TAX EVASION ON A SOCIAL NETWORK

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INTRODUCTION

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

- Growing interest among tax authorities in **how social attitudes to tax evasion are formed**

- "Big data" information systems potentially allow tax authorities to **perceive social networks to an unprecedented degree**

- 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**
  - Is it worthwhile for a tax authority to invest in this technology?

LITERATURE

- **Standard model** of tax evasion treats it as a **private decision**

- **More recent** work allows for **social interactions** to affect compliance (Myles and Naylor, 1996 ; Hashimzade ***et al***., 2014; Goerke, 2013)

Limitations of Existing Literature

- Taxpayers assumed to know aggregate-level statistics
- Implicitly **presupposes** the **network is the complete** one
  - but taxpayers may rely on **heterogeneous "local" information**
  - Also ruling out **heterogeneity in social connectedness**
- Other papers relax the complete network, but maintain other rigidities, i.e., **fixed pattern of connectivity**, **undirected network**

CONTRIBUTION

- → The **social networks so far used** in the literature seem to **deviate importantly from real-world networks**
- → We study a model allowing for an **arbitrary network**
- → **Local relative consumption externalities**, heterogeneous across taxpayers
- → Theoretical underpinnings to **network equilibria**

RESEARCH QUESTIONS

Our analysis has focused on **two** questions:

1. Is it possible to characterize **optimal evasion** in presence of relative utility and how do **social interactions** affect it?

2. 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**?

PRELIMINARIES

- Taxpayer $\imath$ **honest after-tax** income $X_\imath = W_\imath - \theta(W_\imath)$
- Taxpayer **may evade** an amount of tax $E_\imath \in (0, \theta(W_\imath))$
- Evasion is a **risky** activity:
  - The **tax agency** is actively seeking to detect and **shut-down** evasion
  - There is a compound probability $p_\imath$ that:
    - **The taxpayer is discovered** under declaring
    - **The tax agency is successful** in shutting down evasion
- The tax authoritiy levies a **fine** $f > 1$ proportional to the evaded tax debt upon successful action
- Taxpayers care about **relative utility**
  - they benchmark consumption against a reference level R

THE TAXPAYER'S PROBLEM

$$\max_{E_i} \mathbb{E}(U_i) \equiv [1 - p_i]\, U(C_i^n - R_i) + p_i\, [U(C_i^a - R_i)]$$

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

$C_i^n \equiv X_i + E_i$

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

$C_i^a \equiv C_i^n - fE_i$

Utility is linear-quadratic

$U(z) = z[b_i - \frac{a_i z}{2}]$

The **Privately Optimal Evasion** at an interior solution is:

$$E_i^* = \frac{1-p_i f}{a_i \zeta_i}\{b_i - a_i[X_i - R_i]\}$$

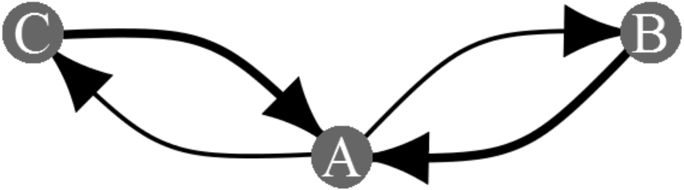
$\zeta_i = [1 - p_i f]^2 + p_i\, [1 - p_i]\, f^2 > 0$

- **Observability of consumption** summarised by a **directed network** (graph), where a link (edge) from taxpayer (node) $\imath$ to taxpayer $\jmath$ indicates that $\imath$ observes $\jmath$'s consumption
- Links are **subjectively weighted**
  - some members of the reference group may be more focal comparators
- **Network** of links is represented as an $N \times N$ (adjacency) matrix, $\boldsymbol{G}$, **of subjective comparison intensity weights** $g_{\imath\jmath} \in [0, 1]$,
- The weights satisfy

$$g_{\imath\imath} = 0; \qquad \sum\nolimits_{\jmath \in \mathcal{R}_\imath} g_{\imath\jmath} = 1$$

- The **set of taxpayers** whose consumption is **observed** by taxpayer $\imath$ is termed $\imath$'s **reference group**, $\mathcal{R}_\imath$

A SIMPLE EXAMPLE



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

ENDOGENISING REFERENCE CONSUMPTION

→ Reference consumption taken as the **weighted average of expected consumption** over the members **of the taxpayer reference group** $\mathcal{R}$

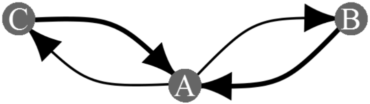
$$R_\imath = \sum_{j \in \mathcal{R}_\imath} g_{\imath\jmath} \mathbb{E}\left(\tilde{C}_\jmath\right)$$

Where:

$$\begin{aligned} \mathbb{E}\left(\tilde{C}_\jmath\right) &= [1 - p_\jmath]\, C^n_\jmath + p_\jmath C^a_\jmath \\ &= X_\jmath + [1 - p_\jmath f]\, E_\jmath \end{aligned}$$

A SIMPLE EXAMPLE

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



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

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

Optimal evasion is defined by a linear system (due to linearity of $R_\imath$):

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

Where $\boldsymbol{M}$ **re-weights the social network** $\boldsymbol{G}$ to account for **differentials in expected returns** from evasion and $\boldsymbol{\alpha}$ weights the sum of paths from a taxpayer by his characteristics

The solution is in form of **weighted Bonacich centrality measure**:

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

NASH EQUILIBRIUM - BONACICH CENTRALITY

$$\mathbf{E} = b(\boldsymbol{M}, 1, \boldsymbol{\alpha})$$

→ **Network centrality** is a concept developed in sociology to quantify the **influence or power** of actors in a network

→ **Multiple definitions**: Bonacich centrality (Bonacich, 1987) relevant in our setting

→ **More central taxpayers evade more**

COMPARATIVE STATICS: LOCAL STRATEGIC COMPLEMENTARITY

- The model exhibits **strategic complementaries in evasion choices**
  - an increase in evasion by one taxpayer induces others to do likewise.

- Formally, **expected utility is supermodular in cross evasion choices**:

$$\frac{\partial^2 \mathbb{E}\left(U_\imath\right)}{\partial E_\imath \partial E_\jmath} = a_\imath g_{\imath\jmath}[1 - p_\imath f][1 - p_\jmath f] > 0 \qquad \jmath \in \mathcal{R}_\imath$$

COMPARATIVE STATICS: OPTIMAL EVASION

→ How is optimal evasion impacted by information carried through the social network?

Evasion is higher if taxpayer's peers are richer

$$\frac{\partial E_\imath}{\partial W_\jmath} = b_{1\imath}\left(\boldsymbol{M}, 1, \frac{\partial \alpha}{\partial X_\jmath}\right) \geq 0$$

Evasion is lower if taxpayer's peers probability of audit is higher

$$\frac{\partial E_\imath}{\partial p_\jmath} = b_{1\imath}\left(\boldsymbol{M}, 1, \frac{\partial \boldsymbol{M}}{\partial p_\jmath}\mathbf{E} + \frac{\partial \alpha}{\partial p_\jmath}\right) \leq 0.$$

→ Results can be strengthened to strict inequalities if $\boldsymbol{G}$ is *connected*

THE VALUE OF NETWORK INFORMATION

- **Observing links in social networks** ought to help tax authorities to **target better** their limited **audit** resources
- Can tax authorities observe links in social networks?
  - Some individuals - celebrities - for whom it is common knowledge that many people observe them
  - “big data”
- The UK tax authority (HMRC) uses a system known as “Connect”
  - cross-checks public sector and third-party information
  - system produces “spider diagrams” linking individuals to other individuals and to legal entities such as “property addresses, companies, partnerships
- IRS also known to have also invested in big data heavily
  - but much more reticent in revealing its capabilities

AUDIT TARGETING AND LIMITED NETWORK INFORMATION

- Tax authority chooses **audit targets conditional** on observing each taxpayers' self-reported **income declaration** d_i

- If tax authority observes $\boldsymbol{G}$ (and the remaining model parameters) it is able to correctly infer true incomes and **evasion**: $\hat{W}(d_i; \boldsymbol{G}) = W_i$ and $\hat{E} = \theta(\hat{W}_i) - \theta(d_i)$

- If the tax authority **does not perfectly observe $\boldsymbol{G}$,** but instead some (related) network $\boldsymbol{G}'$, **estimates** of the W_i **will be incorrect**: $\hat{W}(d_i; \boldsymbol{G}') \neq W_i$ and $\hat{E}_i \neq E_i$

- Suppose the tax **authority observes only a subset of the links** in the network
  - $\kappa \in [0, 1]$ is the **probability** that the tax authority **observes a given link** in the social network
  - **Network observed** by the tax authority denoted $\boldsymbol{G}(\kappa)$ generated by randomly deleting links (with probability $1 - \kappa$)

MEASURING THE VALUE OF INFORMATION

- Audits targeted to the $100\overline{p}\%$ of taxpayers with the **highest** $\hat{E}$
  - Reminiscent of US "DIF score", and similar to UK audit selection rules

- **Max audit revenues** when full-information on network: $\mathfrak{R}_{\max} = \mathfrak{R}(G(1))$

- **Min audit revenues** when no-information is used in targeting (random auditing): $\mathfrak{R}_{RA} = f\boldsymbol{pE}$

- Metric used to assess value of **social network information**:

$$\Psi\left(\kappa\right) \equiv \frac{\mathfrak{R}\left(\boldsymbol{G}\left(\kappa\right)\right) - \mathfrak{R}_{RA}}{\mathfrak{R}_{\max} - \mathfrak{R}_{RA}} \times 100.$$

SIMULATION SPECIFICATION

- Tax system is linear: $\theta\,(W) = \theta\,W$
- Power law distribution of income
- Baseline parameter values
  - $\phi = 0.43$ (Pham ***et al.***, 2016)
  - $N = 200$
  - $a = 2$
  - $b = 80$
  - pf calibrated to achieve evasion of 10%

THE SOCIAL NETWORK

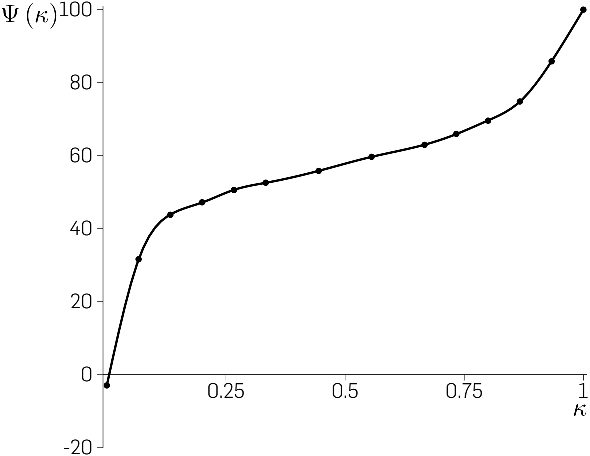
→ We generate a static network using the Bianconi-Barabási **fitness** model

  → *Node-fitness* process: Taxpayers with **higher wealth** have a higher probability of making new connections

  → *Preferential attachment* process: Taxpayers already **heavily connected** have a higher probability of making new connections (sublinear preferential attachment, $\phi < 1$)

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

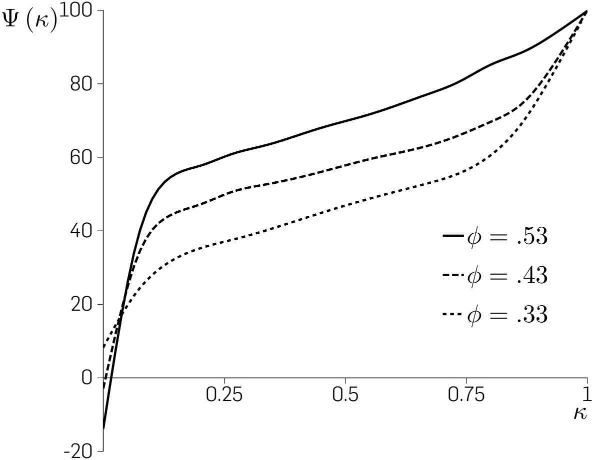
→ **Initial efforts** in collecting network information are characterized by **high returns**



FINDINGS - EFFECTS OF NETWORK STRUCTURE

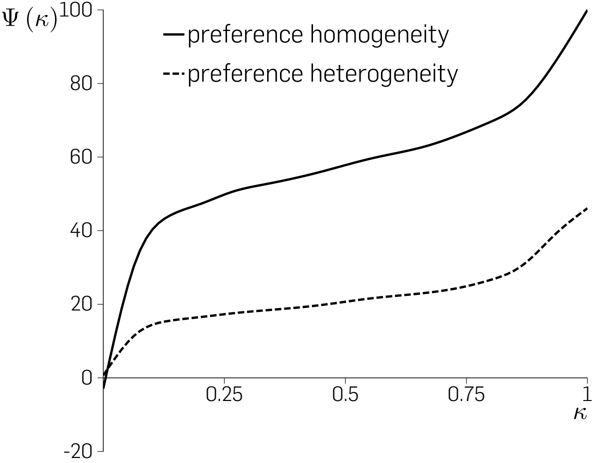
→ The value of network information is **higher if preferential attachment ϕ is stronger**

→ Using **predictive tools when little is know may be counterproductive** in highly concentrated networks



FINDINGS - EFFECTS OF UNOBSERVED PREFERENCE HETEROGENEITY

→ **Limited interaction** between uncertainty over **preference** and uncertainty over the **network**



CONCLUSIONS

- Our model provides a rich framework for understanding how information conveyed through a (arbitrary) social network influences optimal evasion behavior

- We show that **network information can be of value** to a tax authority
  - **strong gains to knowing a little** about the social network
  - **may actually be counterproductive** to utilize highly incomplete network information

- Some network information is **especially important in highly concentrated networks**

FURTHER RESEARCH

- → Introduce **habit** (memory) dependence in reference income
  - → Investigate **dynamic response** to audit interventions
  - → Study **direct and indirect effects** of audit interventions
- → Allow for an endogenous **dynamic network**
- → 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?