TAX EVASION ON A SOCIAL NETWORK

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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

→ As a consequence, the choice on **how much to evade is affected by social interaction**

→ New project studying **tax evasion** that builds on a previous TARC project on **tax avoidance**

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 and group conformity

→ Bianconi and Barabási 2001
   Social network modelling

→ Alm , Bloomquist, McKee 2017
   Peer effects in compliance decision

MODELLING FEATURES

Provide a model where:

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

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

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

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

RESEARCH QUESTIONS

→ Our analysis has focused on **four** 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 **self comparison** able to replicate the **dynamic profile of the response** of evasion to an effective anti-evasion intervention as observed empirically?

3. Is it possible to characterize the direct and indirect **revenue effects** of interventions?

4. 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

  → If evasion is detected, a **fine** f proportional to the evaded tax debt is also imposed

TAX AGENCY ACTIVITY

→ The **tax agency** is assumed to be actively seeking to detect and **shut-down** evasion

→ There is a (compound) probability, p_i, that

  → Taxpayer i is discovered under declaring

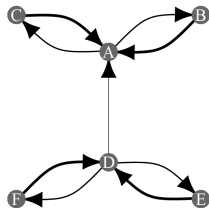 → The tax agency is successful in recovering revenues

TAXPAYERS CHARACTERISTICS

→ Taxpayers are **distinguished** by:

  → Exogenous Income W_i

  → Probability of successful anti-evasion intervention p_i

  → Who they compare to in the social network ("reference group")

SOCIAL NETWORK AS AN ADJACENCY MATRIX

Matrix form of a **weighted directed** network

Directed Network

$$
\begin{array}{c}
\quad A\ \ B\ \ C\ \ D\ \ E\ \ F \\
\begin{array}{c}
A \\ B \\ C \\ D \\ E \\ F
\end{array}
\left(
\begin{array}{cccccc}
0 & .5 & .5 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 \\
.2 & 0 & 0 & 0 & .4 & .4 \\
0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0
\end{array}
\right)
\end{array}
$$

NETWORK STRUCTURE

→ The network is **generated** using the Bianconi-Barabási **fitness** model

  → Taxpayers with **higher wealth** have an higher probability of making new connections

  → Taxpayers already **heavily connected** have an 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 social networks resembles the ones observed empirically

SOCIAL INTERACTION

→ Taxpayers do their evasion decision based on a benchmark or "reference" level of income

→ Reference income depends upon :

→ **Self**: habit consumption h_{it}
- some function of past consumption $C_{it-\mathbf{T}}$

→ **Social**: The (weighted) **average consumption** of individuals in a taxpayer's social network

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:

$$R_{it} = R_{i,t-1} + \varsigma_R \left[Z_{it} - R_{i,t-1} \right]$$

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

OPTIMAL EVASION

THE TAXPAYER'S PROBLEM

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

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

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

> **Optimal Evasion** at an interior solution is:
>
> $$E_{it}^* = \frac{1 - p_i f}{a\zeta_i}\{a[R_{it} - X_i] + b\}, \zeta_i > 0$$

ACCOUNTING FOR SOCIAL NETWORK

Expanding E_{it}^* using the definitions of R_{it}, Z_{it} and q_{it} we solve à la **Cournot-Nash**:

$$E_{it} = \alpha_{it} + \varsigma_R \iota_s \sum_{j \neq i} m_{ij} E_{jt} =$$

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

Where:

$$m_{ij} = \frac{[1 - p_i f][1 - p_j f]}{\zeta_i} g_{ij}$$

$$\beta_{ii} = \varsigma_R \iota_s$$

$$\alpha_{i1,t} = \frac{1 - p_i f}{a\zeta_i}\{b - a[X_i - R(h_{it}, \mathbf{X})]\}$$

WEIGHTED BONACICH CENTRALITY AND EVASION

The nash equilibrium is then:

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

$b(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\alpha}_t)$ is the weighted Bonacich centrality defined on:

$\mathbf{M}$	Edge weights scaled by relative ER of E_i
$\boldsymbol{\beta}$	Scales weight of longer paths
$\boldsymbol{\alpha}_t$	Weights centrality by agent characteristics

Under the condition:

$\mathbf{I} > \rho\left(\mathbf{G}\right)\beta$ Largest absolute value of $\mathbf{G}$ eigenvalues small enough

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

COROLLARIES

Corollary 1

If the probability of audit is equal among taxpayers, i.e. $p_i = p$, then:

$$\mathbf{E_t} = b(\mathbf{M}, \boldsymbol{\omega}, \boldsymbol{\alpha}_t)$$

Where:

$$\omega_{ii} = \frac{\iota_s \varsigma_R [1 - pf]^2}{\zeta}$$

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

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

COMPARATIVE STATICS: CONTEMPORANEOUS AND DELAYED

A marginal parameter change entails contemporaneous and delayed effects on the steady state of the model:

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

Lemma 1

$$\text{if} \quad \frac{\partial X_i}{\partial z}\frac{\partial E_i^{SS}}{\partial z} \geq 0 \quad \text{then} \quad sign\left(\frac{dE_i^{SS}}{dz}\right) = sign\left(\frac{\partial E_i^{SS}}{\partial z}\right)$$

It is sufficient to have same sign for $\partial E_i^{SS}/\partial z$, and steady state consumption, $\partial C_i^{SS}/\partial z$

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MONOTONE COMPARATIVE STATICS

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

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 i_h the more evasion increases in income

$$\frac{dE_i^{SS}}{dW_i}$$
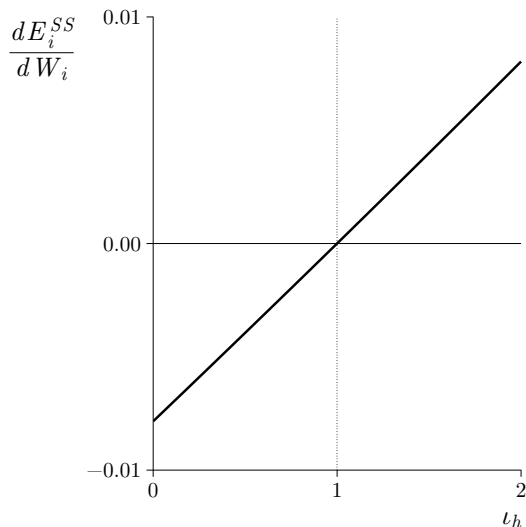
RESPONSES TO INTERVENTION

DYNAMIC RESPONSE TO LEGAL INTERVENTION

→ Empirical evidence shows a **persistent dynamic behavioural response** to interventions

→ The literature argued that **belief updating may be driving** this evidence

→ We show that **self-comparison is able to replicate the same dynamic**

→ Calibrating the persistence ς_R it is possible to **closely match the behaviour observed in reality**

RESPONSE TO LEGAL INTERVENTION VS. PERSISTENCE

→ Here periods
   interpreted as
   years

→ **Deterrence is
   maximal after
   the intervention
   and slowly fades**

→ With high levels of
   persistence the
   dynamic
   behavioural
   response lasts
   ≈ 4 years

ΔE

$--- \varsigma_R = 0.8$
$\quad\varsigma_R = 0.9$

Year post audit

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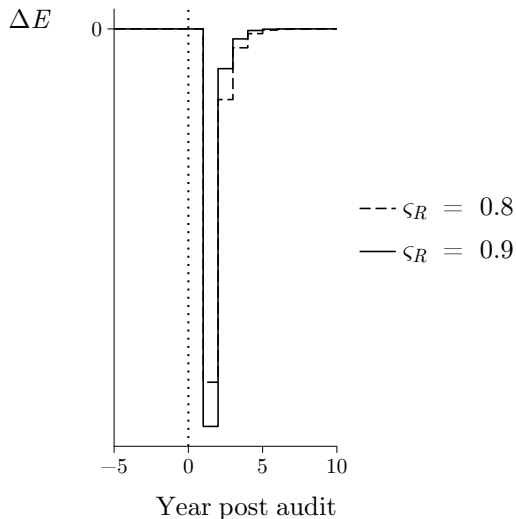
INTERVENTION REVENUE EFFECTS

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**

   → I_{ii} from the audited tapayer

   → I_{ij} from non-audited taxpayers

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

$$\mathbf{I}_i \sim Diag[\mathbf{b}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\alpha}^{SS})]\mathbf{b}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\rho}_i^{SS})$$

where $\mathbf{b}(\mathbf{M}, \boldsymbol{\beta}, \boldsymbol{\alpha}^{SS}) \equiv \mathbf{E}_i^{SS}$ 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**
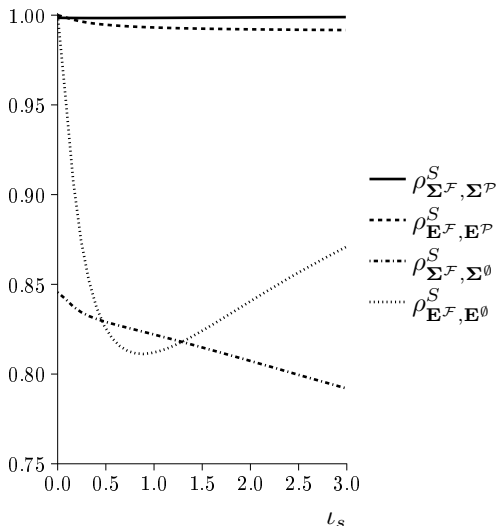
INFERENCE OF REVENUE EFFECTS

→ When there is full observability $\mathcal{F}$ it is possible to exactly determine direct ($\mathbf{E}^{SS}$) and cross indirect ($\mathbf{\Sigma}$) effects

→ Tax agencies infer revenue effects under **limited observability**

How valuable is **network information**?

→ Two cases considered:

1. **Partial observability** ($\mathcal{P}$): The tax agency observes the reference groups of taxpayers but has no information on the comparison intensity

2. **No observability** ($\emptyset$): Everybody attaches equal importance to all the other taxpayers

→ We assess the role of network information in prediction using a the **Spearman rank correlation coefficient**, i.e. $\rho^S_{\mathbf{E}^{\mathcal{P}}, \mathbf{E}^{\emptyset}}$
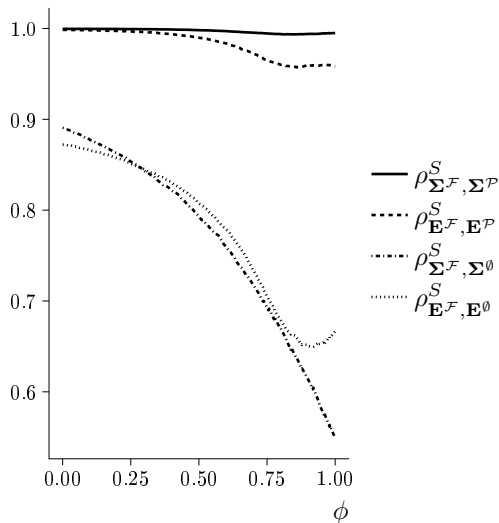
INFERENCE ACCURACY AND SOCIAL COMPARISON

→ **Accuracy improves** significantly from the **no network observability** $\emptyset$ **to partial observability** $\mathcal{P}$

→ Higher concern for social comparison ι_s decrease accuracy

$\rho^{S}_{\boldsymbol{\Sigma}^{\mathcal{F}},\boldsymbol{\Sigma}^{\mathcal{P}}}$

$\rho^{S}_{\mathbf{E}^{\mathcal{F}},\mathbf{E}^{\mathcal{P}}}$

$\rho^{S}_{\boldsymbol{\Sigma}^{\mathcal{F}},\boldsymbol{\Sigma}^{\emptyset}}$

$\rho^{S}_{\mathbf{E}^{\mathcal{F}},\mathbf{E}^{\emptyset}}$

ι_s

INFERENCE ACCURACY AND PREFERENTIAL ATTACHMENT

→ **Accuracy improves** significantly from the **no network observability** $\emptyset$ to **partial observability** $\mathcal{P}$

→ Stronger preferential attachment ϕ decreases accuracy

Legend:
- $\rho^S_{\mathbf{\Sigma}^{\mathcal{F}}, \mathbf{\Sigma}^{\mathcal{P}}}$
- $\rho^S_{\mathbf{E}^{\mathcal{F}}, \mathbf{E}^{\mathcal{P}}}$
- $\rho^S_{\mathbf{\Sigma}^{\mathcal{F}}, \mathbf{\Sigma}^{\emptyset}}$
- $\rho^S_{\mathbf{E}^{\mathcal{F}}, \mathbf{E}^{\emptyset}}$

ϕ

CONCLUSIONS

CONCLUDING REMARKS

→ Social interaction may heavily affect evasion behaviour

→ **Self comparison** is able to **replicate** the persistent dynamic **response of evasion** to intervention observed empirically

→ 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

→ Quantify the additional **revenue recovered using network information**

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

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

Thank You!

Questions?