TAX EVASION ON A SOCIAL NETWORK

Duccio Gamannossi degl'Innocenti [1] Matthew D. Rablen [2]

[1]University of Exeter

www.dgdi.me

[2]University of Sheffield

www.sheffield.ac.uk/economics/people/rablen

Tax Administration Research Centre

CONTENT

INTRODUCTION

TAX EVASION - RELEVANCE AND RESEARCH

→ Tax evasion causes **significant losses of public revenues** (£4.4 bn. in UK)

→ Growing interest by tax agencies to exploit “big data” and network theory to **improve efficiency of deterrence measures**

→ Predictive tools find **patterns in data arising due to the determinants of subjects’ decisions**

→ We investigate the **impact of social network on tax evasion decisions** and develop a framework to **asses the value of social network data**

TAX EVASION AND REFERENCE DEPENDENCE

→ We **relate tax evasion behaviour to** a substantial body of evidence that people seek to "**keep up with the Jones**"

→ Specifically, **one way to keep up with the Jones' is to evade** more tax than others do

→ An immediate consequence is that **individual evasion behaviour is related to how others are behaving**

→ A taxpayer takes into account the behaviour of others through his **reference income**, a "benchmark" of others' consumption

RELATED LITERATURE

→ Kahneman and Tversky 1979
Reference dependence of utility

→ Gali 1994
"Keeping up with the Jones"

→ Myles and Naylor 1996
Tax evasion, social custom and conformity

→ Ballester, Calvo, Zenou 2006
Network games with local payoff complementarities

→ Quah 2007
Monotone comparative statics on network games

MODELLING FEATURES

Provide a model where:

→ Taxpayers may engage in **risky** tax evasion

→ Taxpayers differ in **income**, **probability of detection** and **reference group** (individuals in a taxpayer's social network)

→ **Self** and **social** comparison shape the **reference income**

→ **Social** comparison depends on taxpayer' **reference group**

RESEARCH QUESTIONS

→ Our analysis has focused on **three** questions:

1. Is it possible to characterize **optimal evasion** and how do **changes in the exogenous parameters** (income, risk aversion, etc.) affect it?
2. Is it possible to characterize the direct and indirect **revenue effects** of interventions?
3. How much does the **availability of more information** (especially related to social network) improves the capacity of a tax authority to **infer audit revenue effects**?

MODEL

EVASION AND DETERRENCE

- We define **evasion** E_{it} as the **liabilities under-declarerd** by taxpayer i at time t
- Evasion is a **risky** activity:
  - The **tax agency** is actively seeking to detect and **shut-down** evasion
  - There is a compound probability p_i that:
    - **The taxpayer is discovered** under declaring
    - The **tax agency is successful** in shutting down evasion
  - The tax authoritiy levies a **fine** f proportional to the evaded tax debt upon successful action

REFERENCE INCOME

→ Taxpayers' reference income R_{it} is **linear** in a **Social**-related and a **Self**-related components

→ **Social**:

The (weighted) **expected consumption** of taxpayer's **reference group**

→ **Self**:

Their habit consumption $h_{it} = f(C_{it-\mathbf{1}} \ldots C_{it-\mathbf{T}})$

→ **Reference income is updated** in every period to account for the **effects of deterrence activity**

OPTIMAL EVASION

THE TAXPAYER'S PROBLEM

$$\max_{E_i} \mathbb{E}\left(U_{it}\right) \equiv [1-p_i]\, U\left(C^n_{it} - R_{it}\right) + p_i \left[U\left(C^a_{it} - R_{it}\right)\right]$$

After-tax income ***if not audited***

$C^n_{it} \equiv X_i + E_{it}$

After-tax income ***if audited***

$C^a_{it} \equiv C^n_{it} - (1+f)E_{it}$

Utility is linear-quadratic

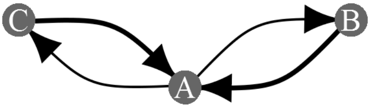
$U(z) = z[b - \frac{az}{2}]$

Optimal Evasion at an interior solution is:

$$E^*_{it} = \frac{1-p_i f}{a\zeta_i}\{a[R_{it} - X_i] + b\}, \zeta_i > 0$$

A SIMPLE EXAMPLE

Taxpayer interaction through the reference income leads to the rise of a network game



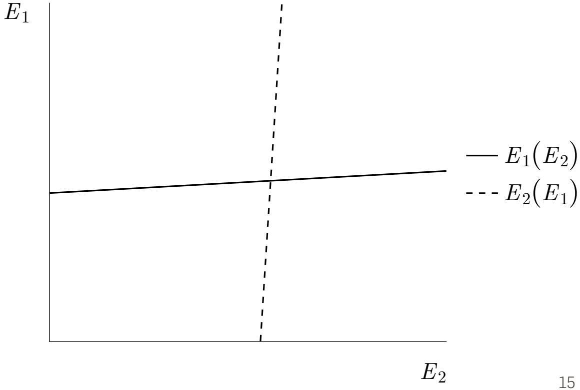
$$\begin{array}{c|ccc} & A & B & C \\ \hline A & & & \\ B & & & \\ C & & & \end{array} \quad \begin{array}{cc} & \begin{matrix} A & B & C \end{matrix} \\ \begin{matrix} A \\ B \\ C \end{matrix} & \begin{pmatrix} 0 & .5 & .5 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \equiv \mathbf{G} \end{array}$$

$$\begin{cases} E_A^* = \frac{1-p_i f}{a\zeta_A}\{a[R_A(h_A; E_B^*, E_C^*) - X_A] + b\} \\ E_B^* = \frac{1-p_i f}{a\zeta_B}\{a[R_B(h_B; E_A^*) - X_B] + b\} \\ E_C^* = \frac{1-p_i f}{a\zeta_C}\{a[R_C(h_C; E_A^*) - X_C] + b\} \end{cases}$$

BEST RESPONSE

→ **Linear best response** follows from **quadratic utility** and **linearity of reference income**

Strategic complementarity of E_{it}, E_{jt} leads to **positive slope** of best response functions



WEIGHTED BONACICH CENTRALITY AND EVASION

Given the linearity of R_{it} the system of equation defining evasion is linear:

$$\mathbf{E}_t = \boldsymbol{\alpha}_t + \mathbf{M}\boldsymbol{\beta}\mathbf{E} \;\equiv\; \begin{cases} E_A^* = \eta_i\{a[R_A(h_A; E_B^*, E_C^*) - X_A] + b\} \\ E_B^* = \eta_i\{a[R_B(h_B; E_A^*) - X_B] + b\} \\ E_C^* = \eta_i\{a[R_C(h_C; E_B^*) - X_C] + b\} \end{cases}$$

And we can solve à la **Cournot-Nash**:

$$\mathbf{E}_t = [\mathbf{I} - \mathbf{M}\boldsymbol{\beta}]^{-1}\boldsymbol{\alpha}_t = b(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\alpha}_t)$$

Where $b(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\alpha}_t)$ is a weighted Bonacich centrality measure

OPTIMAL EVASION

- → Key theoretical result is that **evasion is closely related to the concept of "Bonacich" Network Centrality**
  - → More "central" taxpayers evade more
- → Network centrality is a concept developed in sociology
  - → Measures the amount of influence/power players have within a network

MONOTONE COMPARATIVE STATICS IN TIME

A **permanent** marginal parameter change entails **contemporaneous** and **delayed effects** on steady state evasion:

1. The contemporaneous effect $\frac{\partial E_i^{SS}}{\partial z}$ is not accounting for delayed effects
2. The **full effect** $\frac{dE_i^{SS}}{dz}$ **includes** also the **delayed effect** caused by adjustments of **habit consumption**

We investigate comparative statics w.r.t. a no-audit steady-state ($\mathbf{C}^{SS} = \mathbf{C}^{n,SS} = \mathbf{X} + \mathbf{E}^{SS}$)

MONOTONE COMPARATIVE STATICS RESULTS

Habit consumption	$+$	Other's Income	$+/0$
Own comparison	$+$	Social comparison	$+/0$
Own audit prob.	$-$	Others audit prob.	$-/0$
Risk Aversion	$-$	Fine	$-$
Tax rate	$+$		

Monotone comparative statics for interior E_i^*

These results apply both to contemporaneous and full effects

REVENUE EFFECTS OF AUDIT

INTERVENTION REVENUE EFFECTS

How does an audit to a taxpayer affects revenues collected?

1. **Direct effect $\mathbf{E}^{SS}$**

   Evaded liabilities recovered from the audited taxpayer

2. **Indirect effects I_{ij}**

   Expected additional revenue that arises **from future changes in evasion behaviour** (**negative externality**)

   - → I_{ii} from the audited tapayer
   - → I_{ij} from non-audited taxpayers
     - → $\boldsymbol{\Sigma_i} = \sum_{j \in \mathcal{N} \setminus i} I_{ij}$ **aggregate cross indirect effect**

→ Indirect effects **2X-6X** direct ones

TAX AGENCY'S INFERENCE PROBLEM

- Tax authorities engage in inferring both **direct effects** $\mathbf{E}^{SS}$ and **aggregate gross indirect effects** $\mathbf{\Sigma}$
  - Taxpayers usually ranked by discriminant function and audited sequentially until budget is exhausted
- Crucial information for tax authorities is correct rank of $\mathbf{E}^{SS}$ and $\mathbf{\Sigma}$
  - Optimal audit targeting if tax authorities were able to exactly infer **rankings** of direct and indirect effects.

Tax authorities require measures that are ordinally equivalent to direct and indirect effects

$$\mathbf{A} \sim \mathbf{B} \iff A_{i1} \gtrless A_{j1} \Leftrightarrow B_{i1} \gtrless B_{j1} \forall i, j$$

MEASURES ORDINALLY EQUIVALENT TO REVENUE EFFECTS

The indirect revenue effects of conducting a single audit of i satisfy:

$$\mathbf{I}_i \sim \mathbf{E}_i^{SS}\mathbf{b}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\rho}_i^{SS})$$

where $\mathbf{E}_i^{SS}$ is an $n \times n$ diagonal matrix and $\boldsymbol{\rho}_i^{SS} = \frac{\partial \boldsymbol{\alpha}^{SS}}{\partial C_i^{SS}}$

Sizes of the **own** and **cross indirect** effects are **ordinally equivalent** to the product of the steady state level of evasion and a new measure of **Bonacich centrality**

MEASURES ORDINALLY EQUIVALENT TO REVENUE EFFECTS

An intuition for the result:

$$\mathbf{I}_i \sim \mathbf{E}_i^{SS}\mathbf{b}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\rho}_i^{SS})$$

→ The size of the indirect effect I_{ij} is ordinally equivalent to the size of the initial deviation

→ convergence of evasion back to its steady state value is at a uniform rate for all affected taxpayers

→ Initial effect can be decomposed linearly as the product of:

→ marginal effect of a change in i's consumption on j's evasion $\partial E_j^{SS}/\partial C_i^{SS} = b_{j1}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\rho}_i^{SS})$

→ change in i's consumption $C_i^{n,SS} - C_i^{a,SS} = [1+f] E_i^{SS}$ proportional to just E_i^{SS}

INFERENCE OF REVENUE EFFECTS

→ What is the expected value of implementing predictive analytics on social network data for a tax authority?

We estimate by simulation the **additional audit revenues** $\Delta\mathfrak{R}(\mathbf{G})$ from exploiting **network information** in targeting

→ Two settings considered:

1. **Full observability** ($\mathcal{F}$): The tax agency observes all comparision intensities
2. **No observability** ($\emptyset$): The tax agency has no information on comparison intensities

→ Audit revenues increase by $\Delta\mathfrak{R}(\mathbf{G}) \approx \mathbf{6\%}$ when **social network information** is available

NETWORK GENERATIVE PROCESS

- We generate a static network using the Bianconi-Barabási **fitness** model
  - Taxpayers with **higher wealth** have a higher probability of making new connections
  - Taxpayers already **heavily connected** have a higher probability of making new connections (sublinear preferential attachment, $\phi < 1$)

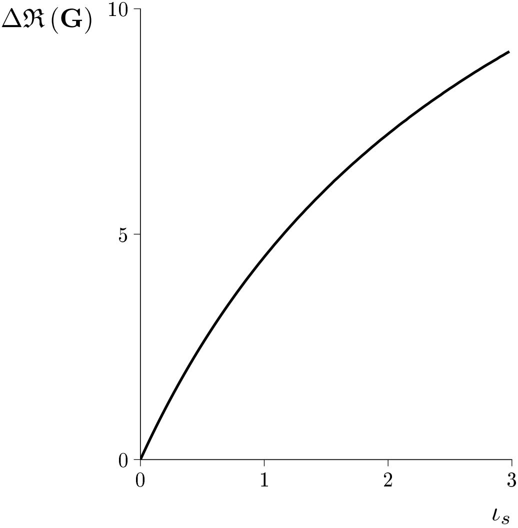
Formally:

$$\Pi_i = \frac{W_i[d^{in}(i)]^{\phi}}{\sum_{j \in \mathcal{N}} W_j[d^{in}(j)]^{\phi}}$$

The resulting **static** social networks used in our simulations resembles the ones observed empirically

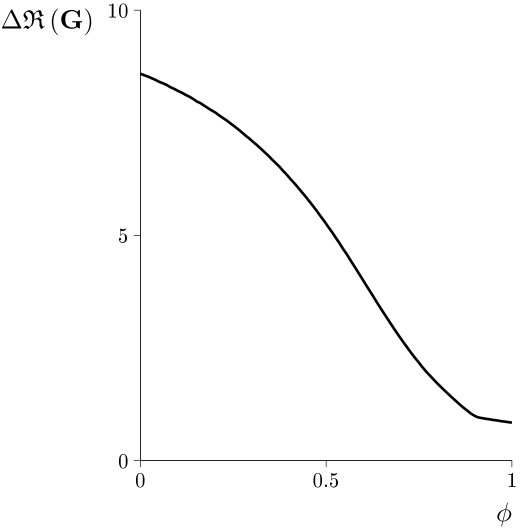
NETWORK INFORMATION AND SOCIAL COMPARISON

→ The value of **network information** increases in the importance of social comparison ι_s



NETWORK INFORMATION AND PREFERENTIAL ATTACHMENT

- → **The value of network information decreases the stronger is preferential attachment ϕ**
- → A stronger preferential attachment **reduces variability across reference incomes**



CONCLUSIONS

CONCLUDING REMARKS

- → Social interaction may heavily affect evasion behaviour
- → Different **Bonacich** measures of centrality characterize optimal **evasion** and **revenues effects** from auditing
- → **Social network information** improve significantly the **prediction** of revenues effects from interventions

Thank You!

Questions?