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Fighting Tax Evasion by Discouraging the Use of Cash?*

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Abstract

We propose a bargaining model of tax evasion with a seller that offers a price discount to a buyer in exchange for a cash payment without a receipt, which allows tax evasion. We study the effect on evasion and government revenue of two policy instruments: a tax on cash withdrawals (TCW), which imposes a cost on the buyers who pay cash, and a tax rebate conditional on having the receipt. The tax rebate reduces evasion but it is costly if tax evasion is low. The TCW reduces evasion only if it is set at a sufficiently high rate, which must be higher the larger is the mass of cash users. We also show that the implementation of a TCW, which poses several challenges, is easier if the cost of cash hoarding is high.

Policy points

- European data show that a higher frequency of cashless payments is actually associated with lower tax evasion. This evidence suggests that

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policies aimed at discouraging the use of cash might actually help curb tax evasion.

- We propose a model of collaborative tax evasion to study the effect of two such policies: a tax on cash withdrawals from ATMs and bank tellers and a tax rebate for customers who keep the receipt from a transaction.
- A tax rebate is a transfer to the (already) honest taxpayers. This implies a high cost for the government when tax evasion is already low, suggesting that such a policy is best used in the context of high levels of evasion.
- Since the rate of the TCW should be higher the larger is the mass of cash users, our results suggest that such a policy is more likely to work exactly in those countries where cashless payments are more widespread. We also show that the tax is problematic, because it can foster a cash economy, unless its rate is lower than the cost of cash hoarding. For this and other reasons, we are wary of introducing a TCW.

I. Introduction

Starting with Allingham and Sandmo (1972), the bulk of the tax evasion literature has focused on individual sellers. What is in general missing in these works, with few exceptions, is a focus on the interaction between sellers and buyers and an active role for the buyers, since they can hamper any evasion attempt by simply asking for a receipt or paying with a credit card. Therefore there is an incentive for the sellers to bargain with them, offering a price discount to induce cooperative behaviour. If they reach a deal, there is a form of cooperative tax evasion (or collaborative tax evasion). The crucial element of this specific type of tax evasion is that the underlying transaction must be settled in cash, since traceable payments are hard to conceal.

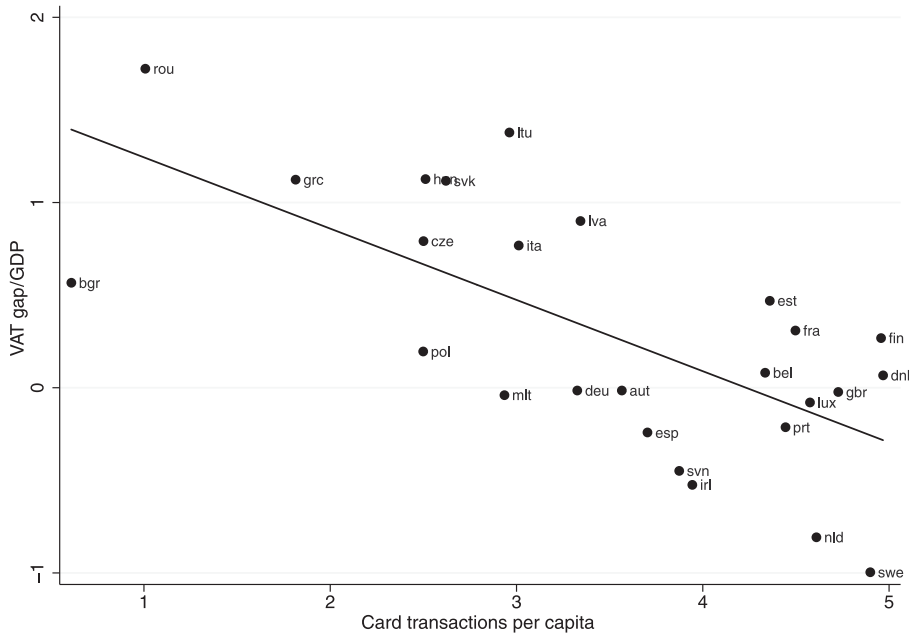
Figure 1 shows that, in Europe, a higher frequency of cashless payments is actually associated with lower tax evasion. The figure plots the average VAT gap, equal to the difference between the theoretical VAT liability and the actual VAT revenue, against the average number of credit and debit card transactions per capita for the period 2000–12. The relationship is clearly negative: countries with more card payments are also characterised by lower VAT evasion. Similar results are obtained when we consider specific years in the sample or alternative indicators of the frequency of cashless payments, such as the number of point of sale (POS) transactions per capita and the number of wire transfers per capita. This evidence suggests that policies aimed at discouraging the use of cash might actually help curb tax evasion.

We propose a model of collaborative tax evasion to study the effect of one such policy: a tax on cash withdrawals (TCW) from ATMs and bank tellers. The model, differently from most of the literature on tax evasion,[1]

[1] Sandmo, 2005; Slemrod, 2007.

FIGURE 1

Card payments and tax evasion in Europe, 2000–12



Note: The countries included are Austria (aut), Belgium (bel), Bulgaria (bgr), Czech Republic (cze), Denmark (dnk), Estonia (est), Finland (fin), France (fra), Germany (deu), Greece (grc), Hungary (hun), Ireland (irl), Italy (ita), Latvia (lva), Lithuania (ltu), Luxembourg (lux), Malta (mlt), the Netherlands (nld), Poland (pol), Portugal (prt), Romania (rou), Slovakia (svk), Slovenia (svn), Spain (esp), Sweden (swe) and the United Kingdom (gbr).

Source: Y axis – log of the ratio between VAT GAP and GDP from CASE and CPB (2014). X axis – log of the number of debit and credit card transactions per capita from European Central Bank (ECB) payment statistics. Average value between 2000 and 2012.

focuses on the interaction between the seller and the buyer in a transaction with evasion, rather than the decision to evade by a stand-alone seller, and thus emphasises the role of policies that can potentially hamper the cooperation between them. More specifically, by increasing the cost of cash payments, the TCW should reduce the buyer's gain from cooperation and thereby reduce tax evasion.

We also study the effects of a related policy: a tax rebate for customers who keep the receipt from the transaction. Similarly to the TCW, this tax rebate decreases the buyer's incentive to cooperate with the seller, since the receipt builds a paper trail of the transaction, which makes it difficult to evade tax.

We model price-taking sellers that enter into a bargaining round with their customers, offering a price discount in exchange for not issuing a receipt. A deal forces the customer to pay cash, to avoid traces of the transaction. Without a deal, there is no discount for the customer, but this leaves him free to choose between cash and non-cash payments. Sellers are heterogeneous with respect to their honesty or tax morale. Customers are heterogeneous in two dimensions: their tax morale and their cost of managing cashless payments. The government commits to a policy before the bargaining game, choosing a tax rebate and a TCW rate.

If buyers and sellers are risk neutral, we have a closed-form solution for the equilibrium levels of tax evasion and government revenue, which allows us to study their comparative statics analytically. We show that a small tax rebate reduces tax evasion and increases government revenue. Since the rebate is a transfer to the (already) honest taxpayers, it is best used in the context of high levels of evasion and at a rate that increases with evasion and with the underlying tax rate.

As for the TCW, we show that it can actually increase evasion, especially in economies where the use of cash is more frequent. The reason is that it makes cooperation more attractive for buyers whose costs of making cashless payments are high. A cooperative buyer pays the TCW on the price of the good net of the discount, while a non-cooperative buyer pays it on the full price. On the other hand, the higher is the TCW, the smaller is the number of cash users and, therefore, the lower is the level of tax evasion. We show that the first effect prevails at low TCW rates, while the second prevails at high rates. We conclude that the TCW is effective at reducing evasion only if its rate is high enough. For instance, the TCW rate must be higher if there are many individuals with high costs of making cashless payments and if the starting level of tax evasion is high.

The TCW is also highly problematic to implement, since it can foster the emergence of a cash economy:[2] if it is costly to withdraw cash from the banking system, there is an incentive to hoard it at home. However, hoarding is also costly, because cash must be stored and protected from theft and because there is inflation. We show that these costs impose an upper bound on the maximum feasible TCW.

The rest of the paper is organised as follows. Section II summarises the related economics literature. Section III describes the baseline model and Section IV illustrates our results. In Section V, we extend the baseline model to include costly cash hoarding. We comment on efficiency in Section VI and on the policy relevance of our results in Section VII, where we also offer some concluding remarks.

[2]Morse, Karlinsky and Bankman, 2009.

II. Related literature

This paper follows the quite abundant economics literature on tax evasion, which has already been extensively reviewed.[3] Despite this abundance, however, there are very few works that deal specifically with cooperative tax evasion or, in other words, that analyse evasion as the outcome of the interaction between a seller and a buyer.

The first 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. Fedeli and Forte (1999) consider instead the bargaining between all the sellers and buyers along the chain of exchanges from producers to final consumers. Boadway, Marceau and Mongrain (2002) model evasion as the collusion between a buyer and a seller. They assume that joint evasion efforts can reduce the detection probability more than individual efforts, which gives an incentive to cooperate. They show that tax evasion might actually increase in the case of harsher sanctions because of the bigger gains from cooperation. Chang and Lai (2004) also model evasion as a bargaining between a seller and a buyer, but to tackle a different question – namely, how social norms shape the agents' incentives. In particular, evading taxes induces psychological costs associated with the feelings of guilt and shame, and these costs are high if there is a social sanction against evasion. The authors show that, if the economy is in a bad equilibrium with widespread evasion, tighter enforcement can actually increase evasion, since it increases the gains from trade. The main difference between these previous works and ours is that, instead of focusing on fines and enforcement, we study the effects of two different policy instruments: the tax rebate and the tax on cash withdrawals.

Piolatto (2015) deals with tax rebates when the legal and underground markets are separate. Although his model is not a proper representation of cooperative tax evasion, he reaches conclusions similar to ours: it is possible to increase the tax proceeds by choosing a suitable level of tax rebate. However, the conditions needed to obtain this result in our setting are more restrictive because there is the additional problem of limiting the cooperation between the seller and the buyer. Arbex and Mattos (2015) also consider the equilibrium effect of tax rebates for customers who ask for receipts, and their optimal design, but do not consider the possible negotiation between buyers and sellers.

The idea of taxing currency dates back to the work of Gesell (1916) and has been discussed by Goodfriend (2000), Buiter and Panigirtzoglou (2003), Buiter (2009), Mankiw (2009) and Rogoff (2014). However, the main focus of all these contributions is how to overcome the zero bound on interest rates faced by the central banks, which is a consequence of the existence of paper currency.

[3]Cowell, 1990; Andreoni, Erard and Feinstein, 1998; Slemrod and Yitzhaki, 2002; Marchese, 2004; Sandmo, 2005; Slemrod, 2007.

In a nutshell, if only bank deposits and electronic payments were available, there would in principle be the possibility of charging negative interest rates, which is akin to taxing currency. In this paper, we abstract completely from these monetary policy issues, to investigate instead whether there is potential for a currency tax to act as a tool to limit tax evasion.

The only work that proposes a tax on cash to fight evasion is Benshalom (2012). His paper offers a thorough discussion of the potential effectiveness of this tax and of its implementation challenges, but it lacks a formal analysis. In this work, we propose instead a model to study the economics of the tax on cash. To our knowledge, it is the first attempt in this direction. Consequently, we are the first to suggest that: (i) a TCW can backfire, encouraging tax evasion, especially if its marginal rate is low; (ii) the TCW rate should be higher the larger is the mass of cash users; and (iii) the implementation of the TCW is easier if the cost of cash hoarding is high.

In a related contribution, Gordon and Li (2009) note that firms and the self-employed can avoid taxes by using cash in all their transactions, but the cost of this strategy is the impossibility of using the financial sector. Therefore, the lower is the benefit of using financial services, the higher is the probability that a firm facing a tax increase will move to the informal sector. This mechanism can explain why developing countries, without fully developed financial systems, can have a hard time taxing income.

Our work is also related to the literature on inflation tax,[4] since the TCW reduces purchasing power. However, the TCW, unlike an inflation tax, discourages cash withdrawals but without discouraging cash hoarding. Thus, since cash-hoarding costs ease the implementation of the TCW, there is a complementarity between the TCW and an inflation tax. In two related contributions, Nicolini (1998) and Koreshkova (2006) discuss the role of inflation as a tax on the underground economy. With respect to their work, we take a different perspective, since we focus on how to increase revenue by reducing the number of concealed transactions, rather than by taxing them.

III. The model

The economy is composed of risk-neutral, price-taking sellers, risk-neutral buyers and the government. The buyers are heterogeneous along two dimensions. The first is the cost of managing cashless payments, such as credit and debit cards, which can be very high for some individuals – for example, the elderly[5] or the less financially educated – but very low for others. Moreover, some buyers are uncomfortable with the idea that their purchases

[4]Friedman (1969), Phelps (1973), Chamley (1985) and Woodford (1990), among others.
[5]Humphrey, Kim and Vale, 2001.

will be tracked and they are willing to pay a price for anonymity.[6] The second dimension is honesty, or tax morale,[7] which compels some buyers to always ask for a receipt, preventing tax evasion, while others choose to bargain with sellers. The sellers are heterogeneous only with respect to honesty or tax morale.

We assume that tax evasion is possible only if there is a cash payment without a receipt, thus leaving no paper trail for the transaction. In such a setting, as indeed holds in many real-world situations (doctors, contractors, plumbers, etc.), a negotiation between the seller and the buyer is likely, with the seller offering a price discount to the buyer in exchange for a cash payment without a receipt. If the buyer and the seller do not reach a deal, tax evasion is not possible, and the buyer is free to choose between cash and non-cash payments.

The government has two policy instruments: a tax rebate $\tau \in [0, \bar{\tau}]$ for buyers who keep the receipt from the transaction, and a tax on cash withdrawals $\vartheta \in [0, \bar{\vartheta}]$ from ATMs or bank tellers. We assume that the government commits to a policy $\mathscr{P} = \{\tau, \vartheta\}$ before the bargaining between the seller and the buyer takes place. We study two different government objectives: the reduction of tax evasion and the maximisation 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 *cooperative tax evasion*. We assume that the seller can either evade the full tax liability of the transaction or nothing, without loss of generality given the assumption of risk neutrality.[8]

1. Sellers and buyers

The expected value for the seller in the case of tax evasion, which requires cooperation from the buyer, is the following:

$$
\begin{aligned}
(1) \qquad v_s^1 &= (1-\pi_s)\,[p(1-t_s) + p\,t_s - d - h] \\
&\quad + \pi_s\,[p(1-t_s) - d - p\,t_s\,f_s - h] \\
&= p(1-t_s) + p\,t_s\,[1 - \pi_s(1+f_s)] - d - h,
\end{aligned}
$$

where p is the price of the good (taken as given by the seller), $t_s < 1$ is the income tax for the seller, d is the discount bargained with the buyer, π_s is the

[6] Garcia-Swartz, Hahn and Layne-Farrar, 2006.

[7] Gordon, 1989; Myles and Naylor, 1996; Andreoni, Erard and Feinstein, 1998; Feld and Frey, 2002; Orviska and Hudson, 2003; Traxler, 2010; Hug and Spörri, 2011.

[8] Details available upon request.

audit probability for the seller,[9] f_s is the fine and h is the seller's cost of tax evasion, which reflects differences in honesty between sellers. We assume that h is distributed according to the cdf G_h, whose pdf is g_h.[10] When no audit occurs, with probability $1 - \pi_s$, the seller earns the evaded amount $p\,t_s$. Where an audit does occur, the seller is forced instead to pay the full amount of taxes plus a fine, which is computed on the evaded amount as $p\,t_s\,f_s$.[11]

If the buyer and the seller do not reach a deal, the value is simply

$$v_s^0 = p(1 - t_s). \tag{2}$$

Comparing v_s^0 with v_s^1, we note that the cost of evading is $d + h$, while the benefit is the evaded amount minus the expected sanction. To make the analysis interesting, we assume that $1 - \pi_s(1 + f_s) > 0$, so that a trade-off exists. This assumption implies that there must be upper bounds to the audit probability π_s and the fine f_s, which seems reasonable.

A buyer that cooperates with the seller accepts a price discount in exchange for paying cash. In this baseline model, we assume that cash must always be withdrawn from the banking system (we relax this assumption in Section V). The expected value for the buyer is the following:

$$v_b^1 = u - (p - d)(1 + \vartheta) - \pi_b p\,t_b(1 + f_b) - s, \tag{3}$$

where u is the benefit from purchasing the good, t_b is a sales tax, π_b is the audit probability for the buyer, f_b is the fine, ϑ is the rate of the TCW, which is paid on the effective amount of the transaction $p - d$, and s is the buyer's cost of tax evasion (or tax morale), distributed according to the cdf G_s (with pdf g_s). We assume that, when an audit occurs, the buyer is forced to pay the tax plus a fine computed on the evaded amount: $p\,t_b(1 + f_b)$ in total.

A buyer that does not cooperate with the seller is entitled to the tax rebate, conditional on having the receipt from the transaction, which we assume he asks for. The non-cooperative buyer is also free to choose whether to use cash

[9] The assumption of a constant auditing probability, which does not depend on the seller's characteristics or on the evaded amount, is a simplification. In practice, a big firm that evades 90 per cent of its profits faces a higher audit probability than a small, less visible, business that seldom evades (Yitzhaki, 1987). We make this assumption because this probability does not affect the main conclusions of our analysis. We also abstract from congestion effects in law enforcement (Galbiati and Zanella, 2012), which imply that, for a fixed amount of government resources, the individual audit probability decreases with the number of evaders. Moreover, the model does not allow for the backfiring effects of enforcement highlighted by Borck (2004).

[10] The cdf is the cumulative distribution function and the pdf is the probability density function.

[11] We set a fine for discovered evasion which depends on the tax understatement ($p\,t_s$) following Yitzhaki (1974), differently from Allingham and Sandmo (1972), who model a fine on the income understatement (p).

or a different payment method, such as a credit or debit card. In the case of a cash payment, his value is

$$v_b^0(cash) = u - p\left[1 + t_b - \tau + (1 + t_b)\vartheta\right], \tag{4}$$

where τ is the tax rebate on the full amount of the transaction p. In the case of a cashless payment, his value is instead

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

where c, the cost of managing electronic payments, is distributed independently from s according to the cdf G_c (with pdf g_c). For simplicity, in this baseline version of the model, we normalise the cost of cash to zero. In practice, this cost is positive, because cash must be withdrawn, stored and protected from theft and because there is inflation. We consider these costs explicitly in Section V. For the time being, we also abstract from the buyers who benefit from the use of cashless payments, with negative c (see the discussion following Proposition 1 in Section IV.1).

Comparing the two possible values for the non-cooperative buyer, we see that cash is preferred if and only if $c \geq p(1 + t_b)\vartheta$. If we define $\Upsilon = p(1 + t_b)\vartheta$, we can write the value for the non-cooperative buyer as

$$v_b^0 = u - p(1 + t_b - \tau) - min\left\{\Upsilon, c\right\}. \tag{6}$$

Finally, notice 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. Nevertheless, both instruments indirectly affect the behaviour of the seller through the bargained discount.

Remark. Note that without a positive cost c of managing electronic payments, no buyer would ever use cash and the model would be unable to tell us anything about the effect of a TCW. However, we do not need any particular assumption about the distribution of c in order to derive the results. Although we have assumed an additive cost c for a cashless payment, this is only done for simplicity. In fact, banks might also charge a proportional fee for their services; however, this proportional component does not affect our results and would only complicate the notation. Specifically, a proportional fee t_c would only change the threshold favouring cash over cards from $\Upsilon = p(1 + t_b)\vartheta$ to $\Upsilon_c = p[(1 + t_b)\vartheta - t_c]$, otherwise leaving all results unaffected.

2. Equilibrium

We model the negotiation between the seller and the buyer as a Nash bargaining. The solution is defined by

$$(7) \qquad d^* = \arg\max_d \; (v_s^1 - v_s^0)^\beta \, (v_b^1 - v_b^0)^{1-\beta}$$
$$s.t. \quad v_s^1 \geq v_s^0 \, , v_b^1 \geq v_b^0,$$

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

$$(8) \qquad d^*(h,s,c) = \beta \frac{p(\tau + \vartheta - t_b) + \pi_b p \, t_b(1+f_b) + s - \min\{\Upsilon, c\}}{1+\vartheta}$$
$$+ (1-\beta)\{p \, t_s \, [1 - \pi_s(1+f_s)] - h\}$$

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

$$(9) \qquad h \leq p \, t_s \, [1 - \pi_s(1+f_s)] - d^*(h,s,c)$$

and

$$(10) \qquad s \leq d^*(h,s,c)(1+\vartheta) - p(\tau + \vartheta - t_b)$$
$$-\pi_b p \, t_b(1+f_b) + \min\{\Upsilon, c\} \, .$$

If conditions 9 and 10 do not hold, there is no evasion and the optimal discount is zero.

Plugging the optimal discount (equation 8) into 10, we find

$$(11) \qquad s \leq (1+\vartheta) \left\{ p \, t_s \, [1 - \pi_s(1+f_s)] - h \right.$$
$$\left. - \frac{p(\tau + \vartheta - t_b) + \pi_b p \, t_b(1+f_b) - \min\{\Upsilon, c\}}{1+\vartheta} \right\}.$$

We then use condition 11 to compute the equilibrium level of tax evasion. First, we consider the buyers with $c \leq \Upsilon$, substituting c for $\min\{\Upsilon, c\}$ in expression 11, to obtain a threshold value $\tilde{s}_1(h,c)$ such that all the buyers of type $c \leq \Upsilon$ with honesty lower than $\tilde{s}_1(h,c)$ cooperate. Next we define the level of seller honesty $\tilde{h}_1$ that makes no buyer willing to collaborate. Doing the same for $c \geq \Upsilon$, substituting Υ for $\min\{\Upsilon, c\}$ in expression 11, we obtain a second threshold $\tilde{s}_2(h)$ (which does not depend on c and coincides with $\tilde{s}_1(h,c)$ for $c = \Upsilon$), such that all the buyers of type $c \geq \Upsilon$ with honesty lower than

$\tilde{s}_2(h)$ cooperate. We also define the level of seller honesty $\tilde{h}_2$ such that no buyer is willing to collaborate. Using the previously defined thresholds, we get the following expression for total tax evasion:

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

where $E_c(c) = \int_0^{\tilde{h}_1} \int_0^{\tilde{s}_1(h,c)} g_s\, g_h\, ds\, dh$ is the mass of evaders with low c, while $E^c = \int_0^{\tilde{h}_2} \int_0^{\tilde{s}_2(h)} g_s\, g_h\, ds\, dh$ is the mass of evaders with high c. Next, we compute total government revenue, which is equal to

$$\begin{aligned} G = \int_0^{\Upsilon} & \{[p\,T + (p - d^*(h,s,c))\,\vartheta]\, E_c(c) \\ & + p(t_s + t_b - \tau)\,[1 - E_c(c)]\}\, g_c dc \\ & + [1 - G_c(\Upsilon)]\,\{[p\,T + (p - d^*(h,s,c))\,\vartheta]\, E^c \\ & + [p(t_s + t_b - \tau) + \Upsilon]\,(1 - E^c)\}, \end{aligned} \tag{13}$$

where $T = \pi_s t_s (1 + f_s) + \pi_b t_b (1 + f_b)$. The first two lines are the revenue from transactions with low-c buyers. In the case of evasion and an audit, both sellers and buyers are forced to pay the tax, augmented by a fine on the evaded amount, i.e. pT. Since cash is used in these transactions, there is an additional revenue of $\vartheta(p - d)$. When the matching does not lead to evasion, the government revenue is instead equal to the taxes net of the rebate, $p(t_s + t_b - \tau)$. The last two lines are the revenue from transactions with high-c buyers. In the case of evasion, the government revenue is the same as in the case of low-c buyers. In the matchings without tax evasion, the government earns instead $p(t_s + t_b - \tau) + \Upsilon$, since it also collects the TCW from the non-cooperative buyers who prefer cash. Indeed, the TCW levied on those individuals is a pure transfer to the government and it should be reimbursed in order to leave the buyers' purchasing power unchanged.

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

$$\int_0^{\Upsilon} c\,[1 - E_c(c)]\, g_c dc. \tag{14}$$

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.

IV. Comparative statics

In this section, we analyse the effect of the tax rebate and of the TCW on the model equilibrium. Our main goal is to understand whether they are effective at fighting evasion (Section IV.1) and raising revenue (Section IV.2).

1. Tax evasion

We start with the effect of a tax rebate on tax evasion. Differentiating E with respect to τ, we have

$$\frac{\partial E}{\partial \tau} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial \tau} g_c dc + [1 - G_c(\Upsilon)] \frac{\partial E^c}{\partial \tau}, \tag{15}$$

which is negative since

$$\frac{\partial E_c(c)}{\partial \tau} = -\int_0^{\tilde{h}_1} p\, g_s\left(\tilde{s}_1(h,c)\right) g_h\, dh \tag{16}$$

and

$$\frac{\partial E^c}{\partial \tau} = -\int_0^{\tilde{h}_2} p\, g_s\left(\tilde{s}_2(h)\right) g_h\, dh \tag{17}$$

are both negative. Increasing the tax rebate τ reduces the buyer's incentive to cooperate with the seller, reducing evasion. Therefore, the optimal policy for a government whose only objective is to reduce evasion entails setting the tax rebate at its upper bound $\bar{\tau}$. In the next subsection, we analyse the cost of this policy, looking at its impact on revenue.

The effect of the TCW on evasion is instead in general ambiguous. The reason is that the threshold $\tilde{s}_1(h,c)$, for buyers with $c \leq \Upsilon$, is decreasing in ϑ, while the threshold $\tilde{s}_2(h)$, for buyers with $c \geq \Upsilon$, is increasing. In other words, high-c buyers prefer to use cash even if they do not cooperate with the seller. The TCW does not impose an extra cost on them, but it actually makes cooperation more attractive: a cooperative buyer pays ϑ on the price net of the discount $p - d$, while a non-cooperative buyer pays it on the full price p. Conversely, non-cooperative low-c buyers prefer to bear this cost to make a cashless payment and, therefore, an increase in the TCW makes cooperation relatively more costly for them. More formally, applying Leibnitz's integral differential rule, we have

$$\frac{\partial E}{\partial \vartheta} = \int_0^{\Upsilon} \frac{\partial E_c(c)}{\partial \vartheta} g_c dc + [1 - G_c(\Upsilon)] \frac{\partial E^c}{\partial \vartheta} + \frac{\partial \Upsilon}{\partial \vartheta} g_c(\Upsilon) \left[E_c(\Upsilon) - E^c\right]. \tag{18}$$

The last term cancels out because, for $c = \Upsilon$, $\tilde{s}_1(h, \Upsilon) = \tilde{s}_2(h)$, implying that $E_c(\Upsilon) = E^c$. Moreover, we have

$$(19) \quad \frac{\partial E_c(c)}{\partial \vartheta} = \int_0^{\tilde{h}_1} g_s\left(\tilde{s}_1(h, c)\right)\{p\, t_s\,[1 - \pi_s(1 + f_s)] - h - p\}\, g_h dh < 0$$

because $t_s < 1$ (by assumption) and $0 \leq 1 - \pi_s(1 + f_s) \leq 1$ (by assumption). We also have

$$(20) \quad \frac{\partial E^c}{\partial \vartheta} = \int_0^{\tilde{h}_2} g_s\left(\tilde{s}_2(h)\right)\{p\, t_s\,[1 - \pi_s(1 + f_s)] - h + p\, t_b\}\, g_h dh > 0.$$

The net effect of ϑ on tax evasion depends on the relative magnitude of 19 and 20. Consider the case of $\vartheta = 0$. Given that Υ is also equal to zero, it follows that all non-cooperative buyers prefer cash. Therefore, we have that $\frac{\partial E}{\partial \vartheta} = \frac{\partial E^c}{\partial \vartheta} > 0$ so that, by continuity, a small TCW always increases evasion. Conversely, for a high TCW, Υ is also high, meaning that there is a big mass of buyers that opt for cashless payments. In this case, the negative effect of the TCW on evasion, captured by 19, is large. We summarise the previous analysis in the following proposition:[12]

Proposition 1. *Tax evasion is always decreasing in the tax rebate τ. The TCW is an effective tool to fight tax evasion only at sufficiently high rates.*

Proposition 1 warns against the use of the TCW to fight tax evasion: there could be a backfiring effect, especially if there is a big mass of buyers with high costs of cashless payments who use cash regardless of the cooperation with the seller. However, if there is a non-zero mass of buyers choosing cashless payments at $\vartheta = 0$, perhaps because of a negative c, this backfiring effect is less likely. This conjecture is easily proved by a simple, although extreme, example. Assume that, for $\vartheta = 0$, all buyers prefer cashless payments when not cooperating. In this case, an increase in ϑ decreases tax evasion for all buyers, regardless of honesty ($E = E_c(c)$) and regardless of the level of ϑ. In practice, they all behave as low-c buyers. We have the following result:

Proposition 2. *If cashless payments are sufficiently widespread, the TCW is an effective tool to fight tax evasion regardless of its level.*

Proposition 2 implies that the actual distribution of the cost c of managing electronic payments is a crucial determinant of the effect of the TCW on tax evasion. Moreover, Proposition 1 has shown how important the heterogeneity in the cost c – i.e. the existence of both high- and low-c buyers – is for our results.

[12] A minimum for the tax evasion minimisation problem exists since the function E is a real-valued continuous function on a non-empty compact domain (Weierstrass Theorem).

2. Net government revenue

We now analyse the effect of the tax rebate and of the TCW on government revenue, since one of the main goals of the fight against tax evasion is to increase tax proceeds. Again we start with the tax rebate. We define $R_c = p\,t_s[\pi_s(1+f_s)-1] + p\,t_b[\pi_b(1+f_b)-1] + [p - d^*(h,s,c)]\vartheta + p\,\tau$ and $R^c = p\,t_s[\pi_s(1+f_s)-1] + p\,t_b[\pi_b(1+f_b)-1] + [p - d^*(h,s,c)]\vartheta + p\,\tau - \Upsilon$. Note first that the sign of both R_c and R^c is, in general, ambiguous, but it is more likely to be negative if t_s is sufficiently large, since $\pi_s(1+f_s)-1$ is negative by assumption. Then we have

$$\frac{\partial G_n}{\partial \tau} = \int_0^{\Upsilon} R_c \frac{\partial E_c(c)}{\partial \tau} g_c dc + (1 - G_c(\Upsilon))\, R^c \frac{\partial E^c}{\partial \tau} - p(1-E) - \frac{\beta p \vartheta}{1+\vartheta} E + \int_0^{\Upsilon} c \frac{\partial E_c(c)}{\partial \tau} g_c dc. \tag{21}$$

The first two terms in equation 21 summarise the effect of the rebate on evasion. In particular, the mass of evaders is always decreasing in the rebate, but the effect on revenue is ambiguous unless the tax rates t_s and t_b are so high that the revenue raised from the new honest taxpayers, net of the rebate, is bigger than the revenue lost from the dishonest ones (through sanctions and the TCW).

The third term is the negative effect on the revenue collected from non-evaders $(1 - E)$, the magnitude of which increases with τ. It is due to the fact that the tax rebate is a transfer from the government to the honest buyers, who are compensated by more if τ increases. The bigger is τ, the smaller is tax evasion and, therefore, the bigger is the cost of fighting it, because there is a bigger mass of non-evaders to compensate and because the compensation for each transaction is bigger. This intuition suggests a potential hump-shaped response of revenue to τ. Furthermore, if there are more honest individuals, with a high cost of evasion, there will be less evasion in equilibrium and, therefore, fighting it with a rebate will be more costly. The hump-shaped response will be less pronounced in this case and, if evasion is low enough to start with, we could also have revenue decreasing in τ. Similarly, the lower is the tax rate, the lower is evasion and, therefore, the less pronounced is the hump, if it exists at all.

There are two further effects of τ on revenue. Since the equilibrium discount increases with the tax rebate, a bigger τ also implies lower revenue from the TCW, captured by the fourth term in equation 21, and a higher cost imposed on the non-cooperative buyers who opt for cashless payments, summarised by the last term. In other words, a high TCW rate makes the tax rebate a less desirable option to fight evasion. Therefore we have the following result:

Proposition 3. *The tax rebate τ decreases government revenue if the tax rates are low or where there are many honest individuals.*

Unfortunately, the analysis of the comparative statics of revenue with respect to ϑ is quite complicated. In particular, an increase in ϑ increases the mass of evaders with high c and decreases the mass of evaders with low c. In the first case, the government loses revenue, but it also saves on the rebate. In the second case, it gains tax revenue, but at the cost of a higher rebate. Moreover, a higher ϑ also increases the revenue at the intensive margin, from both evaders and non-evaders. There is also an effect on the equilibrium discount, which increases for evaders with high c and decreases for evaders with low c. Given the large number of contrasting effects, we conclude that, in general, the effect of the TCW on government revenue is ambiguous.

V. Costly cash hoarding

In the previous analysis, we normalised the cost of cash to zero, but this is unlikely to be true because cash must be withdrawn, stored and protected from theft and because its nominal value is eroded by inflation. In this section, we extend the baseline model to include these costs and we discuss the consequences for our analysis.

The first important consequence is an easier implementation of the TCW. The problem is that the TCW can foster the emergence of a cash economy:[13] if withdrawing cash from the banking system is costly, there is an incentive to keep it at home. In other words, the TCW discourages cash withdrawals but it does not discourage cash hoarding. Nevertheless, there will still be individuals who prefer bank deposits if cash is not costless. For instance, many businesses need financing and, to have access to it, they need a bank deposit. Cash hoarding is very costly for them since it limits their access to the financial system, and it is unlikely that they will completely switch to cash even in the face of an increasing TCW, at least if its rate is not too high.

We extend the model to include an additional cost i for buyers who hoard cash. For simplicity, we assume that this cost is the same for all buyers, but the model could be extended to the case of heterogeneous costs. Moreover, in our static, single-transaction model, the sellers do not have any reason to hoard cash, so we do not include a cost for them.[14] In this extended model, the value for a cooperative buyer is

$$v_b^{1H} = u - (p - d)(1 + min\{\vartheta, i\}) - \pi_b p\, t_b(1 + f_b) - s \tag{22}$$

[13]Morse, Karlinsky and Bankman, 2009.

[14]The alternative is a fully-fledged dynamic cash management model à la Miller and Orr (1966), where each agent has to cover its purchases with cash but also receives cash inflows. This extension would, however, substantially complicate the analysis.

because there is a choice between paying with withdrawn cash, at a cost ϑ, or hoarded cash, at a cost i. The reason this cost is proportional to the price is as follows. In our single-transaction model with complete information, the only reason for the buyer to hoard cash is to pay for the object of the transaction, whose price is p. Therefore, the higher the price of the good or service, the larger the amount of cash she needs to hoard and the larger the expected cost she will bear, both in terms of risk of theft and in terms of loss of value due to inflation.

Conversely, a non-cooperative buyer can choose between making a cash payment with hoarded cash, a cash payment with withdrawn cash or a cashless payment. His value is

$$v_b^{0H} = u - p(1 + t_b - \tau) - min\{p(1 + t_b)\vartheta, p(1 + t_b)i, c\}. \quad (23)$$

Since both the cost i and the tax ϑ are the same for all buyers, we have only two possibilities for the cash users: if $\vartheta \leq i$, they choose to withdraw cash from the bank (we assume that the buyer prefers to withdraw if indifferent), which means that the previous analysis is unaffected; if $\vartheta > i$, they choose to use hoarded cash. In this second case, we need to replace ϑ with i everywhere in the model equilibrium (discount, thresholds, tax evasion). Since ϑ is now absent from the new expression for tax evasion, we have the following result:

Proposition 4. *The TCW ϑ is not effective in fighting tax evasion if set higher than the cost of cash hoarding i.*

Proposition 4 identifies a limit to the possibility of taxing cash withdrawals to fight evasion. To use the TCW, the government needs either to raise the cost of cash i or to keep the TCW low. Putting it differently, Proposition 4 states that the costs of cash are complementary to the TCW, in the sense that they ease its implementation.

Consider, for instance, inflation (perhaps the main cost of cash hoarding) and suppose that interest-bearing bank accounts are available, with an interest rate that partially or totally compensates for inflation. The sellers will then have a lower incentive to evade because accepting cash is more costly: in order to avoid the inflation tax, they have to deposit their cash earnings in a bank account, but doing so will increase the probability of a tax audit.

Inflation, however, is a costly way to implement the TCW. An alternative policy, proposed by Mankiw (2009), is to have a lottery on the actual banknotes in circulation. Specifically, the lottery is based on the last (one or two) digits of the serial numbers of the banknotes that, if extracted, make the 'winners' worthless. For a lottery based on the last two digits, it means that a twentieth

of the banknotes will be withdrawn from circulation at each lottery extraction, which is equivalent to a 5 per cent tax on cash hoardings.[15]

While Proposition 4 claims that the TCW is effective only if it is set at a low rate, Proposition 1 instead claims it is effective only if it is set at a sufficiently high rate. The question, then, is whether it is possible to find a TCW rate high enough to fight evasion but still lower than the cost of cash hoarding. The answer obviously depends on the details of the economy.[16]

VI. Efficiency

One potential side effect of the TCW is the reduction in the volume of trade, resulting from the increased transaction costs for buyers. In this section, we show how setting the tax to avoid this efficiency loss implies an upper bound to the TCW.

First of all, the value for a seller that does not engage in tax evasion is $v_s^0 = p(1 - t_s)$, which is always positive for any $t_s < 1$. In other words, the TCW does not affect the willingness of the seller to supply the good. Indeed, the TCW decreases only the seller's revenue under tax evasion v_s^1 through the discount, while leaving the pay-off under non-evasion v_s^0 unaffected.

Conversely, the policy does affect the buyer's gains from trade, both in the case of cooperative tax evasion v_b^1 and, more importantly, in the case of non-cooperation v_b^0. To guarantee that the buyer always has an incentive to trade, we must have that $v_b^0 = u - p(1 + t_b - \tau) - \min\{\Upsilon, c\} \geq 0$ for any possible cost c and for any policy $\{\tau, \vartheta, t_b\}$. A sufficient condition is that $u - p(1 + t_b - \tau) - \Upsilon \geq 0$ for any policy $\{\tau, \vartheta, t_b\}$. We can rewrite this condition as

$$u - p \geq p\vartheta(1 + t_b) - p(\tau - t_b) \quad \text{for any } \{\tau, \vartheta, t_b\}. \tag{24}$$

In other 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

[15] Another possibility to discourage cash hoarding is the introduction of a ban on cash transactions above a certain threshold, for both financial and non-financial products. Similar laws are in place, for example, in France, Italy and Portugal, and several central European countries are discussing comparable regulations. Assuming that a ban on cash payments above, say, €1,000 is strictly enforced, the revenue consequences of a TCW could become small. For other mechanisms to prevent cash hoarding, see the discussion in Benshalom (2012).

[16] In a previous version of the paper, we solved the model numerically using Italy as calibration target. We used 15 per cent as a target average tax evasion, 12.7 per cent as the average use of payment cards, obtained by dividing the total transactions with credit and debit cards by the consumption component of GDP, and 5 per cent as the upper bound to the TCW, equal to the cost of cash hoarding and slightly higher than average inflation. The revenue-maximising policy entails a small tax rebate of 3 per cent and the TCW at the upper bound of 5 per cent. In this case, evasion is slightly above 10 per cent and revenue is 11 per cent higher than the benchmark.

tax rebate. A sufficient condition for any level of consumer surplus ($u \geq p$) is

$$\vartheta(1 + t_b) \leq \tau - t_b, \tag{25}$$

which imposes another upper bound on the maximum feasible TCW besides the one due to the cost of cash hoarding.

VII. Conclusion

We have shown that a tax rebate for buyers who keep the receipt from a transaction can reduce evasion and increase government revenue and that the rebate must increase with the level of tax evasion. We have also shown that a tax on cash withdrawals from ATMs and bank tellers reduces evasion only if it is set at a sufficiently high rate and that its rate must grow with the prevalence of cash payments. We are aware of only two countries that have implemented a tax on cash: Pakistan in 2001 and India from 2005 to 2009 (the so-called banking cash transaction tax or BCTT). In both cases, however, the tax was not meant to reduce tax evasion directly, but rather was intended as a tool to gather information on evaders to better guide the audits.

Since the rate of the TCW should be higher the larger is the mass of cash users, our results suggest that such a policy is more likely to work exactly in those countries where cashless payments are more widespread. However, as shown in Figure 1, a higher frequency of cashless payments is actually associated with lower tax evasion, implying that those countries are the ones less in need of such a policy.

A tax rebate is a transfer to the (already) honest taxpayers. This implies a high cost for the government when tax evasion is already low, suggesting that such a policy is best used in the context of high levels of evasion. Indeed, differently from the TCW, the tax rebate is a well-known policy and it is embedded in many tax codes around the world especially in countries with high levels of evasion, sometimes creatively.[17] For instance, in China, Portugal, Puerto Rico, Taiwan and the city of São Paulo, receipts can be exchanged for lottery tickets.[18] The most attractive feature of the rebate is that it fights evasion by rewarding honesty, rather than by punishing dishonesty, since many experimental studies suggest that this strategy is preferable.[19] There also exists some evidence that such an instrument might be effective in the fight against tax evasion. For instance, Naritomi (2016) shows that, in São Paulo,

[17] Among others: in Argentina, there is a 5 per cent VAT discount on debit card transactions; in South Korea, there is a lump-sum refund if debit card purchases exceed 20 per cent of personal income; and in Italy, there is a tax deduction for medical expenses and home renovations.

[18] Marchese, 2009; Fabbri, 2013.

[19] Among others, Alm, McClelland and Schulze (1992) and Berhan and Jenkins (2005).

the introduction of a reward for customers who ask for receipts, which is akin to the tax rebate in our work, increased firms' reported revenue.

Also of relevance for our results are the recent advances in payment technologies, which include improved security of online transactions and NFC (near-field communication) for mobile phone payments. Those advances have actually decreased the cost of cashless payments. Despite this progress, however, cash use remains heavy.[20] Nevertheless, there is evidence pointing at a small decrease in cash use.[21] If cash use should decrease further, more frequent cashless payments would per se reduce evasion. Then there would be even less scope for a TCW and more scope for a tax rebate.

We also showed that a TCW is problematic, because it can foster a cash economy, unless its rate is lower than the cost of cash hoarding. Unfortunately, this is not the only implementation challenge of a TCW.[22] A second problem entails the dynamic of its introduction: if the TCW is announced and then implemented, it is likely that a bank run will take place, with individuals withdrawing cash to dodge the tax. A further problem with a TCW is how to compensate the honest taxpayers who suffer a loss after its introduction, such as the elderly or the less financially educated. Since the introduction of a TCW can actually increase tax revenue, there is, in principle, the possibility of compensation. Such compensation schemes are, however, very difficult to design.

Overall, the requirements for a TCW to work as a tool to reduce tax evasion are demanding, so we are wary of its introduction. The tax rebate is much easier to implement although it is costly.

A TCW is not the only way to limit the use of cash. An alternative, discussed by Buiter (2009), is a ban on cash transactions above a given (low) threshold. The drawbacks of this solution are the extremely high enforcement cost, the generalised loss of privacy and the high cost imposed on individuals whose cost of making cashless payments is high, which could substantially decrease their expenditure. In this perspective, we can interpret the TCW as imposing a cost on privacy and on transactions.

Another alternative to reduce the use of cash is a subsidy to cashless payments, since, in our model, decreasing c (the cost of managing electronic payments) has the same effect as increasing ϑ (the TCW). The problem is that a subsidy is costly, which means that it is unfeasible for financially constrained governments. Furthermore, it is extremely difficult to reduce c for some individuals, regardless of the magnitude and type of government expenditure: some of the costs are fees charged by banks, which can be easily

[20] Drehmann, Goodhart and Krueger, 2002; Bagnall et al., 2014.
[21] Drehmann, Goodhart and Krueger, 2002.
[22] For a thorough discussion of TCW implementation issues, we refer the reader to Benshalom (2012).

compensated, but there are also psychological (loss of privacy) and cognitive (financial literacy) costs, which are difficult, if not impossible, to eliminate.

A less obvious alternative to a TCW consists in supporting an explicit cost-based pricing of payment methods. Van Hove (2004) argues that, under current banking pricing, the fees charged to consumers for cash withdrawals do not cover the full cost of cash, which is recovered through cross-subsidisation. 'In this way, infrequent cash-users *de facto* subsidise those who make heavy use of cash (including those active in the underground economy)'.[23]

A further problem with a TCW, which we did not discuss in this paper, is related to the substitution of paper currency with electronic currency. This replacement, as discussed in Rogoff (2014), can potentially decrease evasion and increase the efficacy of monetary policy, but there are several costs: 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. Our simple model is unable to capture all these effects, so our analysis is incomplete in this dimension. We leave this topic for further research.

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[23] Van Hove, 2004, p. 80.

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