Cash Payments and Tax Evasion

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Abstract

We present a bargaining model of tax evasion where a buyer offers a price discount to a seller who does not ask for the receipt and pays cash, easing tax evasion. We show that a tax on cash withdrawals (TCW), which imposes a cost on the buyers who pay cash, is effective at reducing evasion only if it is set sufficiently high, and it must be higher the higher the tax evasion in the country and the larger the mass of individuals that typically pays in cash. One of the main challenges to the TCW is the possibility that it will foster the emergence of a parallel cash economy. We extend our baseline model, including an additional cost to hoard cash, and we show that the costs associated with cash management are complementary to the TCW, in the sense that they ease its implementation.

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Keywords: collaborative tax evasion; tax on cash

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1 Introduction

The first economic model of tax evasion by Allingham and Sandmo (1972) explains evasion as the result of a cost benefit analysis by perfectly rational individuals, who choose to evade if the expected cost of the sanction 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. The crucial element of this collaborative tax evasion scheme is therefore the cash payment, which allows the seller to easily conceal the transaction.

We start our analysis by documenting the negative relationship between the use of non cash payment instruments and tax evasion. We use two sets of data for the period 2000-2012: the ECB payment statistics, that report usage of payment cards and POS terminals, and the vat gap estimates of tax evasion for the EU member states reported in the CASE and CPB report (2014). The VAT gap is defined as the difference between the theoretical VAT liability according to the tax law (VTTL) and the actual revenue collected in any country and in any year.[1] We have a panel of 26 countries.[2]

In Figure **??** we plot, for each country in the sample, the average VAT gap for the period 2000-2012 against the average of the two main indicators of the diffusion of cashless payment instruments for the same period: the number of card transactions (the sum of credit and debit card) per capita and the number of POS transactions per capita. The upshot of the picture is a negative relationship for both measures suggesting that countries where cashless payment instruments are more widespread, also feature lower tax evasion. This evidence also suggests that any policy that discourages the use of cash also reduces tax evasion.

[1] More details on the data and some regression results are available upon request.

[2] Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the UK.

We then build model to study the equilibrium effects of two such policies on tax evasion and government revenue: a tax on cash withdrawals (TCW henceforth) from ATM machines and bank tellers, and a tax deduction for the buyers who keep the receipt of the transaction.

By imposing a cost on the buyers who pay cash, the purpose of the TCW is to reduce the incentive of the buyer to cooperate with the seller. The argument goes as follows: since evasion is facilitated, if not allowed, by the use of cash, making cash more expensive should induce less cooperation and, thus, 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[3].

The tax credit, on the other hand, does not discourage cash usage per se, but breaks the link between cash payments and tax evasion. If the tax credit is based on the receipt of the transaction, then it will induce the customer to ask for one, making it difficult for the seller to evade regardless of the payment method. Differently from the TCW, the tax credit is a standard policy instrument, embedded in many tax codes around the world, sometimes very creatively: in many countries (among others, in Austria, Portugal, 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 the tax credit policy 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). Nevertheless it is costly for the government, unlike the TCW that has, instead, the potential to raise additional revenue.

We present a model where price taking sellers enter in a bargaining round with their customers, offering a price discount in exchange for not issuing the receipt. A deal forces the customer to pay cash, since payment cards, bank transfers, checks and other non-cash instruments leave a trace of the transaction that impedes evasion. Conversely, there is no discount for the customer if there is no deal, but this leaves him free to choose between cash and non-cash instruments. We

[3]Indeed, 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.

model heterogenous sellers with respect to their honesty or tax morale, and heterogeneous buyers with respect to two dimensions: their tax morale and their cost of managing non-cash payment instruments. The government commits to a policy before the bargaining game, choosing a tax rebate and a TCW rate.

If the buyers and the sellers as risk neutral, we have an analytical solution for the model equilibrium, which allows us to study the effects of the policy instruments on tax evasion and government revenue. Nevertheless, since some of the net effects of the policies are ambiguous, we also consider a numerical solution. We calibrate the model to a fictitious "prototype economy" that features empirically plausible values for the deep parameters and for the calibration targets, but that is not representative of a specific real world country. We choose this approach to highlight the principles that should guide the anti-evasion policy in general, for a large set of countries. We also make an effort to study the robustness of our results to a wide range of alternative assumptions (risk aversion), parameter values and calibration targets, which allow us to generalize our results.

We show that a small tax deduction is effective at both reducing tax evasion and increasing government revenue. We also show that the deduction must be higher the higher the 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.

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 instruments prefer to use cash even if they don't want to favor tax evasion. For these individuals, the TCW 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 measure of individuals that prefer to use cash. We show that the first effect prevails for a small TCW rate, while the second prevails for high rates. We conclude that taxing cash is effective at reducing evasion (and increasing government revenue) only if its rate is high enough, where "high enough" depends on the characteristics of the economy. We also find that the TCW must be higher the bigger the measure of individuals with high costs of using non-cash payment instruments and the higher the tax evasion rate. The gain in government revenue determined by the TCW, on the other hand, is higher the higher the tax evasion rate and the higher the percentage of individuals with high costs of non-cash instruments.

One of the main challenges to the TCW is the possibility that it will foster the emergence of a parallel cash economy (Morse et al. 2009). If it is costly to withdraw cash from a bank account, then people will prefer to keep the cash at home dodging the TCW, which will therefore be ineffective. We propose a simple extension to the baseline model, including an additional cost for the buyers who hoard cash, and we identify a limit to the possibility of taxing the use of cash. In order for the TCW to be effective, the government needs either to raise the cost of hoarding cash or to keep the TCW at a low rate. Putting it differently, the costs associated with cash management are complementary to the TCW, in the sense that they ease its implementation. The question, then, is if it is possible to find a TCW rate high enough to be effective in fighting evasion but still smaller than the cost of hoarding cash. The answer clearly depends on the details of the economy: as part of the numerically analysis, we highlight the optimal policy for the Government. We consider the maximization of government revenue conditional on reducing tax evasion below a certain threshold. The main result from this exercise is that, with an appropriate mix of tax rebates and TCW, it is possible to curb tax evasion and, at the same time, increase government revenue.

The rest of the paper is organized as follows. Section 2 summarizes the related economic literature. Section 3 describes the baseline model and summarizes our analytical results. In Section 4 we extend the baseline model to include costly cash hoarding. Section 5 illustrates the numerical results. Section 6 offers some concluding remarks. In the appendix we provide the proofs of the analytical results togheter with the optimal policy for a real world country, Italy.

2 Related literature

The paper follows the quite abundant economic literature on tax evasion which has already been extensively reviewed (Andreoni, Erard and Feinstein 1998, Slemrod and Yitzhaki 2002, Cowell 1990, Marchese 2004, Sandmo 2005, Slemrod 2007 and Franzoni 2008). However, as already stressed in the introduction, there are very few works that deal specifically with collaborative tax evasion or that, in other words, analyze tax evasion as the outcome of the interaction between the seller and the buyer in a transaction.

The first work on collaborative tax evasion is Gordon (1990), who 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. A second work is Boadway, Marceau and Mongrain (2002), who model evasion as collusion between a buyer and a seller. The third is Chang and Lai (2004), who also model collaborative tax evasion as a bargaining game between a seller and a buyer, but to study a different question, namely how social norms shape the incentives of the agents. Differently from all these previous works on collaborative tax evasion, instead of focusing the attention on fines and enforcement, we study the effects of two different policy instruments, the tax rebate and the TCW[4].

The idea of taxing currency dates back to the work of 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 banks, which is actually a consequence of the existence of paper currency: if only bank deposits and electronic payments were available, there would be the possibility to charge negative interest rates, which is akin to taxing currency. In this paper, we focus on the tax of currency as a way to stifle tax evasion and we abstract completely from monetary policy issues.

The only work that proposes a tax on cash to fight tax evasion is Benshalom (2012). It offers a throughout discussion of the implementation challenges posed by the cash tax but lacks a formal analysis. In this work we instead propose a formal model of tax evasion to study the equilibrium effect of the tax rebate and the TCW. To our knowledge, this is the first attempt in this direction.

Our work 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, the TCW, which is paid once and for all, discourages cash withdrawals, but does not discourage hoarding it. In this respect, the inflation tax is complementary to the TCW, because it eases its implementation (on this see

[4]See Santoro (2006), for an argument against the effectiveness of policy instruments meant to reduce the incentives to cooperate on tax evasion and Piolatto (2014) for an opposite argument in favor of the effectiveness of itemized deductions.

Section 5).[5] Nicolini (1998) and Koreshkova (2006) discussed the role of the inflation tax as a way to raise revenue from tax evaders and from the underground sector.

3 Model and Analysis

The economy is composed by price taking, risk neutral, sellers, by risk neutral buyers and by the government. We model heterogenous sellers with respect to their honesty or tax morale (Gordon 1989; Andreoni, Erard and Feinstein 1998; Feld and Frey 2002). The buyers, on the other hand, are heterogeneous along two dimensions. The first is honesty or tax morale as for the sellers: honest buyers will always ask for a receipt, preventing tax evasion, while less honest ones will bargain with the sellers.[6] The second is the cost of managing non-cash instruments such as credit cards, debit cards, bank transfers, cheques etc.: some individuals find it easy to manage them while some others, like the elderly (Humphrey et al. 2003) or the less financially educated, do find it very cumbersome. Moreover, some consumers are uncomfortable with the idea that their purchases will be tracked and they are ready to pay a price to have an anonymous payment (Garcia Swartz et al. 2006).

We assume that there can be tax evasion only if the seller does not issue the receipt of the transaction and if the buyer pays cash. This last requirement is needed because non-cash payments leave a trace of the transaction and that, as a consequence, impairs or precludes evasion. 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, but forcing the buyer to pay cash. If the buyer and the seller do not reach a deal, no tax evasion is possible, and the buyer is free to choose between cash and non-cash payments.

[5] 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.

[6] 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).

The government has two policy instruments: a tax rebate $\tau \in [0, \overline{\tau}]$ for the customers who keep the receipt of the transaction and a tax on cash withdrawals $\vartheta \in \left[0, \overline{\vartheta}\right]$ (TCW) from ATM or bank tellers. We assume that government commits to a policy $\mathcal{P} = \{\tau, \vartheta\}$ before the bargaining between the seller and the buyer takes place. Moreover, we study two different government objectives: the reduction of tax evasion and the maximization of tax revenue. After observing the policy, one buyer and one seller are randomly matched for a single transaction and they bargain over the price discount. If they reach a deal, there is collaborative tax evasion.

3.1 Sellers and Buyers

We assume that the parties of the transaction can either evade the full amount or nothing.[7] The seller's utility in case of tax evasion, which requires cooperation from the buyer, is the following:

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

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 assumed smaller than 1, 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 $pt_s f_s$.[8] 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:

[7] This is without loss of generality for the risk neutral benchmark.

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

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

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.[9] The tax paid by the buyer can be interpreted as a sale or VAT tax. We assume that s is distributed according to the cdf G_s, whose pdf is g_s[10]. 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.[11] For simplicity, in this baseline version of the model we normalize the cost of using cash to zero. In practice, this cost is positive since cash must be withdrawn, stored and protected from theft, and because it looses value in case of inflation. We consider this cost explicitly in section (4). 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

[9]Since detection of one illegal transfer might have asymmetric, and often higher costs for the sellers, we allow for differents sanctions for buyers and sellers.

[10]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.

[11]Notice that we are implicitly assuming that a legal cash payment of $p(1 + t_b)$ costs the buyer $p(1 + t_b)(1 + \vartheta)$, i.e., the tax-on-cash induced markup is paid on the tax inclusive price and that the tax rebate τ is transferred electronically.

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 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

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

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

3.2 Equilibrium

For simplicity, in the remainder of the section, we assume that sellers do not suffer a cost from being dishonest, meaning that v is uniformly equal to zero. We have shown in a previous version of the paper that this assumption is without loss of generality (see Immordino and Russo, 2014).

We model the negotiation as a Nash bargaining. The solution is defined by

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

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

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

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

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

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

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

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

We then use condition (10) to compute the equilibrium level of tax evasion. First, we consider the buyers with $c \leq \Upsilon$, substituting c to the $\min\{\Upsilon, c\}$ in expression (10), to obtain a threshold value $\tilde{s}_1(c)$ such that all the buyers of type $c \leq \Upsilon$, with an honesty lower than $\tilde{s}_1(c)$, cooperate. Next, we do the same for $c \geq \Upsilon$, substituting Υ to the $\min\{\Upsilon, c\}$ in expression (10), and we obtain a second threshold $\tilde{s}_2$ (which does not depend on c and coincide with $\tilde{s}_1(c)$ for $c = \Upsilon$), such that all the buyers of type $c \geq \Upsilon$, with honesty lower than $\tilde{s}_2$, collaborate.

Using the previously defined thresholds it is immediate to get the following expression for total tax evasion E[12]:

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

where $E_c(c) = \int_0^{\tilde{s}_1(c)} g_s ds$ is the mass of evaders with low c, while $E^c = \int_0^{\tilde{s}_2} g_s ds$ is the mass of evaders with high c.

Next, we define total government revenue as

$$\begin{aligned} G = &\int_0^{\Upsilon} \{[p\pi(t_s(1+f_s) + t_b(1+f_b)) + (p - d^*(s,c))\vartheta] E_c(c) + p(t_s + t_b - \tau)(1 - E_c(c))\} g_c dc \\ &+ [1 - G_c(\Upsilon)] \{[p\pi(t_s(1+f_s) + t_b(1+f_b)) + (p - d^*(s))\vartheta] E^c + (p(t_s + t_b - \tau) + \Upsilon)(1 - E^c)\}. \end{aligned} \tag{12}$$

The first line is the revenue from transactions with low c buyers. These buyers are either

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

matched with evading sellers (first term) or not (second term). In case of tax evasion and audit, both the seller and the buyer are forced to pay the full amount of the tax plus a fine, computed on the evaded amount $p\pi[t_s(1+f_s)+t_b(1+f_b)]$. In addition, since there is a cash payment, the buyer also pays the TCW, which amounts to ϑ times the negotiated amount of the transaction net of the discount $(p-d)$. When the matching does not lead to tax evasion, the revenue for the government 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 with high c buyers. In case of tax evasion, the government cashes in exactly the same amount as in the case of low c buyers. Conversely, the revenue is $p(t_s+t_b-\tau)+\Upsilon$ when the matching does not lead to tax evasion, because the government collects the TCW also from the non-collaborative buyers who prefer to use cash. Indeed, the TCW levied on those individuals is a pure transfer to the government and it should be reimbursed to leave the buyers' purchasing power unchanged.

Importantly, the TCW imposes the cost c also on the non-collaborative buyers (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

$$\int_0^{\Upsilon} c(1-E_c(c))g_c dc. \tag{13}$$

Since c is measured in monetary equivalents, it is possible to subtract it from the government revenue, to obtain what we call the "Net Government Revenue", denoted G_n.[13] This measure gives a better idea of the positive net effects of the introduction of the TCW for the government.

3.3 Comparative Static

In this section we analyze the effect of the policy variables on the model equilibrium. Our main goal is to understand if the tax rebate and the TCW are effective at fighting tax evasion (Section 3.3.1) and at raising Government revenue (Section 3.3.2).

[13]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.

3.3.1 Tax Evasion

While a tax rebate always reduces the buyers' incentives to cooperate, decreasing tax evasion, the effect of the TCW ϑ on evasion is in general ambiguous. The reason being that the threshold $\tilde{s}_1(c)$, such that all the buyers of type $c \leq \Upsilon$, with tax morale lower than $\tilde{s}_1(c)$, collaborate, is decreasing in ϑ. Instead, the threshold $\tilde{s}_2$, for types $c \geq \Upsilon$ is increasing. The intuition is that, if the buyer does not collaborate, he must still choose whether to use cash, which is better if and only if $c \geq \Upsilon$. In other words, buyers with high c prefer to use cash even if they do not want to cooperate with the seller. Therefore the TCW does not impose an extra cost on them, but it actually makes cooperation more attractive: a collaborative buyer pays ϑ on the price net of the discount $p - d$, while a non collaborative buyer pays it on the full price p. Conversely, buyers with low c, who do not want to collaborate with the seller, prefer to bear this cost and to use the non-cash instruments. Thus an increase in the TCW rate makes cooperation relatively more costly for them. 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 sufficiently high. We summarize the previous analysis with the following proposition:

Proposition 1. *There exist a minimum of the tax evasion minimization problem. Tax evasion is always decreasing in the tax rebate τ; The TCW ϑ is an effective tool to fight tax evasion only if set sufficiently high.*

The result that tax evasion is increasing in the TCW for low TCW rates come from the interplay of two forces: (i) for buyers who have a low cost of using non-cash instruments (and thus use non-cash instruments when they do not cooperate) an increase in ϑ makes cooperation more costly; (ii) for buyers who have a high cost of using non-cash instruments (and thus use cash when not cooperating) an increase in ϑ actually makes cooperation a better option. Effect (ii) dominates when no TCW is imposed, i.e. $\vartheta = 0$. This is true since at $\vartheta = 0$ everybody uses cash when not cooperating (note from the proof of Proposition 1 that $\partial E/\partial\vartheta$ at $\vartheta = 0$ only features the change in evasion with buyers with high c). This suggest that if there is a non-zero mass of buyers using non-cash instruments at $\vartheta = 0$, effect (i) would play a role even at $\vartheta = 0$, weakening the previous negative result on the possibility of using a TCW to fight tax evasion. An extreme example is one where at $\vartheta = 0$ everybody uses non-cash instruments when not cooperating: in this case only effect (i) would operate, thus reducing evasion when ϑ increases, regardless of the level of ϑ. In the numerical analysis we will consider a probability distribution with a mass at zero, representing the individuals that can manage non-cash instrument without a cost (perhaps also with a gain). In particular, we chose a mixture exponential distribution and showed that (see Section 5.3) if electronic means of payments are sufficiently diffused – meaning that a large fraction of the population uses non-cash instruments when no TCW is imposed – then the introduction of the TCW does not increase evasion. Formally, using a probability distribution with a mass at zero, the $\partial E/\partial\vartheta$ evaluated at $\vartheta = 0$ (equation ... in the appendix) features a new negative term proportional to the probability mass at zero, so that the larger this mass more likely it is that evasion will decrease when ϑ increases. We summarize the previous discussion with the following proposition:

Proposition 2. *If the electronic means of payment are sufficiently diffused, the TCW ϑ is an effective tool to fight tax evasion regardless of the level of ϑ.*

3.3.2 Net Government Revenue

In the previous section we have shown that tax evasion is always decreasing in the tax rebate and we concluded that τ should be set equal to its upper bound $\overline{\tau}$. However, since one of the main goals of fighting tax evasion is to increase the tax proceedings, we now consider the effect of a tax rebate on the maximization of net government revenue. On the one hand, decreasing evasion increases revenue; on the other, the higher the tax rebate, the higher the transfer from the government to non-cooperating buyers.

There is no effect of an increase in τ on the revenue from evaders but a negative effect on the revenue from non-evaders. Since the equilibrium discount increases with the tax rebate, there is a lower revenue from the TCW and a higher cost imposed on the non-collaborative buyers who opt for non-cash payments. Summarizing, low statutory taxes, a large mass of honest individuals $(1 - E)$ and a high TCW rate make a tax rebate undesirable. We have the following proposition:

Proposition 3. *The tax rebate τ decreases the government revenue if the tax rate is low or in case there are many honest individuals.*

Unfortunately the comparative statics with respect to ϑ is quite complicated. In fact, 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 TCW on government revenue is ambiguous and will be studied numerically in Section 5.

4 Costly Cash Hoarding

In the previous analysis, we simplified the model normalizing the cost of using cash to zero. Nevertheless this cost is very unlikely to be negligible. First, because cash must be withdrawn, stored and protected from theft. Second, because the nominal value of cash is eroded by inflation. Indeed, the very existence of a cost to hoard cash was the reason why we assumed, in the baseline model, that the buyers who pay cash withdraw it from the bank. Now we analyze the effect of these costs on the model equilibrium.

One of the main challenges to the TCW is the possibility that it will foster the emergence of a parallel cash economy (Morse et al. 2009). If it gets costly to withdraw cash from a bank account, people might prefer to keep the cash in the mattress dodging the TCW which will therefore be ineffective. The problem is that that the TCW discourages cash withdrawals but not cash hoarding. However, if the cost of cash management is not zero, then there will be individuals who prefer bank deposits to the cash economy. Moreover, the higher these costs, the lower the probability that a cash economy will emerge for a given TCW rate and, therefore, the more likely that the TCW will be effective.

For instance, some businesses need to deposit their proceeding in the banking sector because they need access to financial instruments to function and grow. For them hoarding cash might be very costly, since it will cut them away from the financial sector. It is therefore unlikely that they will switch to cash after the introduction of the TCW. Conversely, other businesses, who are not in desperate need of financing, have a lower cost of cash hoarding and, hence, it is likely that they will respond to the TCW switching to cash.

We extend the baseline model including an additional cost i for the buyers who hoard cash.

For simplicity and with no loss of intuition, we present here the case where the cost i is the same for all buyers. The model could be easily extended to the case of heterogeneous costs. Moreover, since in our static, single transaction model sellers will never want to hoard cash, we do not include a cost for them.[14]

In this extended model, the utility of a buyer, in case of tax evasion, is

$$v_b^{1H} = u - (p - d)(1 + \min\{\vartheta, i\}) - \pi p t_b (1 + f_b) - s. \tag{14}$$

In order to evade, the buyer can pay either with the cash withdrawn from the bank at a cost ϑ or with the cash hoarded at a cost i. If he does not cooperate, he must still choose between using hoarded cash, withdrawn cash or an alternative payment instrument. Thus, the utility of a non cooperating buyer becomes

$$v_b^{0H} = u - p(1 + t_b - \tau) - \min\{p(1 + t_b)\vartheta, p(1 + t_b)i, c\}. \tag{15}$$

Since both the cost i and the tax ϑ are the same for all buyers, we have only two possibilities in case a buyer wants to use cash: i) if $\vartheta \leq i$ (we assume that if indifferent the buyer prefers to withdraw from the bank), every buyer chooses to withdraw from the bank and the previous analysis is unaffected; ii) if $\vartheta > i$ all buyers choose to hoard cash. In this second case we need to replace ϑ with i everywhere in the analysis (discount, thresholds, tax evasion), but the steps are the same. In this case, since ϑ is absent from the new expression for tax evasion and the derivative of tax evasion with respect to τ is unchanged, we have the following result:

Proposition 4. *Tax evasion is always decreasing in the tax rebate τ; The TCW ϑ is not effective to fight tax evasion if set higher than the cost to hoard cash i.*

Proposition 4 identifies a limit to the possibility of taxing the use of cash to fight tax evasion. In order for the TCW to be effective, the government needs either to raise the cost of hoarding cash i or to keep the TCW at a low rate. Putting it differently, Proposition 4 states that the costs associated with cash management are complementary to the TCW, in the sense that they ease its

[14]However, one could imagine a full fledged dynamic cash management model à la Miller and Or (1966) where each agent has to cover its purchases with cash but it also receives cash inflows. We hope to address those issues in future research.

implementation.

Since inflation is one of the main costs of hoarding cash keeping it at a (reasonably) high rate will ease the implementation of the TCW. Suppose, for instance, that interest bearing bank accounts are available, with an interest rate that partially or totally compensates for inflation. The sellers will have a lower incentive to accept cash payments: in order to avoid the inflation tax they should deposit their cash earnings in a bank account, but doing so they will increase the probability of a tax audit.

The government can increase the cash hoarding cost, to foster the TCW, even without resorting to inflation. One possibility, proposed by Mankiw (2009), is to have a lottery on the actual banknotes in circulation. Specifically, the lottery is based on the last digit or on the last two digits of the banknotes serial numbers that, if extracted, make the "winners" worthless. For a lottery based on the last two digits, it means that 1/20, of the banknotes will be withdrawn from circulation at each lottery extraction, which is equivalent to a 5% tax on cash hoardings.

Another possibility to discourage cash hoarding is the introduction of a ban on cash transactions above a certain threshold, both for financial and non-financial products. Similar laws are in place, among others, in France, Italy and Portugal, and several central European countries are discussing comparable regulations. Assuming that a ban of cash payments above, say, 1,000 Euro is strictly enforced, the revenue consequences of a TCW could become small. There are also other ways to prevent cash hoarding, discussed in Benshalom (2012): forcing employers to pay wages in cash, forcing business to deposit in the banking sector a certain fraction of their disclosed sales, ect.

Notice finally that Proposition 4 contrasts with Proposition 1 that, instead, claims the efficacy of the TCW only if it is set at a sufficiently high rate. The question, then, is if it is possible to find a TCW rate high enough to fight evasion but still smaller than the cost of cash hoarding. The answer obviously depends on the details of the economy. We propose two numerical examples: one in Section 5.6 for a fictitious country and one in the appendix, for a real world country, Italy.

5 Numerical Analysis

We consider now the numerical solution of a calibrated version of the model and we relax the simplifying assumption of no cost from being dishonest for the seller, so to make our numerical optimal policies more realistic. We proceed as follows. In the next section (5.1) we define what we call a "Prototype Economy", that features reasonable values for the parameters and for the calibration targets, but that it is not representative of a real world country. We choose this approach to provide the widest possible perspective on these issues, rather than focusing on a specific country, making an effort to generalize the analysis as much as possible. In Section 5.2 and 5.3 we summarize the results. In Section 5.4 we review their robustness. In Section 5.5 we briefly comment on the efficiency issues raised by the TCW. In Section 5.6 we identify the optimal policy. We discuss an example of the optimal policy for a real world country, Italy, in the appendix.

5.1 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, we choose $\pi = 0.01$ (in Section 5.4 we explore the robustness of the results to higher values of π) and we set the fine to $f_s = f_b = 0.5$. Admittedly, we take a shortcut with the assumption of a constant auditing 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. For all these reasons, 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 the cost of enforcement in the model and since there is no easy way of introducing one[15].

We set $\vartheta = \tau = 0$ in the benchmark simulation. For the distribution of the cost c, we consider a probability distribution with a mass at zero, representing the individuals that can manage non-cash instrument without a cost (perhaps also with a gain), and with a small probability mass at

[15]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.

high costs, which reflects the individuals that find it very cumbersome to use non-cash instruments such as the elderly and the less financially educated. In particular, we chose the following mixture exponential distribution:

$$g_c(x, \lambda) = \begin{cases} 0 & \text{Prob}\,\lambda \\ \lambda e^{-\lambda x} & \text{Prob}\,1-\lambda. \end{cases} \tag{16}$$

We set $\lambda = 0.2$ in the benchmark simulation, which entails assuming that, in the absence of the TCW, 20% of the population does not use cash for the transaction. In Section 5.3 we explore the robustness of the results to alternative values of λ.

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 robustness in Section 5.4. As we discuss in Section 5.5, 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 for u. Other than that, the values of p and u are just scalings: different values will only deliver different calibrated parameters, but the same results. We set $p = 10$ and $u = 1.5\,p$ for convenience.

Actually the mass of individuals that prefer to use non-cash instruments is increasing in the transaction price. Thus the cost c should be decreasing in p, but such a model is very difficult to calibrate, because we don't have information on card use by transaction value. Nevertheless, we do account for this variability in a reduced form, varying the fraction λ: a higher (lower) λ is more likely in sectors with higher (lower) average transactions values. Therefore we can interpret the robustness of our results with respect to different values of λ 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: as already noticed, 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, which is essentially a Beta distribution but with a different parametrization. The pdf is the following:

$$g(x; a, b, \bar{x}) = \frac{ab}{\bar{x}} \left(\frac{x}{\bar{x}}\right)^{a-1} \left[1 - \left(\frac{x}{\bar{x}}\right)^{a}\right]^{b-1} \qquad 0 < x < \bar{x} \tag{17}$$

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 ($\bar{s} = \bar{v}$). In fact the occupational choice might be also driven by the opportunity to evade taxes, so that individuals who are more prone to tax evasion, because of moral reasons, would choose to work where it is easier to evade taxes (Pestieau and Possen 1991). We decided to abstract from these issues since there is no robust empirical evidence that confirms this hypothesis (Parker 2003).

To choose the parameters of the distribution of tax morale, 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, there is one that is 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 $\bar{s} = \bar{v} = 2.31$.

The 30% baseline choice for the evasion level is in line with what Pissarides and Weber (1989) find in the UK for self employed individuals, but it is sensibly smaller than the 57% tax evasion on business income for self-employed individuals in the US (Slemrod 2007, using data from the Tax Compliance Measuring Program implemented by the IRS). As robustness, checks we also consider two alternative scenarios of, respectively, high tax evasion (50%), and low tax evasion (15%).

5.2 Comparative statics by levels of tax evasion

Figures 2 and 3 report the comparative statics with respect to the tax rebate and to the TCW for different calibrated evasion levels, 15%, 30% and 50%. The normalized government revenue is equal to 100 in the benchmark model parametrization for each evasion level, so that, subtracting 100 from the value 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 picture are not expressed in the same unit, which means that they are not directly comparable.

Figure 2 reports the effect of a tax rebate τ. Evasion decreases with τ because a higher tax rebate reduces the incentives of the buyer to cooperate with the seller. The effect on government revenue is the result of two contrasting effects: on the one hand, the decreasing evasion increases revenue; on the other, the higher the tax rebate, τ, the higher the transfer from the government to non-cooperating buyers. The left panel shows that there is a threshold level for τ such that the first effect prevails before it, with an increasing net revenue, while the second prevails after it, with a decreasing revenue. In other words, the numerical analysis confirms the analytical results. But 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.

Figure 3 reports the effect of the TCW ϑ. As previously stressed, increasing ϑ increases the incentive to cooperate for the individuals with high cost c (the cash users), increasing tax evasion. For the individuals with low cost c (the non cash users), instead, increasing ϑ decreases the incentive to cooperate, decreasing tax evasion. In addition, the number of non-cash users increases with the TCW while 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 to increases such a number. This confirms the analytical result in Proposition 1. In addition, we also find that the higher the prevailing tax evasion rate, the smaller the TCW rate above which tax evasion is decreasing. This is because there is a big mass of non-collaborative buyers who are cash users in case tax evasion is low.

The effect of the TCW on the net government revenue is twofold: on the one hand, an increase in the TCW affects the cooperation rate and, therefore, the level of tax evasion; on the other, it affects the total cost of non-cash instruments that must be subtracted from the gross revenue. For low levels of the TCW, cooperation and, therefore, evasion, is increasing, which translates in a decreasing gross revenue. However, since more individuals are using cash because of the increased evasion, there is a lower total cost of non-cash instruments. Therefore 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 of the higher total cost of non cash-instruments. Tax evasion is lower than the benchmark for a very high TCW, but the net government revenue might be lower or higher than the benchmark for such values. As shown in the right panel of Figure 3, the response of the net revenue to the TCW has an inverse u shape. 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 the higher the tax evasion level, the smaller the mass of non-collaborative cash users to compensate, since 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.

Summing up, the numerical analysis confirmed the results in Propositions 1 and 2, but also highlighted some additional results. The net government revenue is first increasing and then decreasing in the TCW rate. The higher the baseline tax evasion: i) The higher the optimal tax rebate that maximizes net government revenue; ii) The higher the TCW rate that maximizes net government revenue; and iv) The smaller the TCW rate above which tax evasion is decreasing.

5.3 Comparative statics by use of non-cash instruments

Figure 4 summarizes the comparative static results with respect to the TCW for different levels of λ but for the same 30% baseline evasion rate. The main goal of this exercise is to get insights into what should be the rate of the TCW adopted in countries characterized by different development of the electronic means of payments. For instance, the value of λ used in the appendix for Italy is a very low 0.12 (see Section A.1).

An interesting result of the analysis is that if the electronic means of payments are sufficiently diffused (λ high) the introduction of the TCW does not increase evasion. For instance with $\lambda = 0.5$, tax evasion is always decreasing in ϑ. This confirms the result in Proposition 2. The intuition is that if there is a higher mass of individuals with a small cost c, a smaller TCW is required to prevent evasion. Reduced evasion, in turn, raises the tax revenues both from income and the sale tax and decreases the tax revenue from the TCW, but the first effect prevails.

Finally, as we already stressed, different levels of λ also describe differences in the incidence of the TCW in different sectors. Specifically, higher values of λ correspond to economic sectors with higher average transaction value, where the use of cash is less common.

Summing up, the numerical analysis suggests that the larger the mass of individuals with high cost of using non-cash payment instruments (the smaller λ), the higher the optimal TCW rate.

5.4 Robustness

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. 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 $f = 3$, six 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:

$$e^* = \frac{(1-k)[p(1-t_s)-d]}{t_s(k+f)} \tag{18}$$

where

$$k = \left[\frac{\pi f}{1-\pi}\right]^{\frac{1}{\eta}}. \tag{19}$$

However, all results still hold: the net government revenue has an inverse u shape, similarly to the baseline model, and the comparative statics with respect to τ and ϑ are qualitatively unchanged.

Summing up, the numerical analysis suggest that: i) The tax rebate and the TCW are a substitute for enforcement; ii) Risk aversion affects the response of tax evasion to the tax rate, but not the rest of the analysis.

5.5 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 $v_s^0 = p(1-t_s)$, which is always positive for any $t_s < 1$. 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 this condition as:

$$u - p \geq p\vartheta(1 + t_b) - p\tau \text{ for any } \{\tau, \vartheta\}. \tag{20}$$

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

$$\vartheta(1 + t_b) \leq \tau. \tag{21}$$

We will impose this constraint in the next section when we discuss the optimal policy.

5.6 Optimal Policy

We now look numerically at the optimal policy. Since one of the main goal of fighting tax evasion is to increase the tax proceedings, we 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 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. We stress the gain in gross government revenue with respect to the corresponding benchmark with fixed tax rates, no tax rebates and no TCW. This computation gives an idea of the possibility of the government to compensate honest taxpayers for the side effects introduced by the TCW.

In this section we look at the optimal policy for the benchmark prototype economy parameterized as in Section 5.1. In the appendix we also propose an example of the optimal policy for a real world country, Italy.

The optimal policy to maximize government revenue is $\tau = 4\%$ and $\vartheta = 17\%$, with a 14% evasion level and a 38% bigger government revenue. Evasion is still quite high. The optimal maximin policy that reduces evasion below 1% is, instead, $\tau = 13\%$ and $\vartheta = 14\%$. At this policy the government revenue is 27% larger than the benchmark, which means that it is possible to fight tax evasion and, at the same time, to raise additional tax revenue. The only potential problem is that both these constraint policies entail a loss of efficiency, given that condition (21) is not satisfied. Imposing this further constraint, we find that, to maximize revenue, the optimal policy is $\tau = 8\%$ and $\vartheta = 7\%$, with a 3.7% evasion rate and a 28% larger government revenue. The optimal constrained maximin policy entails a bigger rebate, $\tau = 13\%$ and a bigger TCW $\vartheta = 10\%$, and results in a 20% larger government revenue. Once again, the government can still make money, while fighting evasion.

Summing up, the numerical analysis suggest that: an appropriate mix of tax rebates and TCW allows the government to both curb tax evasion and raise additional tax revenue. However, there is a limit to the amount of revenue that the Government can raise without any loss in efficiency.

All previous numerical exercises, entail a fairly high value of the TCW, which is arguably difficult to implement (see Section 4). Therefore, we perform an additional exercise: we look for the optimal policies conditional on keeping the TCW rate below a threshold value. We chose a 5% upper bound to take into account both a small inflation rate, such as the one experienced in western economies and a small risk of theft and loss associated with ”mattress” cash hoarding.

The revenue maximizing policy entails equating the tax rebate to the maximum feasible TCW, so $\tau = \vartheta = 5\%$, with an 8,7% evasion rate and a 27% gain in revenue. The optimal maximin policy entails, once again, a bigger tax rebate, $\tau = 12\%$ and a binding implementation constraint, $\vartheta = 5\%$, and results in a 12% larger revenue. Both policies satisfy the constraint (21), so there is no loss in efficiency associated. The conclusion is that our results still hold with a reasonable upper bound to the TCW, with the only difference of a lower amount of additional tax revenue that the Government can raise without efficiency losses.

Unfortunately this result is limited. In the appendix, we provide an example for a real world country, Italy, that shows that, under some circumstances, it is not possible to fight tax evasion and raise additional revenue, without potential efficiency losses, if there is a binding implementation constraint to the upper bound of the TCW.

6 Discussion and Conclusion

In this study we present 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, facilitating tax evasion. We studied how a tax rebate for the buyer and a tax on cash withdrawals affect tax evasion and government revenue. A small tax deduction can reduce tax evasion and increase government revenue 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 bigger the mass of individuals using cash. We also identified an important implementation problem for the TCW, that is the emergence of a parallel cash economy. Namely, many individuals, to dodge the TCW tax, will start hoarding cash, bypassing the banking system and, therefore, making it impossible to collect the TCW. Moreover, the lower the cost of cash hoarding, the higher the probability that this scenario will materialize.

Unfortunately this is not the only implementation challenge of the TCW. A second implementation challenge of TCW concerns the dynamic of its introduction: 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. Another, closely related problem, emerges even if the tax is suddenly and unexpectedly implemented without prior announcements. At that moment, the individuals who have most of their accumulated wealth in cash, such as criminals and past tax evaders, will not suffer the consequences of the TCW, which will instead impact the honest taxpayers who deposited their savings in the banking sectors. A further problem associated with the TCW is how to find a way to compensate honest taxpayers. This is a crucial element since proper compensation will boost the acceptability of the TCW. However, since we have shown (Section 5) that the introduction of a TCW can actually increase tax revenue there is, in principle, the possibility to compensate buyers and sellers, for instance subsidizing the use of non-cash instruments. For a thoroughly discussion of those and others implementation issues we refer the reader to Benshalom (2012).

We also found that an appropriate mix of tax rebates and TCW can curb tax evasion while, at the same time, raising additional revenue. However, there is a limit to the additional amount of revenue that can be raised without an efficiency loss.

Alternatively to the TCW, the government can 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 it transfers to the users the costs of these benefits.

An alternative policy to reduce tax evasion entails decreasing the cost to manage non-cash instruments, since a decrease in c, in the model, has the same effect of an increase of ϑ. However, while the TCW increases the government revenue, decreasing c is costly and, therefore, infeasible for financially constrained governments. Furthermore, it is extremely difficult to reduce the cost c for some individuals, regardless of the magnitude and type of government expenditure: some of these costs are, in fact, 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.

A less obvious possibility consists in supporting an explicit cost-based pricing of payment instruments. Van Hove (2004) argues that, under current banking pricing schemes, the fees charged to consumers for cash withdrawals do not cover the full cost of cash, which is recovered through cross-subsidization. These costs include, among others, the warehousing, distribution, transportation and the protection from theft. "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.

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.

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Proof of Proposition 1:

Since the function E is a real-valued continuous function on a non-empty compact domain there exist a minimum (Weierstrass Theorem). Next, we show that tax evasion is always decreasing in the tax rebate τ. Differentiating E with respect to τ we have

$$\frac{\partial E}{\partial \tau} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial \tau} g_c dc + [1 - G_c(\Upsilon)] \frac{\partial E^c}{\partial \tau} < 0 \tag{22}$$

since

$$\frac{\partial E_c(c)}{\partial \tau} = -p g_s(\tilde{s}_1(c))$$

and

$$\frac{\partial E^c}{\partial \tau} = -p g_s(\tilde{s}_2).$$

Therefore, we conclude that τ should be set equal to $\overline{\tau}$.We now study the effect of the TCW on evasion. Applying Leibnitz' integral differential rule we have

$$\frac{\partial E}{\partial \vartheta} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial \vartheta} g_c dc + [1 - G_c(\Upsilon)] \frac{\partial E^c}{\partial \vartheta} + \frac{\partial \Upsilon}{\partial \vartheta} g_c(\Upsilon) \left[E_c(\Upsilon) - E^c\right]. \tag{23}$$

First, notice that the last term cancels out since $\tilde{s}_1(\Upsilon) = \tilde{s}_2$ implies that $E_c(c) = E^c$. Next,

$$\frac{\partial E_c(c)}{\partial \vartheta} = g_s(\tilde{s}_1(c)) \big\{ p t_s [1 - \pi (1 + f_s)] - p \big\} < 0 \tag{24}$$

since $t_s < 1$ (by assumption) and $1 - \pi (1 + f_s)$ is smaller than 1 and larger than zero (again by assumption). Moreover,

$$\frac{\partial E^c}{\partial \vartheta} = g_s(\tilde{s}_2) \big\{ p t_s [1 - \pi (1 + f_s)] + p t_b \big\} > 0. \tag{25}$$

Notice also that for $\vartheta = 0$ we have $\frac{\partial E}{\partial \vartheta} = \frac{\partial E^c}{\partial \vartheta} > 0$ so that for continuity a small TCW always increases evasion. Finally, since the sign of the second derivative is ambiguous we are unable to say neither if there is one or more solution nor if it is interior or a corner. ■

Proof of Proposition 2: Define $R_c = p t_s (\pi(1+f_s) - 1) + p t_b (\pi(1+f_b) - 1) + (p - d^*(v, s, c))\vartheta + p\tau$ and $R^c = p t_s (\pi(1 + f_s) - 1) + p t_b (\pi(1 + f_b) - 1) + (p - d^*(v, s))\vartheta + p\tau - \Upsilon$.

For the rebate we have:

$$\frac{\partial G_n}{\partial \tau} = \int_0^{\Upsilon} R_c \frac{\partial E_c(c)}{\partial \tau} g_c dc + (1 - G_c(\Upsilon)) R^c \frac{\partial E^c}{\partial \tau} + \\ 0 - p(1-E) - \frac{\beta p \vartheta}{1+\vartheta} E + \int_0^{\Upsilon} c \frac{\partial E_c(c)}{\partial \tau} g_c dc. \tag{26}$$

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. ■

A 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.

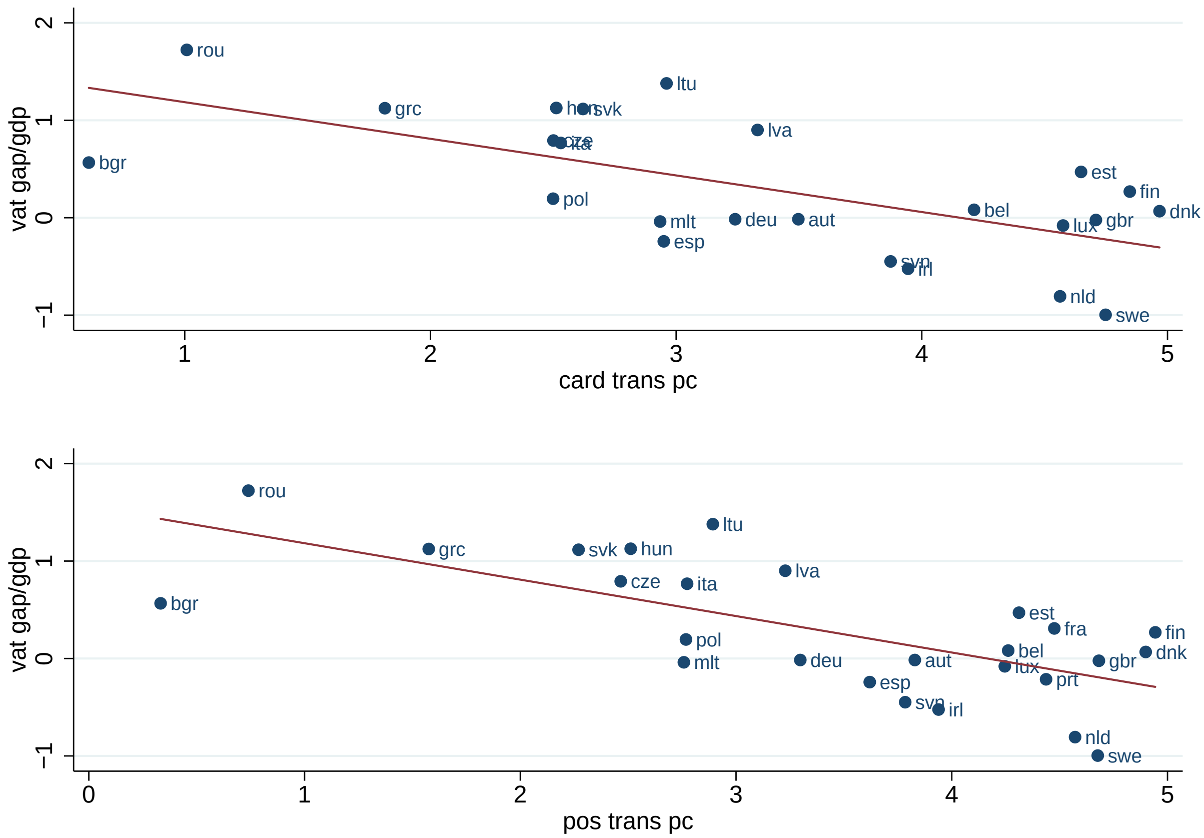
To calibrate the model, we need a target value for tax evasion and we need a shape of the distribution of the tax morale to match. For the tax morale we take the values from the WWS website. For tax evasion, we consider two different sources. The first is the Study by EURES (2012), an Italian independent 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%. Most likely, this is an underestimate of the true tax evasion level in Italy which, in certain sectors, can be much higher, especially in those where seller often bargain with buyers over discounts (construction, lawyers, doctors etc.). Unfortunately, we don't have detailed information about tax evasion at such a disaggregated level, so we stick to the calibration to aggregate data.

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 revenue maximizing policy, which in this particular case coincides with the maximin policy, features no rebates, $\tau = 0$ and a high TCW rate, $\vartheta = 25\%$. At this policy, evasion is equal to 1% and there is a 19% gain in revenue. If the maximum feasible cash tax rate is 5%, the optimal revenue maximizing policy, which again coincides with the maximin policy, entails no tax rebate and the TCW at the upper bound, $\vartheta = 5\%$. Evasion is substantially below 1% at this policy, but the Government revenue is 4.8% lower than the benchmark. Imposing also the efficiency constraint, the optimal policy is $\tau = 2\%$ and $\vartheta = 1\%$, with evasion close to zero but a 14% lower government revenue.

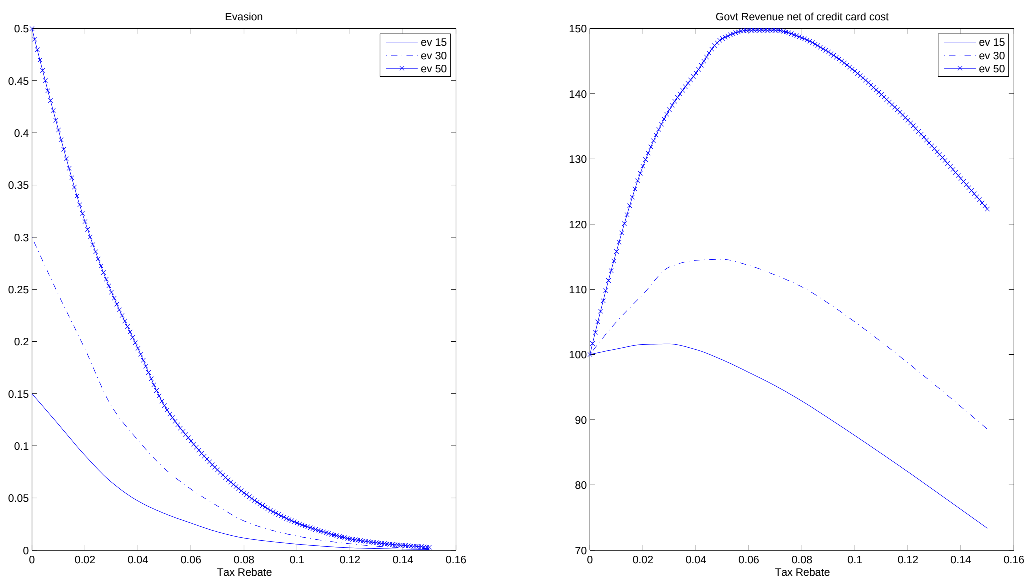
In this particular example, fighting evasion and raising revenue with the TCW is possible only if there is no small upper bound on the TCW. In addition, even without the upper bound, there is still an efficiency loss associated with the optimal policy.

Figure 1: **Electronic Payments and Tax Evasion 2000-2012**



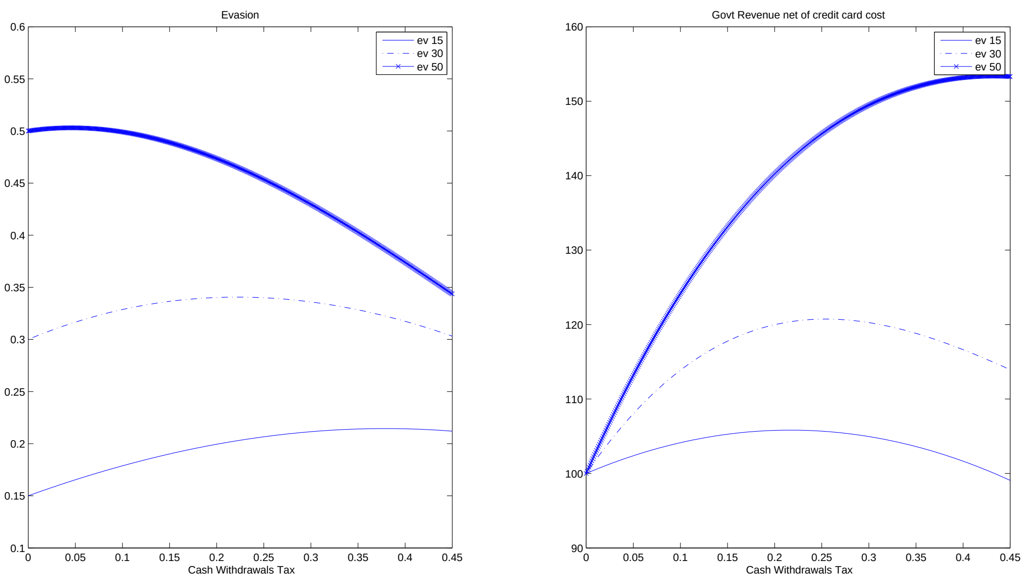
Notes: Upper panel: vat gap over gdp and number of debit and credit card transactions per capita. Lower panel: vat gap over gdp and number of debit and credit cards per capita. Data on the vat gap are from CASE and CPB (2014) report. Data on electronic payments are from the ECB payment statistics. All data refer to 2012.

Figure 2: **Effect of the tax rebate by evasion level**



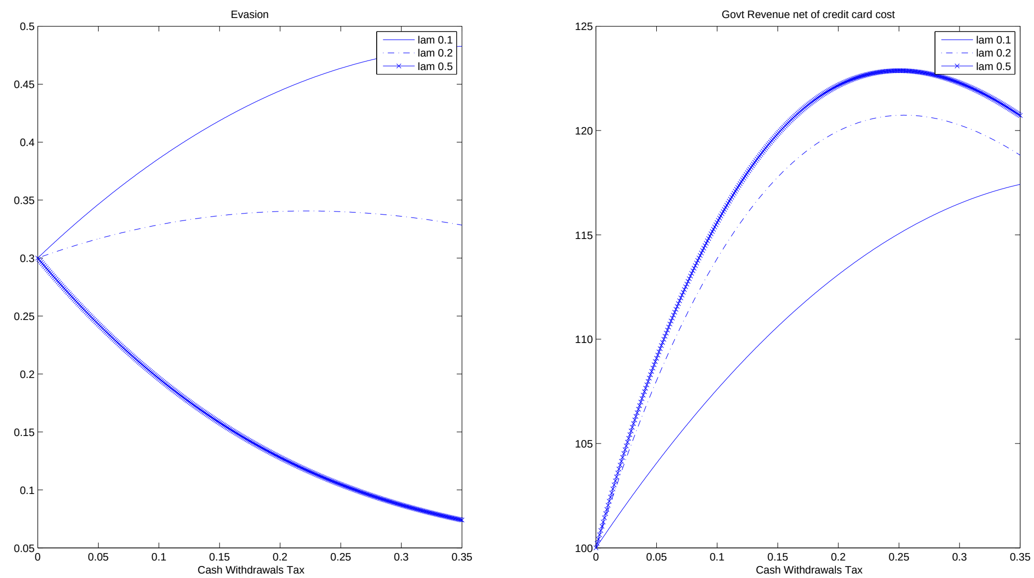
Notes: Left panel: tax evasion in percentage terms. Right panel: total government revenue minus the cost of payment instruments c for all the buyers that do not cooperate with tax evaders, scaled to be equal to 100 if equal to the total government revenue in the baseline model specification ($t_s = 0.3$,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

Figure 3: **Effect of the TCW by evasion level**



Notes: Left panel: tax evasion in percentage terms. 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.

Figure 4: **Effect of the TCW by use on non-cash instruments**



Notes: Left panel: tax evasion in percentage terms. 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. lam is the probability mass at zero cost of using non cash instruments.