Duccio Gamannossi degl'Innocenti

ESSAYS ON TAX COLLECTION AND LOCAL GOVERNMENT EFFICIENCY

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ESSAYS ON TAX COLLECTION
AND LOCAL GOVERNMENT EFFICIENCY

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Introduction

Revenue collection is affected by an informational asymmetry because liabilities are taxpayers' private information. In developed countries, collection schemes are based on the self-declaration and, to contrast the incentive to under-reporting, states perform audits and levy fines whenever misleading declarations are detected. In the first contribution of economics to the analysis of tax non-compliance – the seminal article of Allingham and Sandmo (1972) – the evasion decision is analyzed in a portfolio-choice framework. Their work led to a flourishing microeconomics literature that enriched the understanding of the different variables impacting taxpayers' declaration of their liabilities: socio-psychological factors affecting agents' behaviour, the influence of legislation and enforcement and how the presence of a variety of non-compliance activities alters the decision. The contribution of this thesis is three-fold:

1. First, we model taxpayers' joint decision to avoid and/or evade on the basis of two key assumptions: (i) the decision upon the amounts avoided and/or evaded is performed sequentially and (ii) the avoidance decision is made first. The first feature – that complex decisions are routinely broken down into smaller ones – is often termed *narrow bracketing* (Rabin and Weizsäcker 2009) in the behavioural literature. The second feature – the choice of how to stage the sub-decisions within the larger composite decision – is sometimes termed *decision staging* (Johnson et al. 2012). Crucial w.r.t. the latter is whether the taxpayer is more likely to make the avoidance or evasion choice first. This question is thought to depend heavily on mentally focal qualitative features of the choice set (Kahneman 2003). We argue that a focal feature of the choice set is that avoidance is ostensibly legal whereas evasion is illegal, hence, the latter one is not considered until all gainful avenues for the former one have been exhausted. In this setting, the so-called Yitzhaki paradox – for which an increase in the tax rate decreases the level of evaded income and of evaded tax – is proven to hold

This work has been developed under the supervision of Prof. Matthew D. Rablen and Prof. Andrea Vindigni. This contribution is an extract of the PhD dissertation in Economics defended by the author at IMT School for Advanced Studies, Lucca, Italy on March, 10th 2017. The bibliography is available at: www.dgdi.me/publication/atti_e_memorie_la_colombaria .

also in the case of avoidance. However, a major departure from the results obtained previously by the scientific literature arises, namely, for a small enough audit probability, evasion is an increasing function of the audit probability.

2. In the second contribution, the tax agency ensures perfect compliance by enforcing optimal truthtelling probability while the agents choose simultaneously how much to declare, avoid, and evade. Thus, the optimal (counterfactual) level and composition of non-compliance, along with the impact of the relevant parameters, may be inferred from the analysis of the marginal returns of the different concealing options. We find that for a convex penalty function the incentive-compatibility constraints may bind for the richest taxpayer and at a positive level of both evasion and avoidance. The audit function is non-increasing in reported income and higher marginal tax rates increase the incentives for non-compliance, overturning the Yitzhaki paradox.

3. In the third and last contribution, we provide an assessment of productivity efficiency for the local government of the major Italian municipalities. Leveraging on a state-of-the-art methodology, conditional non-parametric frontier models (Daraio and Simar 2005 and Daraio and Simar 2007), the analysis investigates the impact of environmental factors on efficiency and evaluates measures of performance that correctly account for the variety of conditions faced by the productive units. To provide a thorough characterization of the production activity of municipalities, a rich dataset has been developed building on a variety of sources – i.e., ISTAT, Ministry of Internal Affairs, Legambiente. Our findings show that northern and central municipalities tend to have better performance w.r.t. the ones belonging to south and islands. While the investigation does not provide evidence of an effect of debt stock on efficiency, a negative and significant impact of crime is identified. Finally, municipalities characterized by a higher altitude level/variability tend to be less efficient.

1 The impact of avoidance and evasion on the declaration of liabilities and optimal enforcement

1.1 Introduction

Individuals take a variety of actions to reduce their tax liabilities. The UK tax authority, for instance, distinguishes three distinct types of action (HM Treasury & HMRC 2011): those that breach tax law (tax evasion); those that "use the tax law to get a tax advantage that Parliament never intended" (tax avoidance) (p. 3); and those that "use tax allowances for the purposes intended by Parliament" (tax planning) (p. 7). Following these definitions, both tax evasion and tax avoidance are responsible for significant losses in public revenue. Estimates provided by the UK tax authority put the value of tax avoidance at £1.7 bn. and the value of tax evasion at £5.2 bn. (HMRC 2015). Given the first order significance of tax avoidance, it is of note that the first economic studies relating to tax compliance (e.g., Allingham and Sandmo 1972; Yitzhaki 1974; Christiansen 1980) neglect the possibility of tax avoidance altogether, and the economic literature that followed has largely retained this bias.

The type of tax avoidance modelled in this section is restricted to actions that reduce tax liabilities being so artificial in nature that courts will deem them illegal if the tax authority mounts a legal challenge. These acts are often complex, and – unlike evasion – must be purchased from specialist providers known as *promoters*. A recent example of this type of avoidance scheme is a 2012 legal case in the UK between H.M. Revenue and Customs (HMRC) and a businessman named Howard Schofield. Schofield bought an avoidance scheme to help him reduce the amount of tax due on a £10m capital gain by means of self-cancelling option agreements. Although, viewed separately, the options created exempt gains and allowable losses, when viewed together as a composite transaction they did not. HMRC (2012) described the scheme as "an artificial, circular, self-cancelling scheme designed with no purpose other than to avoid tax", and it was ultimately outlawed.

In section 1.2 we introduce tax avoidance into the portfolio model of tax evasion (Yitzhaki 1974). To model the joint tax avoidance/evasion decision we build on insights developed in psychology and behavioural economics. In particular, we allow for a pervasive propensity among human decision makers facing multiple-dimension problems – that of *narrow bracketing.* In our context, a decision maker who narrow brackets would decompose sequentially the joint decision {avoidance, evasion} into narrow brackets, e.g., {avoidance} followed by {evasion}. A key feature of narrow bracketing is that the decision maker tends to choose an option in each stage without full regard to the other decisions and circumstances that he or she faces (Rabin and Weizsäcker 2009). Important in this context is whether the taxpayer is more likely to make the avoidance or evasion choice first. This question – as to the order in which a complex decision is mentally staged – is thought to depend heavily on mentally focal qualitative features of the choice set. We argue that a focal feature of the choice set is that avoidance is ostensibly legal whereas evasion is illegal. Indeed, judiciaries have long upheld the right of a citizen to challenge the proper interpretation of tax law and to pay only the tax they owe in law. Thus, while tax avoidance can be seen as the rightful exercise of a basic right by some lights, tax evasion lacks an equivalent interpretation. We are by no means the first to propose that taxpayers distinguish qualitatively between legal and illegal actions, however. This distinction has previously been represented by supposing that a cost owing to social stigma and/or personal guilt is attached to the illegal act of tax evasion. Narrow bracketing offers an alternative perspective: in our model, illegal evasion is not considered until all gainful avenues for legal avoidance have been exhausted[1].

In addition to the legal distinction between avoidance and evasion, we further assume that avoidance is costly whereas evasion is costless. Devising avoidance schemes that reduce a tax liability without ostensibly violating tax law invariably requires a detailed understanding of tax law, coupled with a degree of ingenuity. Satisfying this demand for tax avoidance is a substantial industry dedicated to the development and marketing of avoidance schemes (see, e.g., Committee of Public Accounts 2013). By contrast, many forms of tax evasion require no technical or legal expertise. Intentionally understating income on the tax return, for instance, may readily be performed independently. In our settings, upon auditing, the tax authority observes whether a taxpayer is engaging in a tax avoidance scheme and also the extent of any tax evasion. If the tax authority learns of an avoidance scheme, it will move to outlaw it ex-post. The taxpayer is fined on the evaded tax, but the tax authority has no grounds to impose a fine on the avoided tax (it can only take measures to outlaw the scheme and then recover the tax owed on the avoided income). Our results show that (i) an analogous finding to the so-called Yitzhaki paradox for evasion also holds for tax avoidance – an increase in the tax rate decreases the level of avoided income and the level of avoided tax, and (ii) for a small enough audit probability evasion is an increasing function of the audit probability. Some extensions to the analysis here presented may be considered in future research. It would be of interest to allow for imperfect audit effectiveness, as in Rablen (2014) for it might be that evasion and avoidance differ in the amount of tax inspector time required to detect them. Moreover, it would be instructive to embed the model within a general equilibrium framework (see, e.g., Alm and Finlay 2013), for the partial equilibrium setting explored here may miss some important wider interactions between avoidance and evasion that should properly be accounted for.

In section 1.3 we investigate how accounting for the ability of individuals to avoid tax, as well as to evade tax, alters optimal enforcement as identified by models in which only tax evasion is allowed. Similar

[1]Strictly speaking, the stigma cost approach and ours are not mutually exclusive. To present our approach in the simplest possible light, however, we do not allow for a stigma cost.

to the first section, individuals may engage both in tax avoidance and evasion. While dropping the assumption of *narrow bracketing* of section 1.2, we assume that both forms of non-compliance impose psychic harm in the form of a social stigma cost when detected. In this context we characterise the audit function for a linear penalty function as well as for a general penalty function. The tax authority can condition its audit function only on the amount of income declared; it does not observe the amount of non-compliance or how it is split between evasion and avoidance. We therefore look for a taxpayer with income w^* and a level of tax avoidance A^* such that, if this taxpayer (weakly) prefers to report truthfully rather than hide an amount of income A^* then all other taxpayers will also wish to report truthfully. We find that, if the penalty function is linear or strictly concave then, irrespective of the tax function, it holds that (i) if the wealthiest taxpayer is induced to report honestly, so will all other taxpayers; and (ii) at every income declaration, x, enforcement must be just sufficient that the wealthiest taxpayer does not wish to evade the amount of income $w - x$ (if evasion is more attractive than avoidance), or does not wish to avoid the amount of income $w - x$ (if avoidance is more attractive than evasion). That is, if the tax authority enforces to the point where *pure* evasion/avoidance becomes unattractive, then mixtures of evasion and avoidance will also be unattractive. On the other hand, if the penalty function is convex (the marginal rate of penalty is increasing), then it is possible that the focus of enforcement is not the wealthiest taxpayer, but rather a taxpayer with intermediate wealth. The level of wealth of this critical taxpayer is an increasing function of income declared, implying that the focus of enforcement is on lower wealth individuals at lower levels of declared income, and on higher wealth individuals at higher levels of declared income. It also becomes possible that taxpayers prefer engaging simultaneously in evasion and avoidance over pure strategies. When this occurs, the optimal mix of avoidance and evasion moves in favour of avoidance as reported income decreases, as the competitiveness of the market for avoidance schemes increases, and as the social stigma associated with tax non-compliance falls. We also find that an increase in marginal rates of tax stimulates incentives for non-compliance, such that the audit function must rise to maintain truthful reporting. This is the opposite finding of Yitzhaki (1974), in which the incentives to be non-compliant diminish as marginal tax rates increase. The difference in predictions is of interest as Yitzhaki's finding is counter-intuitive and at variance with most empirical evidence. We finish with some avenues for future research. First, it would be of interest to model more carefully the market for avoidance. In practice there are a range of providers of tax advice, ranging from those that offer solely tax planning, to those that are willing to offer aggressive (or even criminal) methods, making it important to understand the separate supply- and demand-side effects. Second, similarly to section 1.2, it may also be of interest to allow for imperfect audit effectiveness in the analysis.

1.2 Income Tax Avoidance and Evasion: A Narrow Bracketing Approach†

1.2.1 Model

A taxpayer has an income (wealth) w and faces a tax on income given by tw, where $t \in (0,1)$. Taxpayers behave as if they maximize expected utility, where utility is denoted by $U(z) = \log z$. The taxpayer's true income is not observed by the tax authority, but the taxpayer must declare an amount $x \in [0, w]$. The taxpayer can choose to avoid paying tax on an amount of income $A \in [0, w]$, and subsequently to evade illegally an amount of income $E \in [0, w - A]$, so $x = w - E - A$. Evasion is financially costless but avoidance technology must be bought in a market in which "promoters" sell avoidance schemes to "users". Although systematic information regarding the contractual terms of avoidance schemes is scarce, we understand from a detailed investigation in the UK that, for the majority of mass-marketed schemes, the avoidance scheme fee is related to the reduction in the annual theoretical tax liability of the user, not the *ex-post* realization of the tax saved (Committee of Public Accounts 2013). Thus, the monetary risks associated with the possible subsequent detection and termination of a tax avoidance scheme are borne by the user [2]. Accordingly, we assume that the promoter's fee is a proportion $\phi \in (0,1)$ of the amount by which the taxpayer's tax liability stands to be reduced, tA. In this way, ϕ may be interpreted as measuring the degree of competition in the market for tax avoidance schemes, with lower values of ϕ indicating the presence of stronger competitive forces. The taxpayer's income declaration is audited with probability $p \in (0,1)$. If audited, E and A are observed and the taxpayer has to pay $[1+f]\,tE$ on account of the amount of evaded tax, where $f > 0$ is the fine rate. The tax authority mounts a legal challenge to the avoidance scheme, which is successful with probability p_L. In the event that the legal challenge is successful, the tax authority obtains the right to reclaim the tax owed (but cannot levy a fine). In this case, instead of paying tx in tax, the taxpayer must instead pay $t\,[x+A]$. The taxpayer's expected utility is therefore given by

$$\mathbf{E}U(A,E) = [1-p]\,U(w^n) + pp_L U(w^{a_s}) + p\,[1-p_L]\,U(w^{a_u}), \qquad (1)$$

†This section has been developed in collaboration with Matthew D. Rablen. A complete version may be found as Gamannossi degl' Innocenti and Rablen (2016).

[2]It is apparent that such arrangements give promoters incentives to misrepresent the level of risk involved in particular schemes. See Committee of Public Accounts 2013, p.11.

where w^n is the taxpayer's wealth in the state in which they are not audited, w^{a_s} is the taxpayer's wealth in the state in which they are audited and the tax authority's legal challenge is successful, and w^{a_u} is the taxpayer's wealth in the state in which they are audited and the tax authority's legal challenge is unsuccessful.

A key distinguishing factor between evasion and avoidance in this context is that avoidance entails a cost $\phi t A$ in all states of the world. Thus, if avoidance is detected and the scheme closed down a taxpayer is worse-off for having chosen to avoid, even though they are not fined on avoided income. To ensure that the amount of taxes, fines and fees never exceeds a taxpayer's wealth for any $A+E \in [0, w]$ we must assume $[1-t]/t > \max\{\phi, f\}$.

We suppose that taxpayers choose their preferred level of avoidance and evasion sequentially: gainful opportunities for tax avoidance are exhausted before the taxpayer decides whether to engage additionally in evasion. Thus, taxpayers first choose avoided income and then evaded income as

$$A^* = \arg\max_A \mathbf{E}U(A, 0); \quad (2)$$
$$E^* = \arg\max_E \mathbf{E}U(A^*, E). \quad (3)$$

1.2.2 Analysis

For analytic tractability, we shall start by considering the special case of the model with $p_L = 1$, such that legal challenges by the tax authority are always successful. It is helpful to define the function $R(z) = [1-z]/z$, such that, e.g., $R(p)$ is the classical odds ratio found in decision theory. We may then state Proposition 1:

Proposition 1 *An interior optimum for avoidance and evasion satisfies*

$$A^* = \frac{pR(t)}{1-\phi}[R(p)R(\phi) - 1]w$$

and

$$E^* = \frac{pR(t)}{1-\phi}\frac{[1-p][1-fR(\phi)]}{f}w$$

Proposition 1 gives closed-form expressions for optimal avoidance and evasion when both are at an interior maximum[3]. To gain insight into how A^* and E^* are related, note that we may write one as a (linear) function of the other:

[3]The conditions needed for a such an interior maximum to arise are omitted for brevity.

$$E^*(A^*) = \frac{p\left[wR(t) - \phi A^*\right]\left[R(p) - f\right]}{f} - pA^*. \tag{4}$$

From (4) we note that

$$\frac{\partial E^*}{\partial A^*} = -\frac{fR(\phi) + R(p)}{f\left[1 + R(p)\right]\left[1 + R(\phi)\right]} < 0, \tag{5}$$

so the amount of evaded income E^* is negatively related to the amount of avoided income A^*. This finding matches that of Alm et al. (1990) using data from Jamaica, who find that evasion and avoidance are substitutes. We now consider the comparative statics of optimal avoidance and evasion:

Beginning with the comparative statics of A^*, we see that wealthier people are predicted to avoid more income than less wealthy people. The second result is an extension of the well-known Yitzhaki paradox for evasion to the case of avoidance – avoided income falls as the tax rate is increased. The intuition for this result is analogous to that for evasion: a higher marginal tax rate makes the taxpayer feel poorer, and thereby more risk averse. As expected, given that no fines are levied upon discovery of avoidance, f displays no effect on it. An increase in the competitiveness of the market for avoidance schemes (a decrease in ϕ) increases avoided income, and an increase in the probability of audit decreases avoided income.

	A^*	E^*
w	$+$	$+$
t	$-$	$-$
f	0	$-$
ϕ	$-$	$+$
p	$-$	$+/-$

Table 1: Comparative statics; interior A^* and E^*

Turning to evasion, the logic of the chain rule implies that, for an arbitrary exogenous variable z, it must hold that

$$\frac{\partial E^*}{\partial z} = \left.\frac{\partial E^*}{\partial z}\right|_{A^*=cons.} + \frac{\partial E^*}{\partial A^*}\frac{\partial A^*}{\partial z}, \tag{6}$$

where the first term on the right side is the direct effect of z on evasion, and the second term captures the indirect effect on evasion arising from the effects of z upon avoidance. Intuitively, the indirect effect is the income effect imparted upon the evasion choice by movements in avoidance. Noting that $\partial E^*/\partial A^* < 0$ it follows that if $\partial A^*/\partial z$ and $\partial E^*/\partial z|_{A^*=cons.}$ are of the same sign – as turns out to be the case for each of the variables $\{w, t, f, p\}$ – then the direct and indirect effects in equation (6) oppose each other. This observation notwithstanding, the first three results in Table 1 – those for $\{w, t, f\}$ – are each unambiguous and consistent with Yitzhaki (1974). Unambiguity in this context arises as the direct effect can be shown to always dominate the indirect effect. To take the tax rate as an example, we find the direct effect – using (4) – as

$$\left.\frac{\partial E^*}{\partial t}\right|_{A^*=cons.} = -\frac{w\,[1+R(t)]^2\,[R(p)-f]}{f\,[1+R(p)]} < 0, \tag{7}$$

Combining equation (7) with $\partial A^*/\partial t$ from Proposition 1 and $\partial E^*/\partial A^*$ we can rewrite the direct effect in terms of the indirect effect and, using equation (6), we obtain:

$$\begin{aligned}\frac{\partial E^*}{\partial t} &= -\frac{[R(p)-f][1+R(p)]R(\phi)}{[R(p)+fR(\phi)][R(p)R(\phi)-1]}\frac{\partial E^*}{\partial A^*}\frac{\partial A^*}{\partial t} + \frac{\partial E^*}{\partial A^*}\frac{\partial A^*}{\partial t} \\ &= -\frac{R(p)[1+R(\phi)][1-fR(\phi)]}{[R(p)+fR(\phi)][R(p)R(\phi)-1]}\frac{\partial E^*}{\partial A^*}\frac{\partial A^*}{\partial t} < 0\end{aligned} \tag{8}$$

As it has no direct effect on evasion, the impact of competition in the market for avoidance (as captured by ϕ) is given by (6) as simply

$$\partial E^*/\partial \phi = [\partial E^*/\partial A^*]\,[\partial A^*/\partial \phi] > 0.$$

Thus, a decrease in the competitiveness of the avoidance industry increases evasion. The final finding is that tax evasion is increasing in the probability of audit if $R\,(p) > 1$ (equivalently, $p < 0.5$) and decreasing otherwise. In this case there are again competing direct and indirect effects upon evasion, but now the direct effect does not always dominate the indirect effect. Following the same steps as in the tax rate example above, we obtain

$$\frac{\partial E^*}{\partial p} = \frac{[R(p)-1]\,[1-fR(\phi)]}{R(p)+fR(\phi)}\frac{\partial E^*}{\partial A^*}\frac{\partial A^*}{\partial p}. \tag{9}$$

From (9) it is immediate that the direct effect dominates when $R(p) < 1$ and the indirect dominates when $R(p) > 1$.

How plausible is the condition $p < 0.5$ required for evasion to be increasing in the probability of audit? A priori it appears highly plausible given that the IRS audits only around 0.96 percent of individual tax returns filed in calendar year 2012 were examined (Internal Revenue Service 2014). If audits are concentrated on the 20 percent or so of people in the United States who are self-employed, the probability for this group would rise to 4.8 percent, still well below the 50 percent level.

1.2.3 Probabilistic Anti-Avoidance Outcomes

Up until this point, the analysis has been undertaken with the simplifying assumption that, if the tax authority mounts a legal challenge to the avoidance scheme, its challenge is always successful. While important in securing a tractable model, clearly tax authorities are not always successful in their attempts to shut-down avoidance schemes, so it is of interest to understand how this consideration affects our findings.

Solving for A^* using the definition in equation (2) and the full expression for expected utility given in (1) we obtain

$$A^* = \frac{pp_L R(t)}{1-\phi}\left[R(pp_L)R(\phi)-1\right]w, \tag{10}$$

which can be obtained from the solution for A^* given in Proposition 1 (for the case of $p_L = 1$) simply by replacing p with pp_L.[4] It follows that the comparative statics results for A^* given in Table 1 continue to hold, and that the effects of p_L upon avoidance are analogous to those of p. The solution for E^* coming from (3) is complex, however. To make further progress we assess the properties of optimal evasion via a numerical optimization procedure. Figure 1 depicts optimal avoidance and evasion as p_L is allowed to vary on the unit interval [5]. For very low values of p_L in the interval denoted $[0, \hat{p}_L|_{E=0}]$ avoidance is seen to be maximal, and the taxpayer does not evade. In a second interval, denoted in the figure by $(\hat{p}_L|_{E=0}, \hat{p}_L|_{A+E=w}]$, the taxpayer both avoids and evades, and reports no income ($x \geq 0$ is binding). In a third interval, denoted $(\hat{p}_L|_{A+E=w}, 1]$, the taxpayer again both avoids and evades, but now $x > 0$ (this is the case to which our comparative statics analysis applies). Within this interval we observe that optimal evasion increases as the probability of a successful legal challenge increases. This is as expected, for an increase in p_L leaves the returns to evasion unaffected, but reduces the returns to avoidance, making evasion more attractive relative to avoidance.

In Figure 2 we explore the effect of varying p_L on our earlier finding that evasion can be increasing in the probability of audit.[6] On the inter-

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[4]Whereas the expression for A^* given in Proposition 1 is the unique solution to a first order condition linear in A^*, the expression for A^* in (10) is one of a pair of solutions to a first order condition quadratic in A^*. The other solution to this first order condition is $A^* = -wR(t)/[1-\phi] < 0$, which however, may be dismissed as, by definition, $A^* \geq 0$.

[5]The parameter values that produce Figure 1 are: $w = 10, p = 0.5, t = 0.8, f = 0.1, \phi = 0.22$. We note that these values are chosen purely to illustrate cleanly the full range of possible outcomes of the model. As is well-known, models such as ours, which implicitly assume taxpayers know the true probability of audit, significantly over-predict non-compliance if calibrated realistically (see, e.g., Alm et al. 1992 , footnote 3). This difficulty does not appear especially consequential in this context, however, for insights such as probability weighting (Kahneman and Tversky 1979) have been shown to dramatically reduce predicted levels of non-compliance, while not importantly affecting its comparative static properties (these being our interest in this paper).

[6]The parameter values that produce Figure 2 are: $w = 10, t = 0.85, f = 0.11, \phi =$

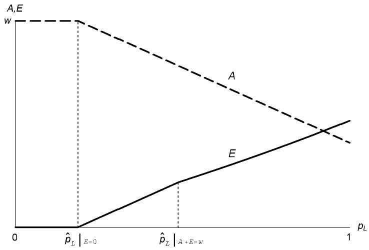

Figure 1: Optimal avoidance and evasion for $p_L \in [0, 1]$.

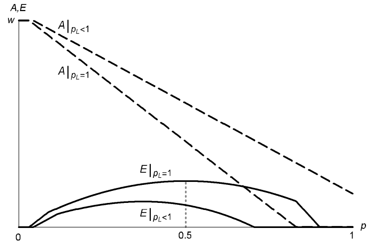

Figure 2: Optimal avoidance and evasion w.r.t. p for $p_L < 1$ and $p_L = 1$.

val of Figure 2 where both optimal evasion and avoidance are interior, we see that reducing p_L below unity reduces to a value below one-half the threshold audit probability above which evasion is decreasing in p. Thus lower values of p_L imply a smaller set of parameter values for which evasion is observed to be increasing in audit probability. Other numerically generated results – not reported here for brevity – indicate that the qualitative nature of the results given in Table 1 continues to hold.

1.3 Optimal Income Tax Enforcement in the Presence of Tax Avoidance ‡

1.3.1 Model

A taxpayer has an income (wealth) w; w differs among individuals on the support $[0, \overline{w}]$, where $\overline{w} > 0$. Each taxpayer faces a tax on income w given by $t(w)$, satisfying $t(w) < w$ and $t' \geq 0$. Taxpayers behave as if they maximise expected utility, where utility is denoted by $U(z) = z$ (risk neutrality). A taxpayer's true income w is not observed by the tax authority, but the taxpayer must declare an amount $x \in [0, w]$. A taxpayer can choose to illegally evade an amount of income E and to avoid paying tax on a further amount of income A, where $x = w - E - A$.

The notions of avoidance and evasion used in this section are inherited from section 1.2. Accordingly, we assume that the promoter's fee is a proportion $\phi \in (0, 1)$ of the tax saving accruing from the scheme. However, the tax saving accruing from the avoidance scheme may be

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$0.17, p_L \in \{0.7, 1\}$. The same qualitative conclusions obtain if the parameter values used to draw Figure 1 are instead used, but these alternative parameter values yield improved visual clarity.

‡This section has been developed in collaboration with Matthew D. Rablen. A complete version may be found as Gamannossi degl' Innocenti and Rablen (2017a) while an extended one is Gamannossi degl' Innocenti and Rablen (2017b).

ambiguous when simultaneous evasion and avoidance is performed in presence of non-linear tax rates. As our results are not especially sensitive to these feature we assume $t(w) - t(w - E)$ to be the evaded tax, and $t(x + A) - t(x)$ to be the avoided tax. Hence, we may write the total fee paid by the taxpayer to the promoter as $\phi[t(x + A) - t(x)]$. A taxpayer reporting income x is audited with probability $p(x)$. If audited, E and A are observed. A taxpayer must then make a payment $f(t(w) - t(w - E))$ on account of the amount of evaded tax, where $f(0) = 0$ and $f' > 1$ (which, together, imply $f(z) > z$ for $z > 0$). The taxpayer cannot be fined on the avoided tax, however. The tax authority mounts a (successful) legal challenge to the avoidance scheme, giving the tax authority the right to reclaim the tax owed. Thus, instead of paying $t(x)$, the taxpayer must pay $t(x + A)$.

In accordance with a rich literature (e.g., Benjamini and Maital 1985, Dell'Anno 2009) we introduce a psychic cost, identified as the social stigma, associated with being caught performing activities that either abuse the spirit of the law, or outright violate it. Social stigma is incurred when $A + E \ (= w - x) > 0$ and the taxpayer is audited. Specifically, we write

$$S(w - x) = \begin{cases} 0 & \text{if } x = w; \\ s > 0 & \text{otherwise.} \end{cases}$$

A taxpayer's expected utility is therefore given by

$$EU = [1 - p(x)]\, U^n + p(x)\, U^a, \tag{11}$$

where U^n is a taxpayer's utility in the state in which they are not audited and U^a is a taxpayer's utility in the state in which they are audited. We then write $U^n \equiv U(w^n)$ and $U^a \equiv U(w^a) - S(w - x)$, where $\{w^a, w^n\}$ are, respectively, a taxpayer's wealth in the audit and non-audit states. We adopt the standard assumption of *limited liability*, whereby the tax and fine payments of a taxpayer cannot exceed their wealth w. Accordingly, we assume $w^a(x, A, w) - s > 0$, a necessary condition for which is that $w - s \geq f(t(w))$.

A *mechanism* for the tax authority consists of a set of possible income reports $M \in [0, w]$, a tax function $t(\cdot)$, an audit function $p(\cdot)$, and a penalty function $f(\cdot)$. In this section we focus only on *incentive compatible* mechanisms i.e., mechanisms that induce all taxpayers to report truthfully. The standard justification for this approach is the *revelation principle*: when this holds then, for any feasible mechanism, one can find an equivalent mechanism that induce taxpayers to report truthfully (see, the pioenristic contribution of Myerson 1979). Chander and Wilde (1998) show that the revelation principle applies when the tax authority has unfettered ability to choose the tax and audit functions, while the penalty function is only constrained to be bounded above. Unfortunately, penalty functions of this type deviate significantly from those observed in practice as the penalty for under-reporting by any amount, no matter how small, is extreme. Whereas most of the literature has implicitly opted for tractability over realism, here we follow the lead of Marhuenda and Ortuño-Ortn (1994) in considering a setting in which the revelation principle does not hold. Implicitly, therefore, we restrict attention to the set of mechanisms that are payoff equivalent to the set of incentive compatible mechanisms we consider here. Our focus shall be primarily on the shape of the audit function for a given penalty and tax function. Accordingly, we do not allow the tax authority to choose the latter two functions.

The utility when reporting truthfully (honestly) is $U^h \equiv U\left(w^h\right)$, where $w^h = w - t(w)$. In order that the mechanism be incentive compatible, a taxpayer must never receive a utility higher than $U\left(w^h\right)$ when reporting $x < w$. This implies that

$$p(x) \geq \frac{U^n - U^h}{U^n - U^a} \text{ for all } A \in [0, w-x],\ x \in [0, w] \text{ and for all } w. \quad (12)$$

Performing an audit costs the tax authority an amount $c > 0$. Given this, a revenue maximizing scheme will always minimize $p(x)$ subject to the condition in (12) holding. Define the function $p(x; A, w)$ as the smallest probability of audit that induces an (A, w)-taxpayer to report truthfully. Then

$$p(x; A, w) = \begin{cases} \frac{U^n - U^h}{U^n - U^a} = \frac{t(w) - t(x) - \phi[t(A+x) - t(x)]}{f(t(w) - t(A+x)) + t(A+x) - t(x) + s} & x < w; \\ 0 & x = w. \end{cases} \quad (13)$$

The restriction $p(x; A, w) \leq 1$ holds necessarily as $U^h \geq U^a$. When $x = w$ the definition of $p(x; A, w)$ becomes arbitrary, for the condition in (12) must hold for any $p(x)$. In what follows we restrict attention to the case $x < w$ unless it is explicitly stated otherwise.

The tax authority cannot, however, use $p(x; A, w)$ since it observes x, but not A or w. Instead, the tax authority must choose $p(x)$ such that, for each x, reporting is truthful for all feasible A and w. Accordingly, we then define $p(x) = \max_{A,w} p(x; A, w)$.

1.3.2 Analysis

We begin without restricting the form of the tax function, but restricting the penalty function to be linear: $f(z) = [1+h]\, z$, $h > 0$. In this way we obtain a very simple version of the model that provides ready intuitions.

Proposition 2 *If the penalty function is linear then*

$$p(x) = \begin{cases} \frac{[1-\phi][t(\overline{w})-t(x)]}{t(\overline{w})-t(x)+s} & \phi < \hat{\phi}; \\ \frac{t(\overline{w})-t(x)}{f(t(\overline{w})-t(x))+s} & \phi > \hat{\phi}. \end{cases} \tag{14}$$

Summarizing this analysis, when the market for avoidance schemes is sufficiently competitive ($\phi < \hat{\phi}$) to ensure truthful reporting by all taxpayers it is required to incentivise the wealthiest taxpayer to not avoid all of his income. If, however, $\phi > \hat{\phi}$ then evasion is more attractive to taxpayers than is avoidance. In this case, to obtain full compliance, it is sufficient that the wealthiest taxpayer does not wish to evade all of his income.

The form of $p(x)$ in (14) applies more generally whenever A^* takes corner values and $w^* = \overline{w}$ (not only when the penalty function is linear). It transpires that a corner solution necessarily arises when $f'' \leq 0$, and may also arise when $f'' > 0$ under further conditions. We now analyze the comparative statics properties of $p(x)$ in (14).

Proposition 3 *In an equilibrium in which $A^* \in \{0, w - x\}$ and $w^* = \overline{w}$ then the comparative statics of $p(x)$ are given as in columns 1 and 2 of Table 2.*

Proposition 3 is most readily understood with respect to the expected marginal returns to evasion and avoidance. The expected return to the gamble of reporting $x < w$ (rather than w) is given, for a fixed p, by

$$R(A, E) = p[w^c(A, E, w) - s] + (1-p)w^n(A, E, w) - w^h(w) \tag{15}$$

And the expected marginal benefit to, respectively, E and A (for a fixed p) are given by

$$\frac{\partial R}{\partial A} = [1 - p - \phi]t'(w - A - E) \tag{16}$$

$$\frac{\partial R}{\partial E} = \frac{\partial R}{\partial A} - \{p[f' - 1] - \phi\}t'(w - E) \tag{17}$$

The corner solution $A^* = 0$ arises when $\partial R/\partial E > \partial R/\partial A$ for all A and the corner solution $A^* = w - x$ when $\partial R/\partial A > \partial R/\partial E$ for all A. As the $p(x)$ in Proposition 3 is predicated on requiring the wealthiest taxpayer to report truthfully, it is responsive to changes in $\overline{w}$. In particular, it is gainful to the wealthiest taxpayer to increase evasion (when $A^* = 0$) and avoidance (when $A^* = w - x$). Hence, whichever corner solution for A applies, the audit function is increasing in the wealth of the wealthiest taxpayer.

	$A^* = 0$	$A^* = w^* - x$	$A^* \in (0, w^* - x)$	
	$p(x)$	$p(x)$	A^*	$p(x)$
x	−	−	−	−
$\overline{w}$	+	+	+	+
ϕ	0	−	−	−
s	−	−	−	−
pivot $f(\cdot)$	−	0	+	−
pivot $t(\cdot)$	+	+	+	+

Table 2: Comparative statics

When the avoidance market is sufficiently competitive that avoidance is a superior instrument in reducing a taxpayer's liability than is evasion (i.e., $\partial R/\partial A > \partial R/\partial E$), a further increase in the competitiveness of the market for avoidance schemes (a fall in ϕ) induces the wealthiest taxpayer to wish to avoid more, and forces $p(x)$ to increase to maintain truth-telling. When, however, the avoidance market is sufficiently uncompetitive that in any case avoidance is unappealing (relative to evasion) as a means of reducing one's tax liability, then the audit function becomes independent of ϕ. Similarly, a multiplicative shift in the penalty function (which increases the marginal rate of penalty by a fixed proportion) only affects $p(x)$ when the wealthiest taxpayer wishes to evade rather than avoid ($A^* = 0$). In this case evasion becomes more costly at the margin, thereby relaxing the truth-telling constraint. We also see that an increase in social stigma results in a fall in the attractiveness of both evasion and avoidance, allowing $p(x)$ to fall while maintaining honest reporting.

A proportional increase in marginal tax rates (a multiplicative shift of the tax function such that $t(\overline{w}) - t(x)$ increases for every x) increases both the expected benefits and costs of evasion and avoidance, making its effect difficult to anticipate with intuition alone. In the absence of avoidance it is well-known that the standard model of tax compliance of Yitzhaki (1974) predicts that an increase in the marginal tax rate decreases the incentive to evade, which implies (in a model without avoidance) that the tax authority would therefore be able to lower the audit function while still achieving truthful reporting. In columns 1 and 2 of Table 2 we observe the opposite result: as marginal tax rates increase the audit function increases. When $A^* = 0$ it is crucial how the expected return to evasion responds to a multiplicative shift of the tax function. Writing $t(\cdot)$ as $\varepsilon t(\cdot)$ we find $\lim_{\varepsilon\to 1} \partial R/\partial\varepsilon|_{A=0} > 0$. Conversely, when $A^* = w - x$ it is pivotal how the expected return to avoidance responds to a multiplicative shift of the tax function. Since also $\lim_{\varepsilon\to 1} \partial R/\partial\varepsilon|_{A=w-x} > 0$, a multiplicative shift of the tax function will increase the expected return to non-compliance.

Having established that a linear penalty function always leads to a corner A^* we now examine the case in which the penalty function is kept general. In particular, we are interested in understanding the conditions under which $A^* \in (0, w - x)$. Using the implicit function theorem (IFT)

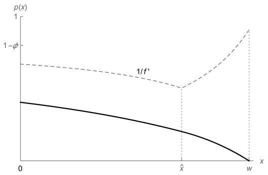

Figure 3: Audit function for $A^* \in (0, w^* - x]$.

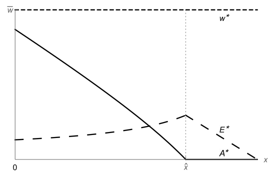

Figure 4: $\{A^*, E^*, w^*\}$ for $A^* \in (0, w^* - x]$.

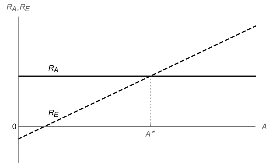

Figure 5: $\frac{\partial R}{\partial A}$ and $\frac{\partial R}{\partial E}$ for $A^* \in (0, w^* - x)$.

it can be shown that for an interior maximum with respect to one or both of A and w it must hold $f'' > 0$. We now investigate the case in which $A^* \in (0, w - x)$:

Lemma 1 *If* $A^* \in (0, w - x)$ *then* $p(x) f' < 1 < [1 - \phi] f'$ *and* $p(x) < 1 - \phi$

In respect of the expected marginal returns to evasion and avoidance, Lemma 1 implies, first, that at an interior value of A^* the expected marginal return to evasion must equal the expected marginal return to avoidance:

$$R_A \equiv \partial R(A, E) / \partial A = \partial R(A, E) / \partial E \equiv R_E.$$

Second, it implies that both expected marginal returns must be positive. Using Lemma 1 and the optimality condition for A^*, it can be shown that interior values of A^* arise for sufficiently high social stigma costs, namely $s > \varepsilon_f (t(\overline{w}) - t(x + A^*)) - 1$, where $\varepsilon_f(z) = z f'(z) / f(z)$ is the elasticity of the penalty function w.r.t. evaded tax.

These findings are illustrated in Figures 3, 4, and 5.We depict $p(x)$ in Figure 3, the associated $\{A^*, E^*, w^*\}$ in Figure 4, and the expected marginal returns drawn at $p = p(x)$ and $E = E^*$ in Figure 5[7]. For $x \in [0, \hat{x})$ A^* is interior while for $x \geq \hat{x}$ $A^* = 0$.

We see in Figure 3 that $p(x)$ is decreasing and concave in x. Consistent with Lemma 1 we see that the audit function lies below $1/f'$, which is itself bounded above by $1 - \phi$. In Figure 4, A^* is initially decreasing and concave in x, and E^* is initially increasing and convex in x. In Figure 5 the expected marginal return to avoidance is seen to be constant in x. This is due to the choice of a linear fine rate; more generally, it is clear from (16) that tax avoidance displays increasing/constant/diminishing marginal returns as the tax function is regressive ($t'' < 0$)/linear ($t'' = 0$)/progressive ($t'' > 0$).

The analysis of the case in which $w^* \in (x + A, \overline{w})$ is omitted for space limitations.

[7]Figures 3, 4, and 5 are drawn for a linear tax function, $t(z) = 0.3z$, a quadratic penalty function of the form $f(z) = [1.1 + z/2] z$, $\phi = 0.2$, $s = 3$, and $\overline{w} = 10$.

We now formally investigate the comparative statics of the case $A^* \in (0, w^* - x)$:

Proposition 4 *In an equilibrium in which A^* takes an interior value the comparative statics of $\{A^*, p(x)\}$ are given as in column 3 of Table 2.*

When A^* takes an interior value the results in Table 2 (column 3) for the comparative statics of $p(x)$ are mostly consistent with those obtained in Proposition 3. We now return to the question of the effects of a proportional increase in marginal tax rates (an anti-clockwise pivot about the intercept of the tax function). Matching our finding in Proposition 3 for the case of a corner solution, the findings in Table 2 predict the opposite of the Yitzhaki (1974) result: as marginal tax rates increase the tax authority must raise the audit function to maintain truthful reporting. This finding is of note as Yitzhaki's result is not only paradoxical intuitively, but much empirical and experimental evidence finds a negative relationship between compliance and the tax rate (see, e.g., Bernasconi et al. 2014, and the references therein). The reversal of Yitzhaki's prediction relies on the idea that, even in cases where evasion becomes less attractive following an increase in marginal tax rates, tax avoidance will more than offset this effect. Thus the overall incentives for non-compliance grow, even if the incentives for evasion weaken. We illustrate this point graphically in Figure 6, which shows the effect on the expected marginal returns to evasion and avoidance of a multiplicative shift of a (linear) tax function[8].

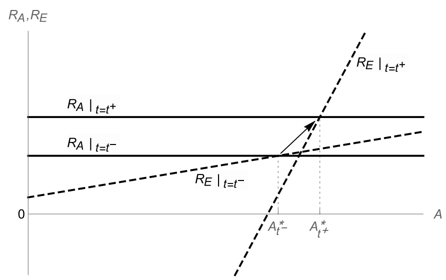

Figure 6: Effect of a multiplicative shift of $t(\cdot)$ on R_E and R_A

[8]Specifically, we increase the marginal tax rate from $t^- = 0.2$ to $t^+ = 0.7$ in the model specification used in Figures 3, 4, and 5.

2 Local Government Efficiency

2.1 Introduction

Local governments, especially in developed countries, provide for a sizeable part of the public good and services supply. The considerable amount of public spending and decision making attributed to local governments calls for an evaluation of their performances. Indeed, efficiency assessment of local governments may provide meaningful information to numerous agents, first among others, the central government, which is interested in the design of performance-based transfers and constraints for the local level. In fact, the decentralization of both taxation and provision determines different effective tax bases and expenditure needs depending on potential spill-overs (Oates 1999) and local socio-economic dimensions. Hence, federal taxes are usually integrated with transfers from the central government based on fiscal efficiency and fiscal equity considerations (on the topic, see Prud'homme 1995). Measures of performances may then be used, along with the socio-economic composition and past expenditures, to determine transfers and constraints imposed on local branches (e.g., Bordignon 2001). Moreover, local politicians may take advantage of efficiency assessments as a relevant information on the production function of the local bureaucratic apparatus. This information may be used to better evaluate the electoral returns offered by different options to increase, therefore, their political power (e.g., Persson et al. 1997) and/or to implement policies to attract mobile factors of production (on the determinants of firm localization, see Buettner and Ruf 2007). Finally, efficiency assessment would provide voters with a signal of the managerial skills of the local incumbent (see the seminal contribution by Seabright 1995). While in the literature it is disputed whether additional information would result in positive or negative net welfare effects (see Ferejohn 1986; Besley and Smart 2007), it is apparent that the electorate, or at least a part of it, is interested in the matter.

Evaluation of *allocative* efficiency may be performed using both input and output quantitative indicators along with unit prices as weights. However, in the municipalities case, market prices for outputs are usually not available. To overcome this issue, the literature proposes to estimate the production function frontier (parametrically or non-parametrically) and to derive *technical* efficiency scores on the basis of relative distances of inefficient observations from the frontier (see e.g. Farrell 1957). Although the use of parametric methods would enhance estimation efficiency, we adopt the non-parametric approach due to the lack of a convincing theory in the literature on the true form of the production function (or of the distribution of inefficiencies) for municipalities. The non-parametric framework offers two fundamental models, the Data Envelopment Analysis (DEA) and the Free Disposal Hull (FDH). Despite the lower rate of convergence, in the present study we consider the latter (and particularly its robust counterpart, the Alpha frontier measure) because it does not rely on the assumption of a convex production space. The heterogeneity of exogenous conditions faced by the unit of interest has a deep effect on efficiency evaluation and, if not considered in the estimation, leads to biased and unfair efficiency measures: some units score poorly because they are impaired by unfavourable exogenous factors, while other result efficient without merit. In this study we account for exogenous conditions using an advanced methodology presented in Daraio and Simar (2005) and Daraio and Simar (2007) (an organic introduction to this strand of literature is provided in Badin et al. 2014). This approach includes the exogenous factors by means of a bootstrapped-conditional-FDH model and then employs smoothed regression to evaluate the mean/variance effects of exogenous variables on the efficiency scores.

We apply conditional frontier models to assess the efficiency of major Italian municipalities for the year 2011. Leveraging on a novel data set with an unprecedented coverage of goods and services offered by municipalities, we introduce a composite indicator of local government output that provides a comprehensive evaluation of the wide range of productive activities performed by municipalities. Based on the functions ascribed to Italian municipalities, we use accounting data to compute expenditure-related input measures and match them with the variables in the output indicator. Finally, we implement conditional frontier models to provide an assessment of municipalities efficiency scores. In the first stage, we evaluate the degree of improvements attainable by any municipality w.r.t. the *relevant* best-practice frontier. In the second stage, we investigate the role of non-discretionary inputs on performance and remove their effect from a measure of efficiency. The obtained *pure* efficiency scores – managerial efficiency – can be correctly imputed to the public manager and used to compare performance across municipality facing different exogenous conditions.

We investigate three external/exogenous dimensions: (i) we analyze whether physical constraints impact on the level of attainable efficiency. To this end, we consider the level and variability of altitude characterizing the municipality territory; ii) we investigate the impact of the social environment as proxied by the level of crime in the municipality, and (iii) we consider a measure of indebtedness to gauge the potential effects of financial constraints. Our findings show that municipalities with a high altitude level and/or dispersion are hindered in their provision activity. Similarly, the social context matters and negative social conditions are, as expected, found to be unfavourable to production efficiency. The level of indebtedness appears to be marginal, having no significant effect on the likelihood to reach the efficient frontier. We also provide a bi-variate analysis combining both physical and social measures. This enriched view mostly confirms the univariate results and allows to identify conjoint effects neglected otherwise. Furthermore, this allows to estimate *pure* managerial efficiency, i.e., measures where the effect of multiple external/exogenous variables is removed by means of a two-stage procedure, that may be used as a more reliable measure of efficiency. The finding of a negative impact of altitude on efficiency is novel in the literature and likely obtained thanks to the improvements here introduced in terms of both data and methodology w.r.t. previous studies. Similarly, evidence of a negative relationship between crime and performance has never been presented before and we wish it may encourage further debate on the topic. Finally, our investigation on the role of the stock of debt is the first one performed on Italian municipalities.

The methodology adopted in the analysis – i.e., the conditional frontier model – has remarkable strengths and weaknesses. From one hand, the results obtained are based on an extremely narrow set of assumptions and can therefore be considered particularly robust. From the other hand, the high computational burden needed to perform the analysis limits the dimensionality of the exogenous variables that can be considered. Taking into account those traits is vital to a correct interpretation of the presented results. *Pure* managerial efficiencies here provided have been washed out from the effects of just two of the plausibly many exogenous factors affecting it. Hence, while representing a better measure relative to the unconditional one, the *pure* managerial efficiency provided in the bivariate exercise should be taken with caution if exploited for policy guidance. Still, we remark that the inclusion of just two exogenous factors has major effects on the estimated managerial efficiencies and, therefore, an analysis failing to account for this aspect would be fundamentally flawed.

Theoretical and implementation improvements that would allow to include a wider set of environmental variables in the analysis is of primary interest for further research. Furthermore, an additional avenue for future research lies in the expansion of the analysis along the time dimension in order to investigate the dynamics of efficiency also in relation to governmental and local policies. Finally, an extension of the current work to the whole set of Italian municipalities would both improve estimation reliability and provide useful information to the policy-makers.

2.2 Italian municipalities efficiency: A conditional frontier model approach[§]

2.2.1 Data Description

This study focuses on performance evaluation for the year 2011, the date of the latest census made by the Italian National Institute of Statistics (ISTAT 2011). Our units of interest (i.e. DMUs, Decision Making Units) are Italian administrative centres. We select cities corresponding to the province capitals, hence the analysis covers the most important municipalities in terms of population. Among the 110 province capitals, 10 of them correspond to unions of municipalities[9]. We do not consider these unions due to comparability issues and for data coverage[10]. The analysis presents a static ranking of Italian municipalities (hereinafter we refer interchangeably to municipalities/DMUs) efficiencies. We consider as inputs the sums (in Euro) spent by the DMUs on each of its main function as reported in their financial statements. This information is made public by the Italian Ministry of Internal Affairs[11]. The functions included are[12]: i) general activities related to administrative and control tasks; ii) local police; iii) education and schooling; iv) infrastructures and transportation; v) environment; vi) welfare. Hence, we consider the most relevant municipalities' functions[13]. The construction of the output vectors is based on several sources[14]: ISTAT, Istituto Tagliacarne, the Italian Ministry of Internal Affairs, the Italian Ministry of University and Research, and Legambiente. Our intent is to provide, for each input, a corresponding output measure. Due to the variety of outputs produced by every municipality, we provide small lists of outputs for each input. Table 3 shows the list of inputs and the corresponding outputs.

[§]This section has been developed in collaboration with Andrea Flori and it is undergoing revisions before being submitted.

[9]These province capitals are: Barletta-Andria-Trani, Carbonia-Iglesias, Forlì-Cesena, Massa-Carrara, Medio Campidano, Monza e della Brianza, Ogliastra, Olbia-Tempio, Pesaro-Urbino, Verbano-Cusio-Ossola.

[10]Similarly, Aosta is excluded due to the high number of missing values.

[11]Data may be found at: http://finanzalocale.interno.it/apps/floc.php/in/cod/4 .

[12]There is a repartition of competencies among Italian State, Regions, Provinces (nowadays cancelled by the Law n.56 of 7 April 2014, but present in 2011) and Municipalities. In September 2003 the Constitutional Law n.3 modified the Title V of Italian Constitution, determining also the revision of the "Testo Unico degli Enti locali" (approved by d.lgs. 18th August 2000, n.267), which represents the collection of regulations on local public entities.

[13]The omitted functions represent only a minor part of municipality total expenditures. These functions are: justice, management of cultural heritage, sport and leisure and economic development. Other public bodies are typically leading these activities where municipalities play a marginal role.

[14]ISTAT is the Italian Institute of Statistic. Istituto Tagliacarne (belonging to the Italian statistics system) gathers and analyze data from the Chambers of Commerce. Legambiente is a leading environmental association in Italy.

Inputs	Outputs	Outputs Sources
General activities related to administrative and control tasks	Total Population	ISTAT
Local Police	Number of Vehicles	Ministry of Internal Affairs
	Number of Km Travelled	Ministry of Internal Affairs
Education and Schooling	Number of Classes	Ministry of University and Research
	Number of Students	Ministry of University and Research
	Number of Meals	Ministry of Internal Affairs
	Number of Applications for the Canteen Service	Ministry of Internal Affairs
	Number of Satisfied Requests for the Canteen Service	Ministry of Internal Affairs
Infrastructures and Transportation	Light Points	ISTAT
	Km of Roads Lightning	Ministry of Internal Affairs
	Km of Urban Roads	Ministry of Internal Affairs
	Km of Extra-Urban Roads	Ministry of Internal Affairs
	Users of Public Transport Service	ISTAT
	Number of Km Travelled by Public Transport	Legambiente
Environment	Power of Photovoltaic Solar Panels installed on Municipal Buildings	ISTAT
	Population Connected to Urban Waste water	ISTAT
	Solid Waste Treated	ISTAT
Welfare	Home Help with Social Care Services: Disability	ISTAT
	Home Help with Social Care Services: Elderly	ISTAT
	Home Help with Social and Healthy Care Services: Disability	ISTAT
	Home Help with Social and Healthy Care Services: Elderly	ISTAT
	Cash Benefits for Delivery of Social and Healthy Care at Home: Disability	ISTAT
	Number of Day-Nursery	ISTAT
	Number of Available Seats in Day-Nursery	Ministry of Internal Affairs
	Day-Nursery: Number of Children Aged 0-2 Years Attending Infancy Day-Care Services	ISTAT
	Number of Applications for the Day-Nursery Service	Ministry of Internal Affairs
	Number of Satisfied Requests for the Day-Nursery Service	Ministry of Internal Affairs
	Supplementary or Innovative Services for Infancy Day-Care	Ministry of Internal Affairs

Table 3: **Inputs and outputs data**. The first column shows the selected inputs corresponding to the main municipality functions. The second column reports the outputs considered for each input. The third column displays the source of output data.

The external variables considered stand for dimensions over which municipalities are supposed to not have discretionary power. Following notation in literature, we indicate this list of external/exogenous variables as the Z vector (z when considering a unidimensional variable). We employ measures of the level and of the standard deviation of altitude elaborated by ISPRA[15] using the *zonal statistics* algorithm on ISTAT data. For each municipality we multiply its altitude by the variance of municipality territory to take into account not only altitude level but also its irregularity. We label this indicator as *Compound Altitude*. Crime is introduced to consider the *quality* of the social environment; although it may be argued that municipality managers have an influence on local crime levels, we believe that the latter are only marginally affected by municipality policies. Indeed, the main actor involved in crime deterrence is the central government[16]. We compute the indicator *Crime Incidence* as the average of per-capita crimes reported to the judicial authorities during the years 2008-2010. The characteristics of the resident population depend on many socio-economic drivers and

[15]Italian National Institute for Environmental Protection and Research.

[16]The law n.121 of 1st April 1981 attributed duties of security and enforcement of public order to the (central) Ministry of Internal Affairs.

both local and central policies affect migration net-flows and the local social environment alike. However, we argue that this is a viscous process, which we assume will not lead to substantial changes in the short run. Finally, we investigate whether the stock of debts is unfavourable to the provision of public services. Obviously, there might be endogeneity related to the funding sources that we include in the input vector. To ameliorate the possible endogeneity issues, we take a four year average before 2011. The corresponding indicator *Funding* is then normalized by the number of residents.

2.2.2 Results

Results presented in this section are based on the methodology introduced in Daraio and Simar (2005) and Daraio and Simar (2007). First[17], we investigate if the z-s have a statistically significant effect on efficiency by computing ratios of conditional-Alpha frontier to unconditional-Alpha frontier along with bootstrapped confidence intervals. Second, a location-scale kernel regression is performed on efficiencies to identify the magnitude of the impact of external factors. Finally, we remove the influence of exogenous conditions obtaining *pure* managerial efficiencies.

Confidence Intervals In Figure 7 we present the marginal effect (the continuous line) with the corresponding 95% confidence intervals (the dashed lines) on the ratio of conditional-Alpha frontier for each measure z. Efficiency ratios are shown to be increasing for the lowest and highest levels of *Compound Altitude* while a plateau characterizes its central part. Hence, there is a significant non-negative influence of *Compound Altitude* on the attainable set of efficient levels. The effect of *Crime Incidence* on efficiency ratio is positive and becomes increasingly positive moving from low to high values of z. Hence, DMUs with higher values of crime tend to be less efficient. Finally, *Funding* seems to be only marginally related with efficiency ratio and the graph displays just small deviations around a plateau that spans along the whole range of the z variable. The marginal analysis suggests that two external measures, namely *Compound Altitude* and *Crime Incidence*, have a significant and negative impact on the production process while for the third one, *Funding*, there is no evidence of an impact on efficiency scores.

Bivariate Analysis: the Joint Impact of Compound Altitude and Crime Incidence In this paragraph we explore the conjoint impact of *Compound Altitude* and *Crime Incidence* on municipalities'

[17]The outlier detection procedure and the local effect analysis have been performed as a preliminary step in order to ensure compliance of the data with the assumptions underlying conditional-frontier models. We are omitting them, however, due to space limitations.

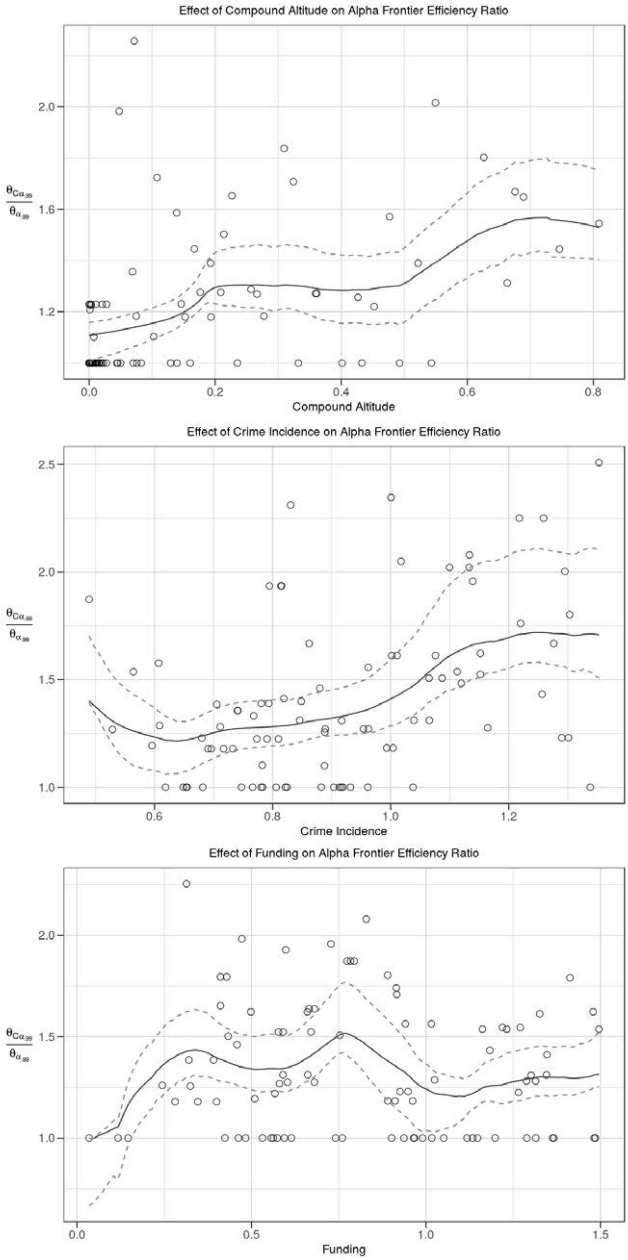

Figure 7: **Confidence intervals of efficiency ratios**. Solid lines show the marginal effects of exogenous variables while the dashed ones depict the bootstrapped 95% confidence intervals. From top to bottom: *Compound Altitude*, *Crime Incidence* and *Funding* effects.

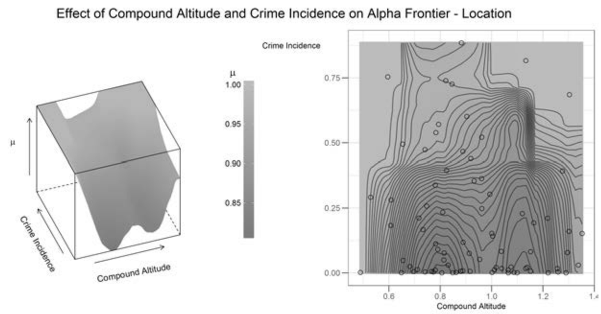

Figure 8: **Bivariate analysis of exogenous effects**. Surface and contour plots (respectively, left and right panel) of the joint impact of *Compound Altitude* and *Crime Incidence* on conditional-Alpha efficiency when $\alpha = 0.99$.

efficiencies. *Funding* is not accounted for since the univariate analysis has established its negligible impact. Figure 8 illustrates the location effect of *Compound Altitude* and *Crime Incidence* on the conditional-Alpha frontier. The local mean effect of *Compound Altitude* is U-shaped along the whole range of *Crime Incidence* with a curvature that is less pronounced when moving from low to high values of the latter. An increasing effect of *Crime Incidence* holds for the whole range of *Compound Altitude* but with a lower slope occurring on extreme values. The multidimensional specification of the location-scale model succeed in removing the effects of the two exogenous variables: the correlation of managerial efficiencies with *Compound Altitude* and *Crime Incidence* is -0.01 and 0.09 respectively. In Figure 9, we plot on the Italian map[18] the unconditional-Alpha measures of efficiency (the *basic* technique that conditional frontier models extend to account for exogenous factors) and the *pure* managerial efficiencies obtained from the multidimensional specification. According to the unconditional measure, South is the area with higher efficiency levels while North-West and Centre are ranked in second and third position respectively. The Island area is ranked fourth while North-East is the one with lowest performances. Considering exogenous factors heavily affects the results: North-West becomes the most efficient area while South joins the Centre in second position. However, it needs to be noted that a marked variability characterizes intra-area efficiency, especially for the North-East area.

[18]in the figure, municipality efficiency is imputed to its whole province to improve clarity.

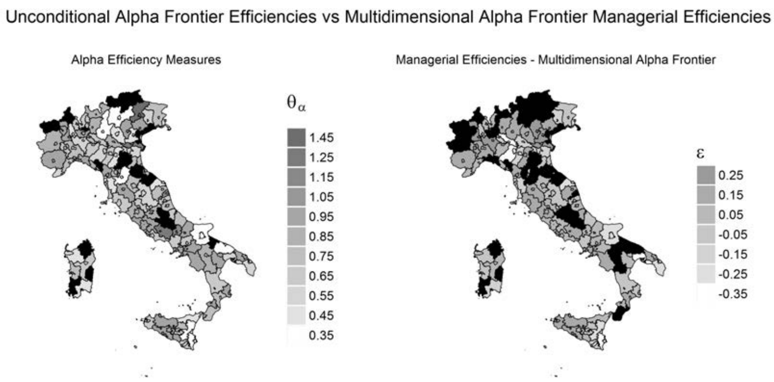

Figure 9: **Geographical distribution of efficiency**. Unconditional-Alpha efficiencies and *pure* managerial efficiencies (respectively, left and right panel) from bivariate analysis. Darker colour denote higher efficiency, missing observations in black.

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