

# TAX EVASION ON A SOCIAL NETWORK

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# 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-declared** 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 authority levies a **fine**  $f$  proportional to the evaded tax debt upon successful action

# REFERENCE INCOME

- Taxpayers determine their reference income  $R_{it}$  based on **Social** and **Self** comparison
  - **Social:**  
The (weighted) **expected consumption** of taxpayer's **reference group**
  - **Self:**  
Their habit consumption  $h_{it} = f(C_{it-1} \dots C_{it-T})$
- **Reference income is updated** in every period to account for the **effects of deterrence activity**

# OPTIMAL EVASION

# THE TAXPAYER'S PROBLEM

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

**After-tax income if not audited**

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

**After-tax income if audited**

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

**Utility is linear-quadratic**

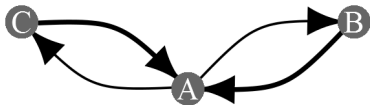
$$U(z) = z[b - \frac{az}{2}]$$

**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



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

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

## REFERENCE DEPENDENCE

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

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

We can then define:

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

And reference income:

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

where:

$$X_i = (1 - t) W_i$$

Honest after-tax income

$$\iota_h, \iota_s$$

Self and social comparison parameters

$$\mathbf{g}_i$$

Weights of  $i$ 's reference group

$$\varsigma_R \in (0, 1)$$

Reference consumption reactivity

# WEIGHTED BONACICH CENTRALITY AND EVASION

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

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

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
  - In our setting the more central taxpayers are celebrities”

# 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**  $E^{SS}$

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 taxpayer

→  $I_{ij}$  from non-audited taxpayers

→  $\Sigma_i = \sum_{j \in \mathcal{N} \setminus i} I_{ij}$  **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**  $\Sigma$ 
  - 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  $\Sigma$ 
  - 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

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

# 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 comparison intensities
2. **No observability** ( $\emptyset$ ): The tax agency has no information on comparison intensities

→ Audit revenues increase by  $\Delta\mathfrak{R}(\mathbf{G}) \approx 6\%$  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,  $\phi < 1$ )

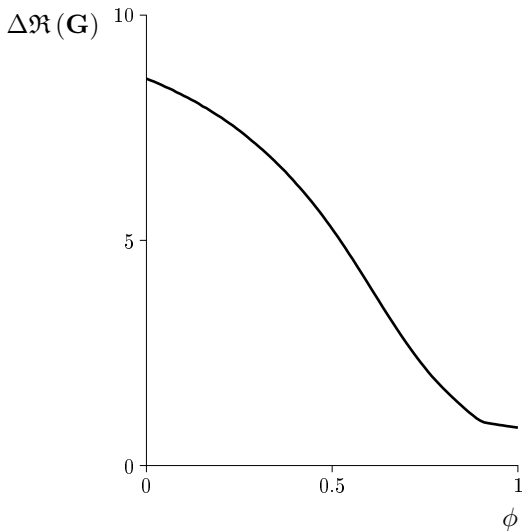
Formally:

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

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

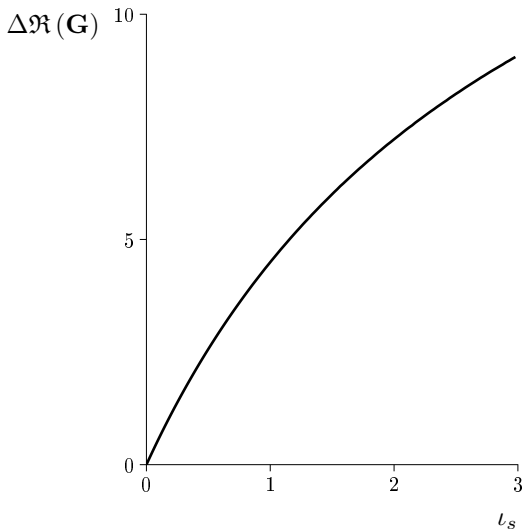
# NETWORK INFORMATION AND PREFERENTIAL ATTACHMENT

- The value of network information **decreases the stronger is preferential attachment**  $\phi$
- A stronger preferential attachment **reduces variability across reference incomes**



# NETWORK INFORMATION AND SOCIAL COMPARISON

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



# 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?