TAX EVASION ON A SOCIAL NETWORK

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

[1]University of Exeter

d.gamannossi@exeter.ac.uk

www.dgdi.me

[2]University of Sheffield

m.rablen@sheffield.ac.uk

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

CONTENT

INTRODUCTION

COMPLIANCE AND REFERENCE DEPENDENCE

- → We relate non compliant behaviour to a body of evidence on the **importance of positional concerns** (keeping up with the Jones)
- → Tax evasion may be used to improve agents' relative standing
- → The choice of **how much to evade is affected by social interaction** and depends on **reference income**

TAX EVASION - RELEVANCE AND RESEARCH

- → Tax evasion causes **significant losses of public revenues** (4.4 bn. £ in UK)
- → Growing interest by tax agencies on understanding evasion so to **design efficient deterrence measures**
- → **Rich literature** using different approaches to study evasion decision and optimal policies

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

→ Agents differ in **income**, **probability of detection** and **reference group**

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

→ **Social** comparison depends on agents' **social network**

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 revenue effects**?

MODEL

MODELLING OF EVASION

- We define evasion E_{it} as the **liabilities under-declarerd** by taxpayer i at time t
- Evasion is a **risky** activity:
  - The tax agency may detect evasion
  - Upon detection, the taxpayer is levied a **fine** f proportional to the evaded tax debt in addition to his true liabilities

REFERENCE INCOME

- Taxpayers determine their reference R_{it} income based on **Social**-related and **Self**-related considerations
  - **Social**:
    The (weighted) **average consumption** of taxpayer's **reference group**
  - **Self**:
    Their habit consumption $h_{it} = f(C_{it-\mathbf{1}} \ldots C_{it-\mathbf{T}})$

OPTIMAL EVASION

THE TAXPAYER'S PROBLEM

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

After-tax income **if not audited**

$$C_{it}^n \equiv X_i + E_{it}$$

After-tax income **if audited**

$$C_{it}^a \equiv C_{it}^n - (1+f)E_{it}$$

Utility is linear-quadratic

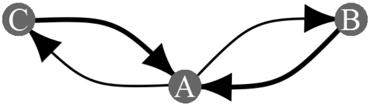
$$U(z) = z[b - \tfrac{az}{2}]$$

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 game



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

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

REFERENCE DEPENDENCE

Taxpayer i expected after-tax income when evading E_{it} is:

$$q_{it} = X_i + [1 - p_i f] E_{it}$$

We can then define:

$$Z_{it} = \iota_h h_{it} + \iota_s \mathbf{g}_i \mathbf{q}_t$$

And reference income:

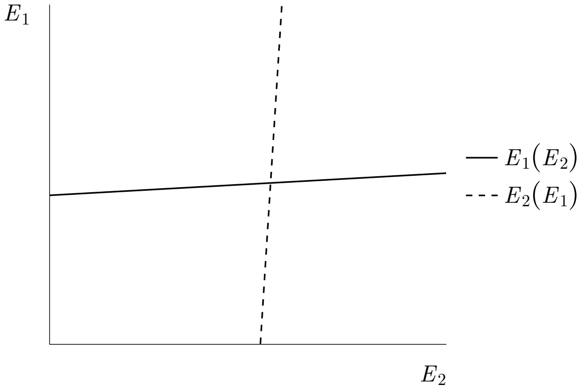
$$R_{it} = R_{it}(h_{it}; \mathbf{q}_t(\mathbf{E}_t)) = R_{i,t-1} + \varsigma_R \left[Z_{it} - R_{i,t-1} \right]$$

where:

$X_i = (1-t) W_i$	Honest after-tax income
ι_h, ι_s	Self and social comparison parameters
$\mathbf{g}_i$	Weights of i's reference group
$\varsigma_R \in (0,1)$	Reference consumption reactiveness

BEST RESPONSE

Quadratic utility leads to linear best response



Positive slope of best response functions follows from strategic complementarity in E_{it}, E_{jt}

WEIGHTED BONACICH CENTRALITY AND EVASION

Expanding E^{*}_{it} using the definitions of R_{it}, Z_{it} and q_{it} we can rewrite:

$$\begin{cases} E^{*}_{A} &= \eta_i\{a[R_A(h_A; E^{*}_{B}, E^{*}_{C}) - X_A] + b\} \\ E^{*}_{B} &= \eta_i\{a[R_B(h_B; E^{*}_{A}) - X_B] + b\} \\ E^{*}_{C} &= \eta_i\{a[R_C(h_C; E^{*}_{B}) - X_C] + b\} \end{cases}$$

$$\mathbf{E}_t = \boldsymbol{\alpha}_t + \mathbf{M}\beta\mathbf{E}$$

And 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**

STEADY STATE EVASION

- → Audit events influence comparative statics results
- → We investigate CS wrt a no-audit steady-state

Corollary 2

In a steady state of the model consumption satisfies $\mathbf{C}^{SS} = \mathbf{C}^{n,SS} = \mathbf{X} + \mathbf{E}^{SS}$.

Steady state evasion $\mathbf{E}^{SS}$, is then given by the vector of Bonacich centralities, $\mathbf{b}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\alpha}^{SS})$, with

$$\alpha_i^{SS} = \frac{1 - p_i f}{a\zeta_i}\left\{b - a\left[X_i - R\left(h_i^{SS}, \mathbf{X}\right)\right]\right\}$$

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

EVASION AND INCOME

→ In the case of **income, contemporary and delayed effects have opposite signs**

→ The **contemporaneous effect causes evasion to fall** due to the increased income, i.e. $\frac{\partial E_i^{SS}}{\partial X_i} < 0$

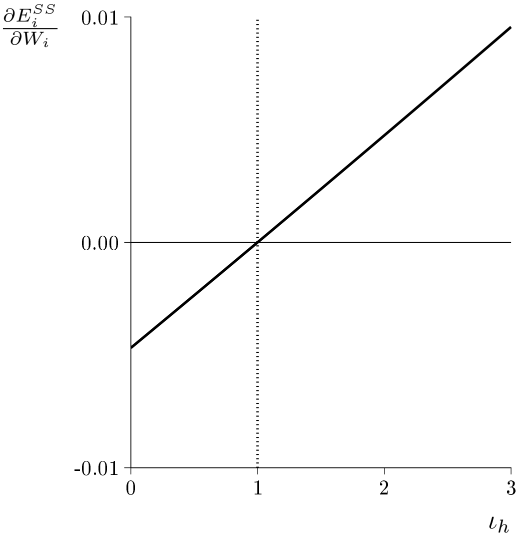
→ However, **the delayed effect causes an increase in habit consumption** $\frac{dC_i^{SS}}{dX_i} < 0$ that as a positive effect on evasion.

This allows our model to replicate the observed behaviour

of evasion increasing in income $\frac{dE_i^{SS}}{dX_i} > 0$

EVASION VS. CONCERN FOR HABIT

The higher a taxpayer's concern for habit ι_h the more evasion increases in income



RESPONSES TO INTERVENTION

INTERVENTION REVENUE EFFECTS

How does an audit to a taxpayer affect the steady-state evasion of the model?

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

   On targeted taxpayer, by **averting attempted evasion**
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

- When there is full observability of the network it is possible to exactly determine direct ($\mathbf{E}^{SS}$) and cross indirect ($\mathbf{\Sigma}$) effects
  - **However** tax agencies infer revenue effects under **limited observability**

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 the comparison intensity from any taxpayer against anyone else
  2. **No observability** ($\emptyset$): The tax agency has no information about the network - same comparison intensity for every link is assumed
- 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, $\phi < 1$)

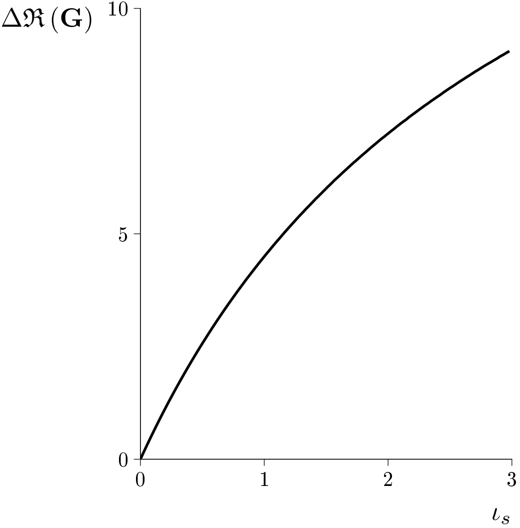
Formally:

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

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

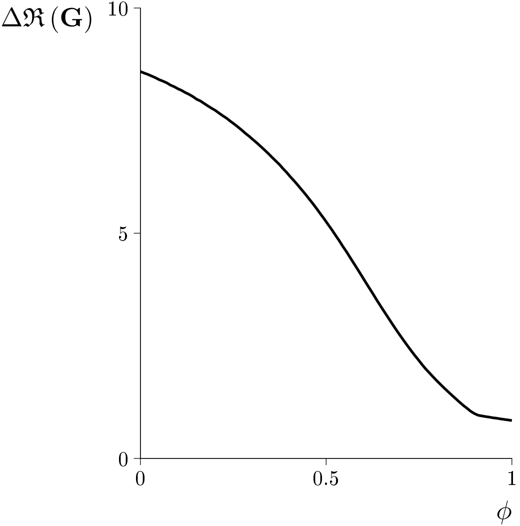
NETWORK INFORMATION AND SOCIAL COMPARISON

- Higher concern for social comparison ι_s **increases value of network information**
- **Audit revenues may improve significantly** from no network observability $\emptyset$ to full observability $\mathcal{F}$



NETWORK INFORMATION AND PREFERENTIAL ATTACHMENT

- → Stronger preferential attachment ϕ **reduces variability across reference incomes**
- → **Audit revenues may improve significantly** from no network observability $\emptyset$ to full observability $\mathcal{F}$



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

FURTHER RESEARCH

→ Extend the analysis to **avoidance** and **crime** as a whole

→ Analyse how adding or **removing taxpayers** from the network (detention) may affect compliance

Thank You!

Questions?