policy when fixing the tax rates at their benchmark levels or, in other words, when the government can freely adjust only the tax rebate and the TCW. The motivation behind this further exercise is that, since we are considering an extremely stylized microeconomic model, we are not able to capture all the possible micro and macroeconomic effects of a change in the tax rate. The policy that maximizes welfare subject to keeping gross revenue at least as high as in the benchmark entails $\tau = 14\%$ and $\vartheta = 3\%$, with evasion below one percent, a 9% bigger total welfare and a 58% bigger non evaders welfare. If we slightly change the constraint and consider the welfare maximizing policy conditional on increasing the government revenue by 20%, we obtain $\tau = 11\%$ and $\vartheta = 7\%$. The tax evasion rate at this policy is around 1%, total welfare is 3.8% bigger than the benchmark and non evaders welfare is 49% bigger.

The optimal maximin policy for fixed taxes is instead $\tau = 13\%$ and $\vartheta = 14\%$. At this policy the government revenue is 27% bigger than the benchmark and total welfare is 1% higher, with a 46% bigger non evaders welfare. This maximin policy entails a potential loss of efficiency, since condition (26) is not satisfied. Imposing this further constraint, we find that the optimal policy is $\tau = 13\%$ and $\vartheta = 10\%$, with a 20% bigger government revenue, a 3.8% bigger total welfare and a 50% bigger non evaders welfare.

The following proposition summarizes the main result of this exercise:

Proposition 6. *An appropriate mix of tax rebate and tax on cash can curb tax evasion and raise additional tax revenue while, at the same time, increasing welfare. Moreover, there is a limit to the amount of revenue that can be raised without any loss in efficiency and welfare.*

In all the previous numerical exercises, we abstracted from all the issues associated with the implementation of the policies. The problem is that the maximin policy entail a fairly big value of the TCW, which is arguably difficult to implement, and the more difficult the higher its rate (see Section 5 for a discussion). Therefore we perform an additional exercise: we look for the maximin policy conditional on keeping the TCW rate below 5%. For fixed tax rates, we end up with $\tau = 12\%$ and $\vartheta = 5\%$, with a 12% bigger revenue, a 6% bigger total welfare and a 53% bigger non evaders welfare. Using also the tax rates, we found the optimal policy to be $t_s = 20\%$, $t_b = 15\%$, $\tau = 6\%$ and $\vartheta = 5\%$, with a 16% bigger government revenue, a 5% bigger total welfare and a 51% bigger non evaders welfare. For both policies the constraint on the TCW and the efficiency constraint are binding. The conclusion is that Proposition 6 still holds with a upper bound to the TCW with the only difference of a lower amount of additional tax revenue that can be raised without welfare or efficiency losses.

B.2 Optimal Policy: the Case of Italy

In this section we provide an example of the optimal policy for a real world country, Italy. For the income tax rate we choose $t_s = 0.35$, which is a (rounded) weighted average of the different rates with weights equal to the percentage of income in the bracket. We also set sale tax to $t_b = 0.2$, which was the main VAT rate in Italy before 2011 (raised to 22% in 2013). For the distribution of the cost of payment instruments other than cash c, we consider data on payment instruments from the ECB (gathered through the national central banks). We divide the sum of all transactions made with credit cards and debit cards by the consumption component of GDP (goods, including durable, and services). We obtain $\lambda = 0.127$. We stick to the assumption of $\beta = 0.5$ and to $p = 10$ and $u = 1.5p$.

For the enforcement probability π, we divide the number of tax audits made in 2011 by the "Guardia di Finanza", the main tax enforcement authority in Italy, by the number of economic units (firms, entrepreneurs, individual professionals) operating in Italy in 2011. There are two kinds of audits implemented by this tax enforcement authority: a more in-depth one, which is less frequent but that detects evasion with certainty (a careful screening of all the fiscal documents, together with a detailed analysis of the economic activity) and a more superficial one, much more frequent but less effective (a simple spot control where the agents monitor the day to day activity and step in if there is a violation). In the first case we have $\pi = 0.0067$ while in the second $\pi = 0.172$. We present the results for the first value and we assume that all audits are random and independent from sellers subjective characteristics. While this is certainly true for the spot controls, it is not for the more thorough controls, which are typically the final step of some monitoring activity that takes into account the business characteristics, also based on the past tax reports. For the fine we use the value $f = 0.3$ according to the Italian tax law that prescribes a fine from 6% to 30% to be paid on the evaded amount. In Italy, tax evasion is also subject to jail sentences, in addition to the fines, but only in extreme cases (very high amount), which makes them extremely unlikely. Thus we focus on pecuniary fines only.

To calibrate the model, we need a target value for tax evasion and we need a shape of the distribution of the tax morale to match. For the tax morale we take the values from the WWS website. For tax evasion, we consider two different sources. The first is the Study by EURES (2012), an Italian independent research institute. Total tax evasion in Italy is estimated to be between 16.3% and 17.5% of the GDP. Both numbers are obtained averaging over different sectors (32.8% agriculture, 12.4% Industry and between 20% and 27% for services) and across different geographic areas. The other source is the ISTAT, the Italian statistical institute, that reports an average of 12.7%, also obtained averaging over different sectors (22% agriculture, 6% industry, 11% construction, 14% services) and geographic areas (9% North, 11% center, 20% South). We set our benchmark close to the average of the two numbers at 15%.

For the 15% benchmark tax evasion level, we end up with $b = 1$ and $a = 5.87$ and $\bar{s} = \bar{\upsilon} = 3.451$.

The optimal welfare maximizing policy for Italy conditional on keeping gross revenue at least as high as in the benchmark entails an unchanged vat tax rate $t_b = 20\%$, a smaller income tax rate $t_s = 25\%$, a small tax rebate $\tau = 4\%$ and a small TCW rate $\vartheta = 6\%$. Tax evasion is below one percent at this policy, total welfare is 7% bigger and non evaders welfare is 28% bigger. The optimal welfare maximizing policy conditional on raising at least 20% revenue more than the benchmark entails the same tax rates but $\tau = 1\%$ and $\vartheta = 16\%$. The tax evasion rate at this policy is equal to 1.7%, but total welfare is 4% smaller than the benchmark and non evaders welfare 12% bigger. In case the constraint on the additional revenue to be raised is 10% instead of 20%, we found that it is possible to reduce evasion at 1%, raise 10% more revenue and increase total welfare by 2%

fixing $t_s = 25\%$, $t_b = 22.5\%$, $\tau = 4\%$ and $\vartheta = 9\%$. In other words, Proposition 6 still holds for Italy, although the amount of extra government revenue that it is possible to raise without any welfare cost is more limited than in the prototype economy. This last policy, however, does not satisfy the efficiency constraint. If we add it, we find that the optimal welfare maximizing policy that raise 10% more revenue is $t_s = 35\%$, $t_b = 22.5\%$, $\tau = 16\%$ and $\vartheta = 12\%$, with a 1.7% total welfare gain and a 19% non evaders welfare gain.

The optimal maximin policy for Italy entails a reduction in both tax rates, $t_s = 25\%$ and $t_b = 17.5\%$, a small tax rebate, $\tau = 2\%$ and a high TCW rate, $\vartheta = 23\%$. At this policy the revenue is 20% bigger than the benchmark, total welfare 5% smaller and non evaders welfare 12% bigger. Imposing the efficiency constraint, the optimal maximin policy entails keeping the tax rates fixed, $\tau = 15\%$ and $\vartheta = 12\%$, with a 7% increase in revenue and a 3% bigger total welfare and a 22% bigger non evaders welfare. We conclude that, in the case of Italy, it is not possible to eliminate tax evasion and raise a lot of extra revenue, in excess of around 10%, without a cost in terms of total welfare.

Fixing the tax rates, the policy that maximizes total welfare conditional on raising as much revenue as in the benchmark is $\tau = 16\%$ and $\vartheta = 9\%$, with an almost 8% gain in total welfare and tax evasion below 1%. If we consider a 20% higher target for the revenue, the optimal welfare maximizing policy for fixed taxes is $\tau = 7\%$ and $\vartheta = 13\%$. At this policy the tax evasion is 6%, total welfare is 5% smaller than the benchmark and non evaders welfare 6% bigger. Looking at the second policy objective, the maximin, the optimal policy for fixed taxes entails $\tau = 16\% = \vartheta$, with a 10% bigger government revenue, a 1% bigger total welfare and a 20% bigger non evaders welfare.

If the maximum feasible cash tax rate is 5%, the optimal welfare maximizing policy that raises at least 10% more revenue is $t_s = 25\%$, $t_b = 25\%$, $\tau = 1\%$ and $\vartheta = 4\%$, with a 3.5% evasion rate, a 2% bigger total welfare and a 19% bigger non evaders welfare. The optimal maximin policy is instead $t_b = 0.25$, $t_s = 22.5\%$ and $\tau = \vartheta = 5\%$, with a 1% bigger gross revenue, a 7% bigger total welfare a 27% bigger non evaders welfare. Therefore, even if it is unfeasible to have high TCW rates, it is still possible to reduce tax evasion and raise a small amount of additional tax revenue without welfare costs, although it looks like a high TCW rate above 5% is important to raise revenue.

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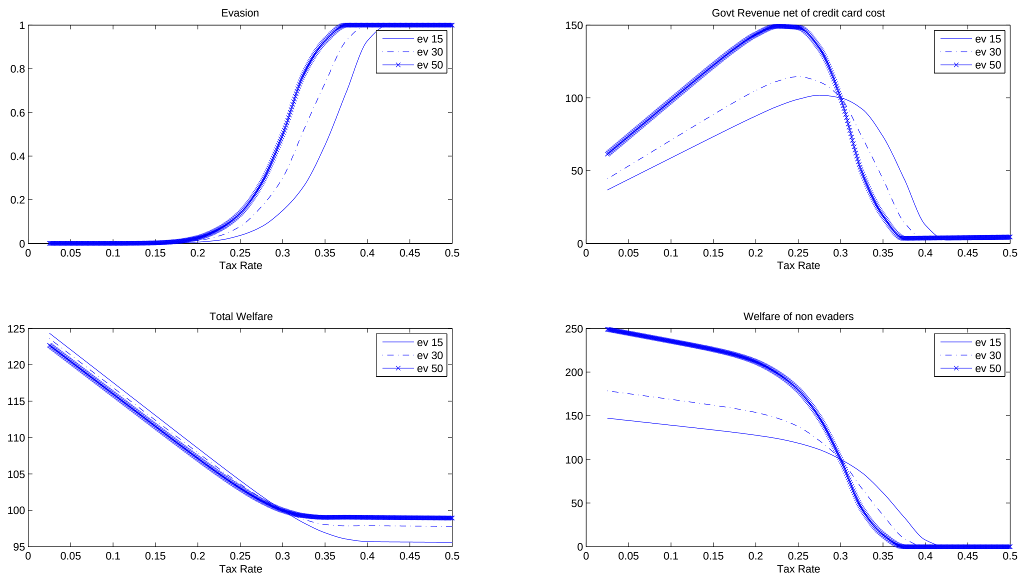
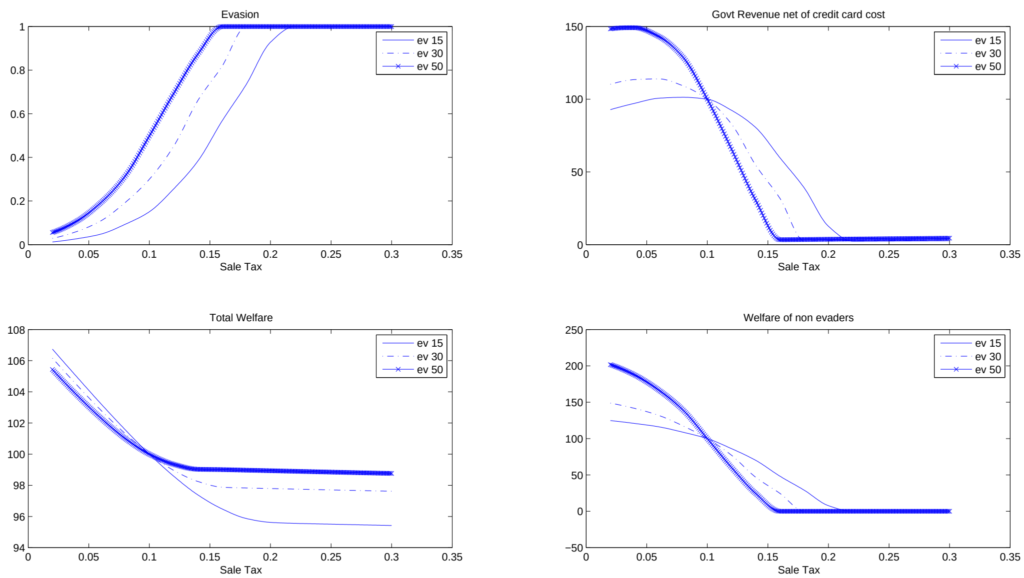
Figure 1: **Effect of Income Tax**



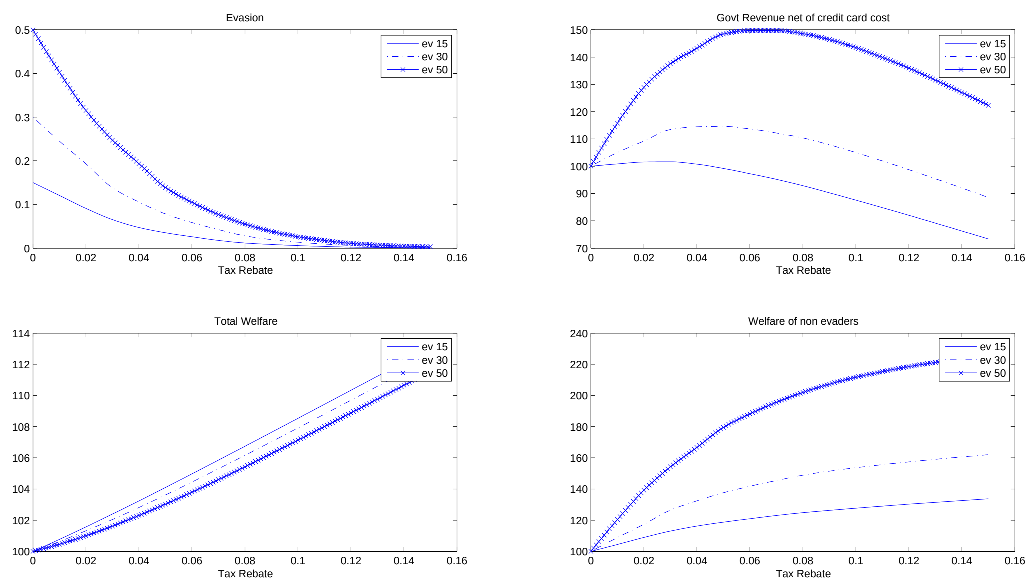
Notes: Upper left panel: tax evasion in percentage terms. Upper right panel: total government revenue minus the cost of payment instruments c for all the buyers that do not cooperate with tax evaders, scaled to be equal to 100 if equal to the total government revenue in the baseline model specification ($t_s = 0.3$, $t_b = 0.1$, $\tau = 0$ and $\vartheta = 0$) for each tax evasion level. Lower left panel: total welfare, scaled to be 100 in the baseline model specification for each tax evasion level. Lower right panel: welfare of non evading sellers and buyers, scaled to be 100 in the baseline model specification for each tax evasion level.

Figure 2: **Effect of Sale Tax**



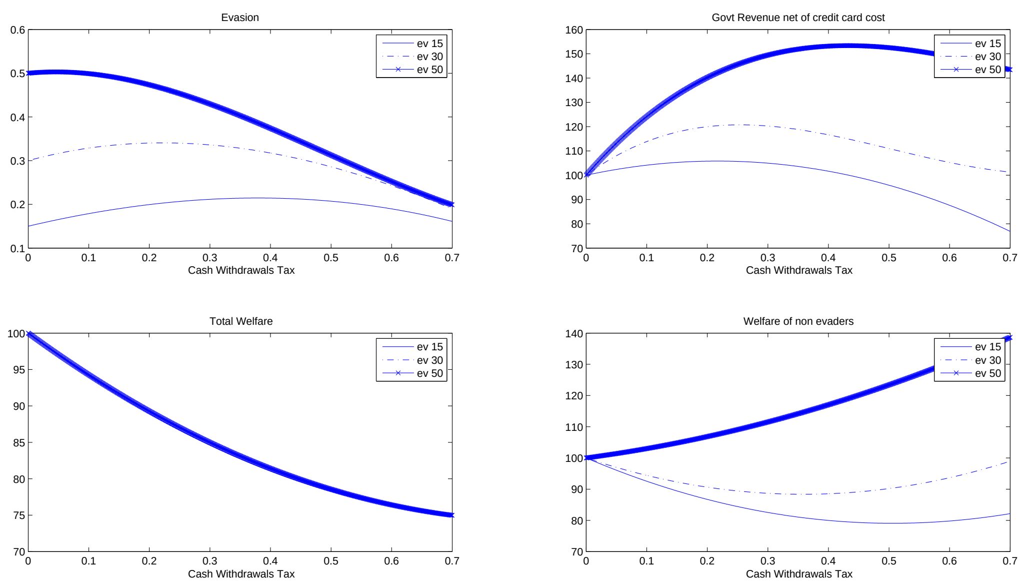
Notes: Upper left panel: tax evasion in percentage terms. Upper right panel: total government revenue minus the cost of payment instruments c for all the buyers that do not cooperate with tax evaders, scaled to be equal to 100 if equal to the total government revenue in the baseline model specification ($t_s = 0.3$, $t_b = 0.1$, $\tau = 0$ and $\vartheta = 0$) for each tax evasion level. Lower left panel: total welfare, scaled to be 100 in the baseline model specification for each tax evasion level. Lower right panel: welfare of non evading sellers and buyers, scaled to be 100 in the baseline model specification for each tax evasion level.

Figure 3: **Effect of Tax Rebate**



Notes: Upper left panel: tax evasion in percentage terms. Upper right panel: total government revenue minus the cost of payment instruments c for all the buyers that do not cooperate with tax evaders, scaled to be equal to 100 if equal to the total government revenue in the baseline model specification ($t_s = 0.3$, $t_b = 0.1$, $\tau = 0$ and $\vartheta = 0$) for each tax evasion level. Lower left panel: total welfare, scaled to be 100 in the baseline model specification for each tax evasion level. Lower right panel: welfare of non evading sellers and buyers, scaled to be 100 in the baseline model specification for each tax evasion level.

Figure 4: **Effect of TCW**



Notes: Upper left panel: tax evasion in percentage terms. Upper right panel: total government revenue minus the cost of payment instruments c for all the buyers that do not cooperate with tax evaders, scaled to be equal to 100 if equal to the total government revenue in the baseline model specification ($t_s = 0.3$, $t_b = 0.1$, $\tau = 0$ and $\vartheta = 0$) for each tax evasion level. Lower left panel: total welfare, scaled to be 100 in the baseline model specification for each tax evasion level. Lower right panel: welfare of non evading sellers and buyers, scaled to be 100 in the baseline model specification for each tax evasion level.