Digitization in Tax Enforcement – a Guns vs. Butter Approach

Digitalisierung im Steuervollzug – eine 'Guns vs. Butter'-Betrachtung

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Abstract — Digitization shapes overall progress and so it does for tax enforcement in particular as well. Tax payers face better evasion possibilities whereas tax authorities are getting better in disguising them. This paper presents a model framework in which individuals evade and the government decides on the optimal share of expenditures for audits on total revenues. The inclusion of digitization over time changes conditions for both players and drives the optimal allocation up or down depending on who is favored by the progress. Finally, a tangible simulation is provided in order to illustrate theoretical results.

Zusammenfassung — Digitalisierung formt den gesamten Fortschritt und damit insbesondere auch den Steuervollzug. Steuerzahler finden bessere Hinterzugsmöglichkeiten, wohingegen Behörden besser darin werden jene aufzudecken. Dieses Papier präsentiert ein Modell, in welchem Individuen hinterziehen und der Staat über den optimalen Anteil der Ausgaben für das Prüfungsverfahren am gesamten Steueraufkommen entscheidet. Das Einbeziehen von Digitalisierung mit der Zeit verändert die Bedingungen für beide Spieler und treibt die optimale Allokation in die Höhe oder Tiefe, abhängig davon wer vom Fortschritt begünstigt wird. Schlussendlich werden die theoretischen Ergebnisse mithilfe einer Simulation verdeutlicht.

I. Introduction

Within the past decades, digitization and globalization appeared to be curse and blessing at the same time. New opportunities create new fields, new jobs an simplify existing processes. However, those who do not keep up with the times will get back to the bottom of facts: In 2016 the International Consortium of Investigative Journalists (ICIJ) revealed the Panama Papers, itself providing the information on current offshore tax evasion. Authorities face more sophisticated circumvention measures and tax payers incentives of being dishonest rise with the more and more widing range of possibilities. Alstadsæter et al. (2019) [1] perform an analysis on the extend of Scandinavia's offshore evasion based on several leaked data. At that time, tax authorities were simply not able to trace complicated evasion structures, but digitization also enables more sophisticated audits. Communication between foreign authorities becomes easier and upcoming reporting requirements scotch less elaborated evasion possibilities. Bacchetta and Espinosa (1995) [2] describe the advantages and limitations of information exchange from a model point of view and Keen and Ligthart – see e.g. [3] and [4] – discuss two distinct approaches in that matter.

However, these are just channels, through which digitization influences tax enforcement. The aim of this paper is to provide a model framework which considers digital progress as an explicit influence. Therefore, we adopt the canonical Allingham/Samdmo (1972) tax evasion model [5] to our needs. In a guns vs. butter approach the government could use tax revenues either for the provision of a public good or for the improvement of the auditing structure. Finally, we introduce digitization for the hunted as well as the hunters and separate the respective effects.

The remainder of this paper is organized as follows: Section II presents the model and Section III illustrates theoretical results in a small simulation application. Section IV concludes.

II. The Model

First of all, let us introduce the two players: Following the widely admitted Allingham/Sandmo (1972) model on personal tax evasion [5], we consider a risk-averse individual with exogenously given taxable base y – i.e. income, wealth or capital gains – and utility $U(y)$ derived from it. A risk-neutral government imposes a specific tax τ on each unit of y. However, the individual is able to hide amount s of y from its tax authority, though – different from the original model – it comes with costs c per hidden unit of y. In that case, the available net stock displays as

$$y^{na}(s) := y - \tau \cdot (y - s) - cs.$$

The tax authority, in turn, performs random audits and picks the individual with probability $p \in (0, 1)$. In case of being audited, the tax officer is able to reveal the real extend of evasion. By this, additional to the taxes on the hidden amount, a penalty payment of order $f \cdot \tau$ per unit of s is enforced. In the bad case, the individual faces

$$y^{a}(s) := (1 - \tau) \cdot y - (c + f\tau) \cdot s.$$

In an expected utility maximization approach the individual chooses $s^\star$ as a solution to

$$\max_s \mathbf{EU}(s) = \max_s (1-p)\cdot U\left(y^{na}(s)\right) + p\cdot U\left(y^{a}(s)\right),$$

providing First-Order-Condition (FOC)

$$(1-p)\cdot U'(y^{na})\cdot(\tau - c) + p\cdot U'(y^{a})\cdot(-c - f\tau) = 0. \quad (1)$$

Via implicit differentiation of FOC (1), we are able to deduce the individual's responses in s depending on marginal changes in the hiding costs c and the probability of detection p:

$$\frac{\mathrm{d}s}{\mathrm{d}p} = -\frac{\frac{\partial \mathrm{FOC}}{\partial p}}{\mathrm{SOC}} < 0 \qquad \text{and} \qquad \frac{\mathrm{d}s}{\mathrm{d}c} = -\frac{\frac{\partial \mathrm{FOC}}{\partial c}}{\mathrm{SOC}} < 0,$$

where SOC is the second derivative of $\mathbf{EU}(s)$. It is negative in the optimum due to the maximum property of $s^\star$. Together with

$$\frac{\partial \mathrm{FOC}}{\partial p} = U'(y^{a})\cdot(-c - f\tau) - U'(y^{na})\cdot(\tau - c) < 0,$$

we obtain the first estimation and a quite similar result for the derivative in c.[1] Therefore, the individuals' hidden amount is decreasing with either hiding costs or the probability of being audited.

The risk-neutral government, in turn, faces the expected tax- and penalty-revenues

$$\mathbf{ER} = (1-p)\cdot\tau\cdot(y - s) + p\cdot(\tau y + f\tau s),$$

which could be spent arbitrarily either on the provision of a public good or service – such as schooling, infrastructure or administration – or on the improvement of the tax auditing process itself. At this point, we incorporate the *guns vs. butter* concept, modelling the state's struggle in maximizing the provision of the public good on the one hand while, on the other hand, using parts of the dedicated revenue for the defence of the revenue itself.
In our model, this translates as follows: the government chooses a share $\alpha \in [0,1]$ of the expected revenues $\mathbf{ER}$ for the maintenance of the detection probability, which is now a function of α and satisfies

$$\frac{\mathrm{d}p(\alpha)}{\text{ﬄ}\mathrm{d}\alpha} > 0, \quad p(0) = 0 \quad \text{and} \quad p(1) \in (0,1).$$

The more of the tax revenues is used for the tax enforcement, the better are the odds of detecting tax evaders. Nevertheless, if no resources are used for the auditing process, individuals do not face any consequences and will be total dishonest, generating no revenue at all.
The remaining share $(1-\alpha)$ of $\mathbf{ER}$ is used for public good's supply, being also the target value for the maximization decision of the government:

$$\begin{aligned} &\max_\alpha (1-\alpha)\cdot \mathbf{ER}(\alpha) \qquad (2)\\ =&\max_\alpha (1-\alpha)\cdot\Big\{\big(1 - p(\alpha)\big)\cdot\tau\cdot\big(y - s[p(\alpha)]\big)\\ &\qquad + p(\alpha)\cdot\big(\tau y + f\tau\cdot s[p(\alpha)]\big)\Big\}\end{aligned}$$

[1]Conditional on a significantly high probability p of detection and a reasonable choice of $U(\,\cdot\,)$.

Please note, that with the choice of α, the individual's evasion behavior is affected as well since it reacts to the change in probability and takes it into account in its own maximization decision. Having a look at the derivative of (2), we obtain

$$-\mathbf{ER} + (1-\alpha)\cdot\frac{\mathrm{d}\mathbf{ER}}{\mathrm{d}\alpha} \qquad (3)$$

For $\alpha = 0$, this implies $p = 0$ as well and suggests $s^\star = y$ and, therefore $\mathbf{ER} = 0$. The latter term shrinks to

$$\frac{\mathrm{d}\mathbf{ER}}{\mathrm{d}\alpha} = (1-0)\cdot\tau\cdot\left(-\frac{\text{ﬄ}\mathrm{d}s}{\mathrm{d}p}\right)\cdot\frac{\mathrm{d}p}{\mathrm{d}\alpha} + \frac{\mathrm{d}p}{\mathrm{d}\alpha}\cdot\tau\cdot(1+f)\cdot y > 0$$

and $\alpha = 0$ cannot be a solution, as expected revenues increase with marginal sacrifices of revenues for the collecting effort itself. However, $\alpha = 1$ is no solution either, because expression (3) simplifies to $-\mathbf{ER} < 0$ and public good's provision could simply be raised by allowing marginal expenses for the public good itself.[2] Consequently, there exists an inner solution $\alpha^\star \in (0,1)$ which satisfies expr. (3) $= 0$ and yields the optimal response of the government. Given that the taxable base y, the statutory tax rate τ and the penalty factor f are exogenously given parameters, term (3) $= 0$ provides a closed-form solution for the optimal share $\alpha^\star(c)$ depending on the costs c of hiding. Thus, the resulting audit probability $p^\star = p(\alpha^\star(c))$ can also be understood as a function of the costs.

Now, let digitization find its way into the setting. We grasp progressive digitization via ongoing discrete time $t \in \mathbb{N}_0$, which enters the model through two distinct channels:

(*i*) Costs of hiding $(c_t)_{t\in\mathbb{N}_0}$, non-increasing over time:

$$c_t \geq c_{t+1}.$$

(*ii*) Probability of detection $(p_t(\,\cdot\,))_{t\in\mathbb{N}_0}$, satisfying

$$p_t(0) = 0, \qquad \left.\frac{\mathrm{d}p_t(\alpha)}{\mathrm{d}\alpha}\right|_{\alpha=\overline{\alpha}} > 0 \quad \text{and} \quad p_t(\overline{\alpha}) \leq p_{t+1}(\overline{\alpha}),$$

for all $t \in \mathbb{N}_0$ and $\overline{\alpha} \in [0,1]$.

Justification for these assumptions comes from the following ideas: On the one hand, costs of hiding shrink as possibilities of tax duties' circumvention rise, e.g. the internet facilitating the movement of wealth and investment and the opening of offshore bank accounts. These costs are assumed to be fixed for every t. However, they basically fall over time. On the other hand, tax authorities' reach on information rises with technical progress: cash is replaced by more tracable online transactions, international information exchange is negotiated and automatized and tax havens dry out or start cooperating. The incoming flood of information allows more targeted audits and evokes a rise in the likelihood of being detected – all based on keeping up the share $\overline{\alpha}$ of expected revenues that is used to enforce tax collection.

In the final step of the analysis, we could simply optmize for every point of time $t \in \mathbb{N}_0$ and trace paths of optimal

[2]Supposed that $p(1)$ is sufficiently large in order to prevent individuals from being totally dishonest with their tax authority.

evasion amounts $(s_t^\star)_{t\in\mathbb{N}_0}$, optimal shares $(\alpha_t^\star)_{t\in\mathbb{N}_0}$, optimal detection probabilities $(p_t^\star)_{t\in\mathbb{N}_0}$ and the corresponding expected supply $\left((1-\alpha_t^\star)\cdot \mathbf{ER}_t\right)_{t\in\mathbb{N}_0}$ of the public good. However, we would like to use a more sophisticated approach and isolate effects:

$$\begin{aligned}\Delta\alpha^\star &= \alpha_{t+1}^\star - \alpha_t^\star \\ &= \underbrace{\alpha_{t+1}^\star - \alpha_{t+1}^{(\star)}}_{\text{(II)}} + \underbrace{\alpha_{t+1}^{(\star)} - \alpha_t^\star}_{\text{(I)}}. \end{aligned} \tag{4}$$

Here, $\alpha_{t+1}^{(\star)}$ is the share of expected revenues that would be optimal with digitization in hiding costs – i.e. c_{t+1} – but without progress on governmental level – i.e. $p_t(\cdot)$. Therefore, (I) measures the change in $\alpha^\star$ which is due to the individual's improved evasion conditions given that the state does not experience progress in the audit detection process ('*cost shrinkage effect*' CSE) and (II) quantifies the change in $\alpha^\star$ that results from the updated audit conditions given the progress in the evasion setting already took place ('*audit improvement effect*' AIE). If we insert the $\alpha_{t+1}^{(\star)}$ into s, p and $(1-\alpha)\cdot\mathbf{ER}$, respectively, we are able to seperate effects and account for the pure reactions that results from the improved framework conditions on the authority side.
However, for an overall evaluation of digitization in a $(c_t, p_t(\cdot))_{t\in\mathbb{N}_0}$ setting, we have to consider aggregated net effects. We will call a digitization step $t \to t+1$ *tax-favoring* if available resources $(1-\alpha)\cdot\mathbf{ER}$ for the public good increase, *tax-neutral* if they remain constant and *tax-aggressive* if they decline. The definition manifests a vague intuition of whether progress is stronger on evasion or enforcement side, i.e. the question of digitization favoring rather the hunters or the hunted. Please note that there is not necessarily an inverse 1:1-relation to the share α. A rise in α might cause a higher **ER** such that the latter increase overweighs lower public good's share $(1-\alpha)$ on available resources. The exact relation might be subject to further research.

III. Simulation

In the following simulation we visualize the theoretical results of the previous section. Please note that tax evasion, by definition, is not that simple to measure. Alstadsæter et al. (2019) [1] were able to estimate its extend in the Scandinavian case due to Leakage data, which is a rather lucky circumstance. There is literature on the extend of shadow economy (see e.g. Buehn and Schneider (2012) [6]), but real extend of evasion is hard to measure and, therefore, our simulation does not claim any quantitative correctness and is for illustrative purpose only. The calculation was performed in `R` [7] and is based on the following specification:
We consider an individual with taxable base $y = 1{,}000$ and a utility function $U(x) = \sqrt{x}$. The state enjoins a statutory tax rate $\tau = 50\%$ and punishes misconduct with an additional penalty rate of $f = 1$. Since the individual cannot lose more than the taxable base itself in the bad case, $s^\star$ must be chosen such that $y^a(s)$ remains non-negative. Moreover, we limit ourselves to a time horizon of $T = 100$, where costs of hiding and probability of detection at time t shape as

$$c_t = 0.1\cdot(1+0.95^t)$$
$$\text{and}\quad p_t(\alpha) = 0.5\cdot\left(1-\tfrac{1}{1+\alpha}\right)\cdot\left(1+\tfrac{t}{100}\right).$$

Since it is not possible to derive results analytically on computational level, we optimize along a grid of parameters with step width 1 for s and 0.01 for α. The respective optima are then retrieved by a simple maximum query.
For $t = 0$ we obtain an optimal share $\alpha_0^\star = 0.302$, indicating itself an audit probabilty of $p_0(\alpha_0^\star) = 11.6\%$ and an evasion amount $s_0^\star = 622$. The expected revenues amount to $\mathbf{ER} = 261.1$, whereof public goods worth 182.3 are provided and the remaining 58.8 monetary units are used for the maintenance of tax enforcement. The overall revenues as well as the amount spent for public goods depending on α are presented in Fig. 1.

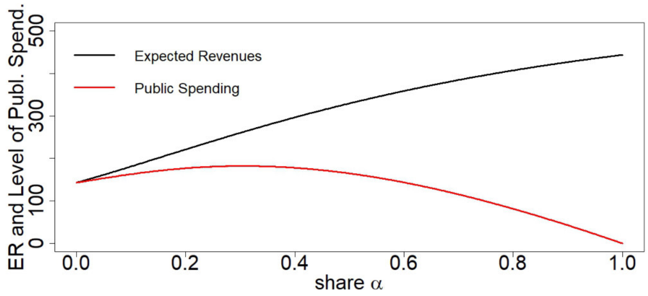

Fig. 1. Expected Revenues and Public Spending depending on α in case of $t = 0$.

Inserting digitization via consideration of the ongoing time component t now, we can trace the path of amount of public spending $(1-\alpha_t)\cdot\mathbf{ER}_t$ over time, which is displayed in Fig. 2.

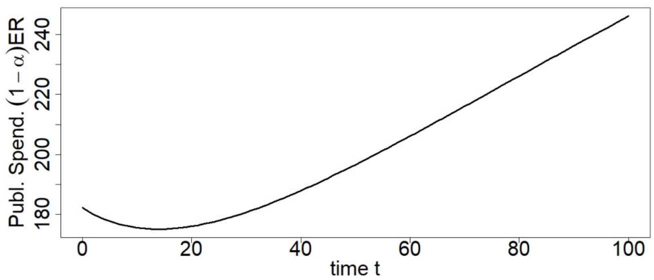

Fig. 2. Public Spending depending on time t.

Here, it is obvious that up to $t \approx 15$ digitization works against public spending, which we classified as *tax-aggressive progress*. Costs decline exponentially, whereas the probability of detection potential basically just rises in a linear way. However, beyond around $t \approx 15$, technical progress favors rather the governmental side, i.e. digitization is *tax-favoring*, as the detection framework overrules the cost savings on the individual level. The optimal evasion amounts and audit probabilities (not shown here) behave roughly inversely shaped to the public spending and almost linearly increasing, respectively, which also goes in line with the intuition. More interesting in that matter

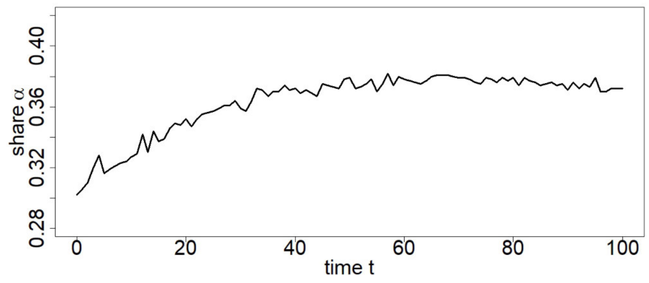

Fig. 3. Share α depending on time t.

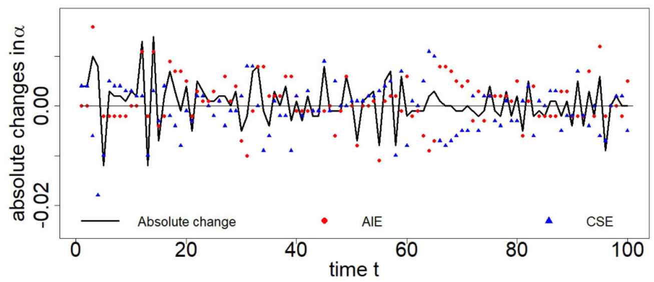

Fig. 4. Time-dependent absolute changes in α, incl. decomposition into CSE and AIE.

might be the corresponding shares of tax enforcement expenditures: they are portrayed by Fig. 3 and seem to be quite volatile. For a general tendency, they increase from 0.3 to 0.37 in the first half of the observation period and stagnate in the second half.

As for the decomposition into CSE and AIE, Fig. 4 proves that there is quite some variation in the effects. They are not even unambiguous in their sign, which might be due to the deep and intertwined rootedness of the costs and the probability into the target value or the unsmooth computational optimization.[3]

However, this short simualtion shall be understand rather as a short application than deep a insight into the matter. Therefore, an extended analysis of the interaction of model key figures is needed and will be subject to further research.

IV. Conclusion

This paper provides a model for the analysis of the optimal share of expenditures for tax enforcement on total tax revenues with consideration of individuals' evasion responses. In a guns vs. butter framework, the government chooses the optimal allocation of resources in order to maximize the provision of public goods and services. Depending on digitization influences and whom they favor, the optimal share might change over time and, therefore, should not be treated as a static component. From a governmental perspective, digitization can be a curse – as it widens and simplifies the individual's evasion incentives – or a blessing – as it improves the state's monitoring options. However, effects are still ambiguous in their signs and additional investigation of the model is needed in order to provide reliable information on the interaction of the included levers.

Some criticsm, that often comes along with the Allingham/Sandmo model, is the breaking down of a complex evasion decision to pure economic thinking alone. In practice, evasion amounts are less than the model suggests, which is certainly due to unconsidered moderating factors, such as psychological or social components.

Moreover, computerization and globalization have been treated as exogenously given. Endogenizing progress might provide a more realistic framework, because higher expenditures rise progress itself (as more resources can be dedicated to consultancy or research). Nevertheless, regarding the preceding development of tax enforcement since the beginning of collecting levies, 'digtization' has been working for both sides. People and governments do always react to incentives and all in all, digitization is just another brick in the wall.

[3] Even other cost and probability functions do not erase ambiguity.

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