COMPLIANCE ON NETWORKS

07/02/2018

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

[1] Tax Administration Research Centre, University of Exeter

[2] University of Sheffield

CONTENT

OVERVIEW

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 avoidance and evasion may be used to improve agents' relative standing

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

→ In our current project we develop **two models to investigate separately evasion and avoidance**

TAX AVOIDANCE - RELEVANCE AND RESEARCH

→ Tax avoidance causes **significant losses of public revenues** (1.6 bn. £ in UK)

→ Growing interest by tax agencies on understanding avoidance so to **design efficient deterrence measures**

→ Formal understanding of avoidance is limited

- → No established modelling approach
- → Most research focused on evasion

PURPOSE OF THE MODEL

→ Investigate how tax avoidance is impacted by social network interaction

→ Analyse how network information may be exploited by the tax agency to target interventions

→ Study the dynamic response of avoidance to interventions

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
- → Ballester, Calvo, Zenou 2006
  Network game with local payoff complementarities
- → Quah 2007
  Monotone comparative statics on network games

RESEARCH GOALS

Provide a Model where:

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

→ Taxpayers may engage in **costly** and **risky** tax avoidance

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

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

→ **Monotone comparative statics** to analyse optimal avoidance and **agent based modelling** to address policy questions

MODEL

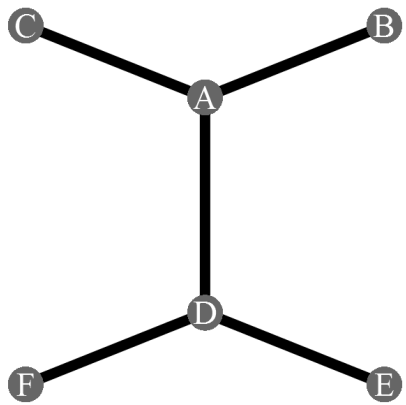
SOCIAL INTERACTION

- → Taxpayers do their avoidance decision based on a benchmark or “reference” level of income

- → Reference income depends upon :
  - → **Self**: Own past consumption (habit consumption)
  - → **Social**: The (weighted) average consumption of individuals in a taxpayer’s social network

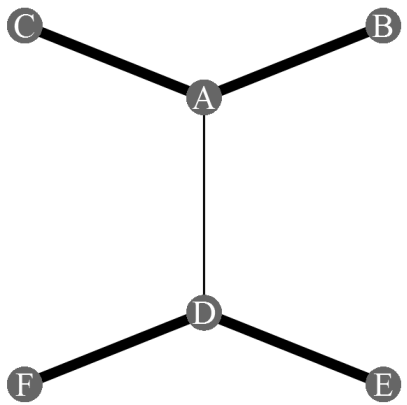
SOCIAL NETWORK AS AN ADJACENCY MATRIX

Undirected Network



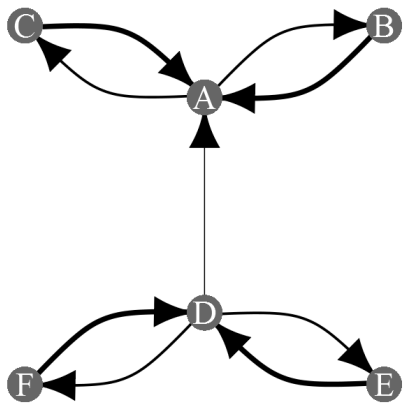
$$\begin{array}{c} \\ A \\ B \\ C \\ D \\ E \\ F \end{array} \begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \begin{pmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix} \end{array}$$

Weighted Network



$$\begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \begin{pmatrix} 0 & 1 & 1 & .2 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ .2 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix} \end{array}$$

Directed Network



$$\begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \begin{pmatrix} 0 & .5 & .5 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 \\ .2 & 0 & 0 & 0 & .4 & .4 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix} \end{array}$$

MODELLING OF AVOIDANCE

- → We define avoidance as actions that "use the tax law to get a tax advantage that Parliament never intended"
- → Avoidance is **risky**
  - → The tax agency may succeed in shutting down the avoidance scheme if it learns of it
- → Avoidance is **costly**
  - → A fraction of the tax payments that the taxpayer stands to avoid paying are paid as a fee to the "promoter" of the scheme
- → If the avoidance scheme is shut down, only the avoided income is paid – **no fine can be imposed** –

ANTI AVOIDANCE INTERVENTION

- → The **tax agency** is assumed to be actively seeking to detect and **shut-down abusive schemes**
- → There is a (compound) probability, p_i, that
  - → Taxpayer i is discovered as using a scheme
  - → The tax agency chooses to take legal action against the scheme
  - → The tax agency legal action is successful in closing the scheme

TAXPAYERS CHARACTERISTICS

- → Taxpayers are **risk averse** (quadratic utility)
- → Taxpayers are **distinguished** by:
  - → Income
  - → Who they compare to in the social network (“reference group”)
  - → Probability of successful anti-avoidance intervention

NETWORK STRUCTURE AND UPDATING

→ The network is **generated** using preferential attachment (Barabási–Albert)

→ Model allows for **lagged updating of the social network** based on consumption

→ We know people compare to similar others (homophily)

→ Accordingly, we allow taxpayers to update their comparisons when their own characteristics change

THEORETICAL FINDINGS

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

RESEARCH QUESTIONS

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

1. How do **changes in the exogenous parameters** (income, risk aversion, etc., affect avoidance?

2. How do the of **marginal revenue effects** of an additional intervention vary between taxpayers with different degrees of **centrality** in the social network?

3. What is the **dynamic profile of the response** of avoidance to an effective **anti-avoidance intervention**?

WHAT INFLUENCES AVOIDANCE

→ The parameters of the model have differing short-run and long-run effects:

→ **Short-run**

→ Before taking into account the effects of lagged adjustments in habit consumption and network updating

→ **Long-run**

→ After taking into account the effects of lagged adjustments in habit consumption and network updating

MONOTONE COMPARATIVE STATICS

	A_i^*		A_i^*
Risk Aversion	$-$	Tax rate	$+$
Habit consumption	$+$	Avoidance cost	$+/-$
Audit prob. pi	$-$	Audit prob. pj	$-/0$
Own comparison	$+$	Social comparison	$+/0$

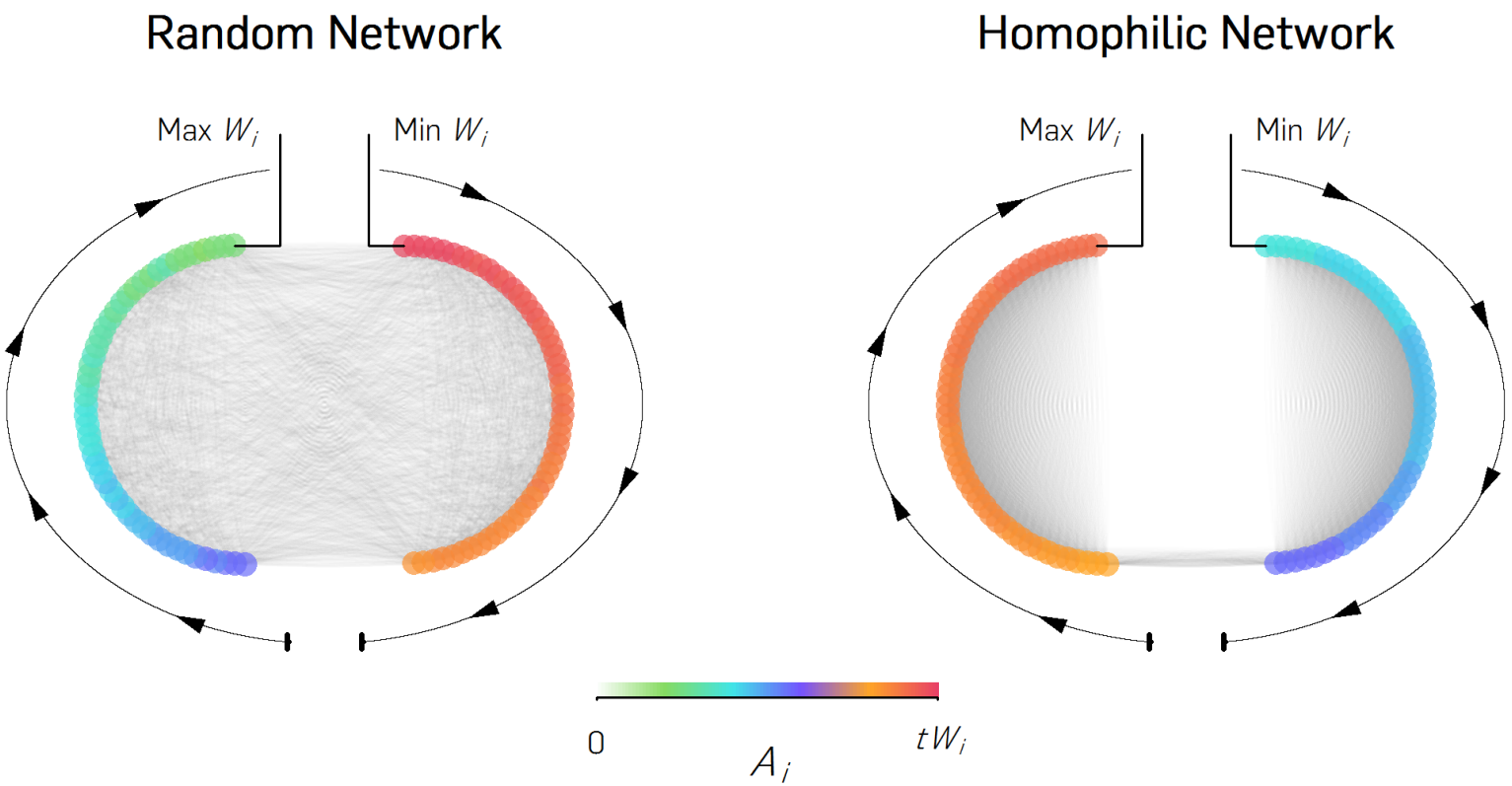
Monotone comparative statics for interior A_i^*

These results apply in the short and long run

AVOIDANCE AND INCOME

- → In the case of **income the short-run and long-run effects can go in different directions**
- → Short-run effect is for avoidance to fall after an increase in income
- → But, in the long-run, taxpayers:
  - → compare to higher income taxpayers
  - → increase their habit consumption

NETWORK STRUCTURE AND INCOME



If taxpayers with similar income tend to **group together** (homophily) and **social comparison plays a relevant role** in shaping reference income, the model predicts **avoidance to be increasing in income**

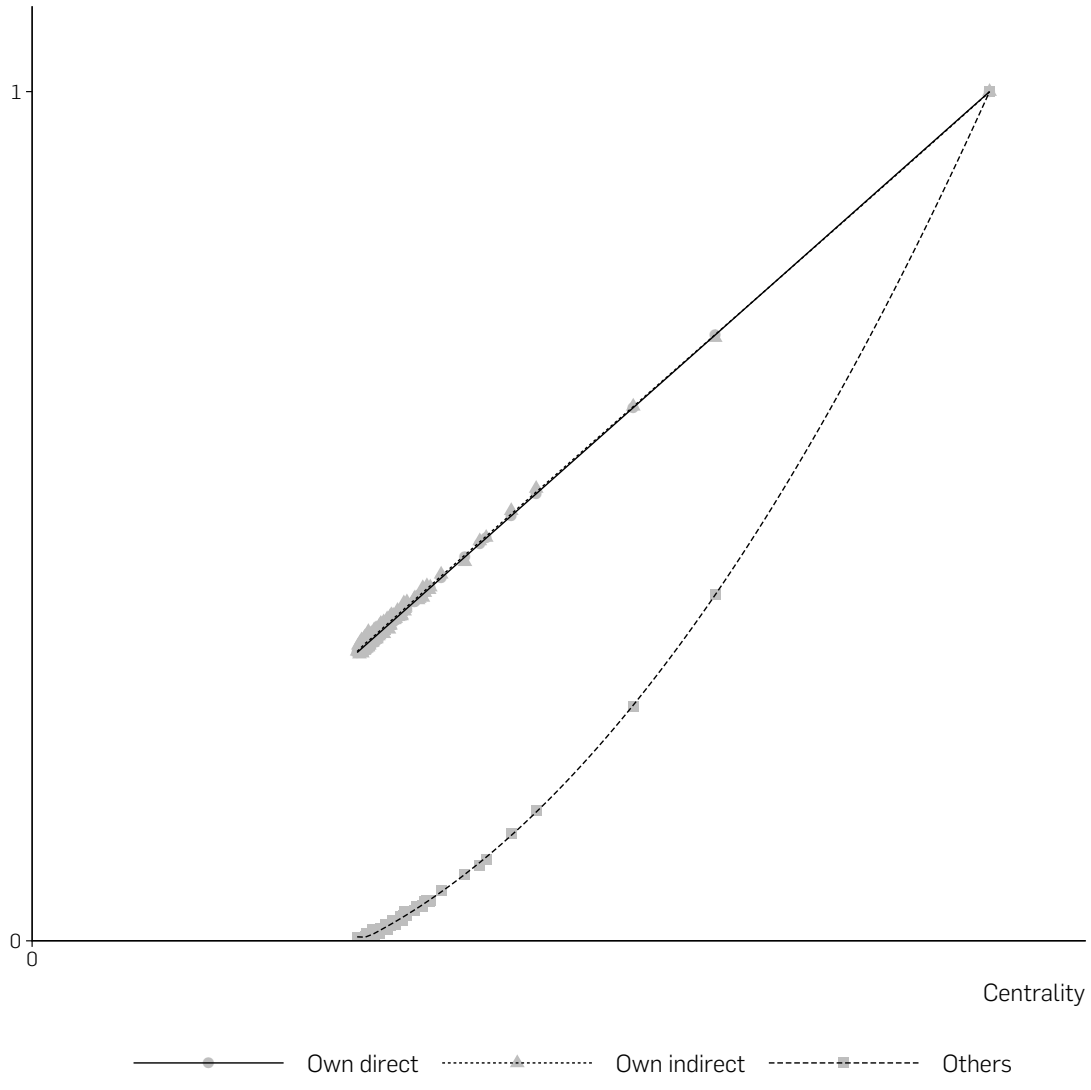
INTERVENTIONS AND CENTRALITY

Is there any evidence in favor of targeting interventions against more central taxpayers ("celebrities")?

In general, **three revenue effects** follows from an anti-avoidance intervention

- → **Own effect**
  - → Direct - on targeted taxpayer, by averting attempted avoidance
  - → Indirect - on targeted taxpayer, from change in future avoidance behaviour
- → **Others effect**
  - → From induced change in the avoidance behaviour of non-targeted taxpayers

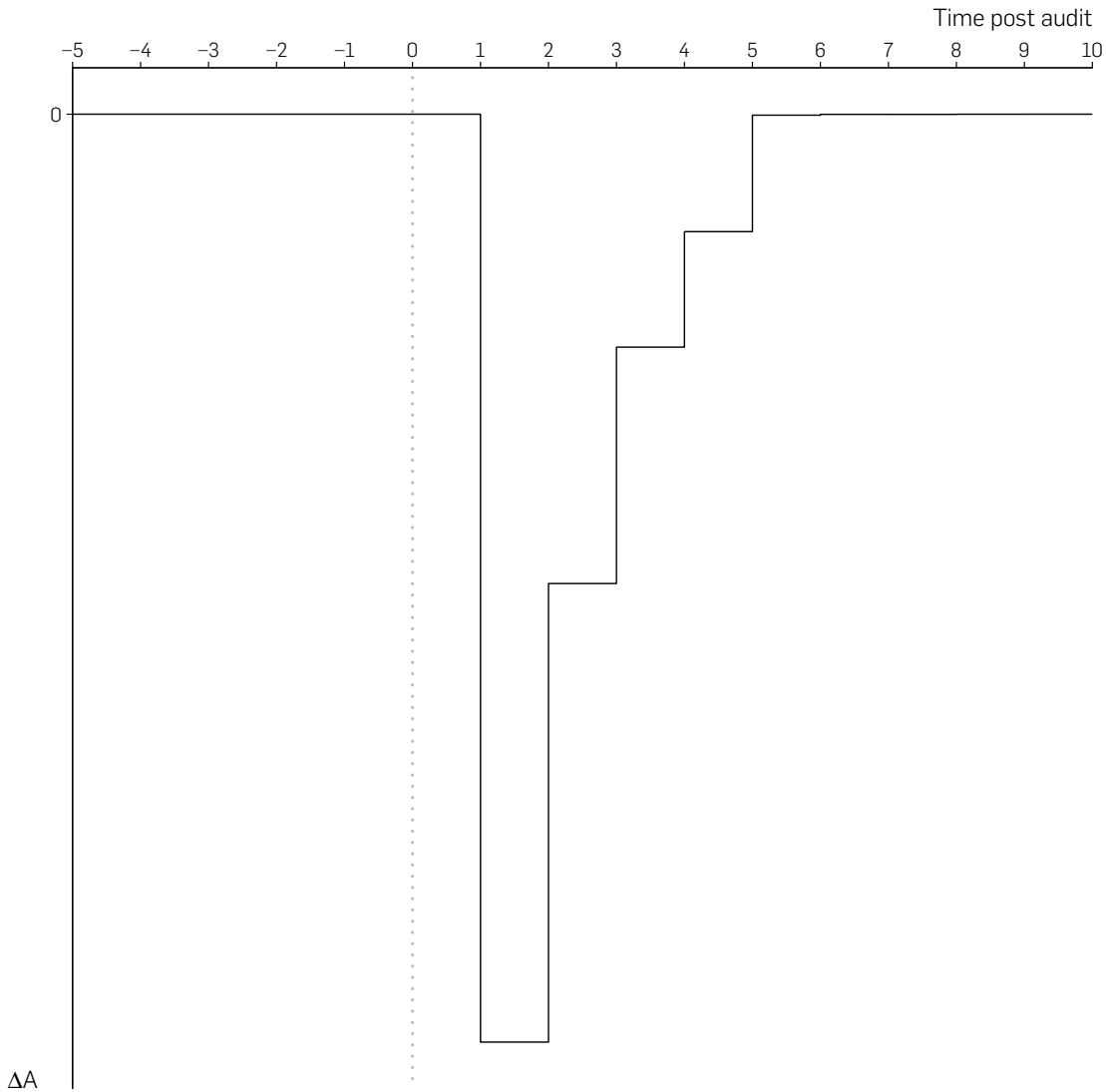
INTERVENTIONS AND CENTRALITY



INTERVENTIONS AND CENTRALITY

- → The **own effects increase linearly** in centrality (avoidance)
- → The **others indirect effect is highly non-linear** (convex)
  - → Taxpayer with the lowest centrality in the network has around 35% of the centrality of the most central taxpayer, yet commands an indirect effect on other taxpayers of just 0.44% of that of the most central taxpayer.
- → **Targeting most central taxpayers maximises all three revenue effects**!

DYNAMIC RESPONSE TO LEGAL INTERVENTION



DYNAMIC RESPONSE TO LEGAL INTERVENTION

→ Here periods interpreted as years

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

→ There is a **return to baseline after 5 years**

→ Consistent with empirical literature showing a persistent effect of interventions on behaviour

FURTHER RESEARCH

→ Extend the analysis to tax evasion

→ Analyse how different measures of centrality that may be available to the tax agency correlate with revenue effects

→ Derive theoretical steady state results to avoid computational burden of simulations

CONCLUSIONS

CONCLUDING REMARKS

- → The evolution of the **taxpayer's reference group and habit consumption may heavily affect avoidance behaviour**
- → **There are objective grounds** for tax authorities **to target taxpayers who are central in the network**
- → A tax authority **interventions have a persistent effect** on avoidance, with a return to baseline occurring in around five years

Thank You!

Questions?

MODEL

Relevant parameters and variables:

$t \in (0,1)$	Linear tax rate
$\phi \in (0,1)$	Per-unit linear fee on avoided tax
$p_i \in (0,1)$	Probability of audit
$W_i \in [\underline{W}, \overline{W}]$	Exogenous income
$X_i = (1-t)\,W_i$	Honest after-tax income
$A_i \in (0, tW_i)$	Avoided income
R_i	Reference Income

THE AVOIDANCE PROBLEM

Taxpayer's problem is:

$$\max_{A_i} \mathbb{E}[U] = (1 - p_i)\, U(W_i^n - R_i) + p_i\, U(W_i^a - R_i)$$

After-tax income if not audited

$$W_i^n = X_i + [1 - \phi] A_i$$

After-tax income if audited

$$W_i^a = X_i - \phi A_i$$

Utility is quadratic

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

Optimal Avoidance at an interior solution is:

$$A_i^* = \frac{1 - p_i - \phi}{a\zeta_i}\{a[R_i - X_i] + b\}, \zeta_i > 0$$

REFERENCE DEPENDENCE

Agents' reference income is a weighted average of habitual income and the average of her reference group

Taxpayer i expected after-tax income when avoiding A_i is:

$$q_i = X_i + [1 - p_i - \phi]A_i$$

And the reference income may be expressed as:

$$R_i = \iota_h D_i + \iota_s \sum_{j \neq i} g_{ij} q_j$$

ι_h	Relative importance of habit
D_i	Habit income
ι_s	Relative importance of peers
g_{ij}	weight of agent j in i reference group

ACCOUNTING FOR SOCIAL NETWORK

Expanding A_i^* using the definitions of R_i and q_i we solve à la **Cournot-Nash**:

$$A_i = \alpha_i + \iota_s \sum_{j \neq i} g_{ij}^{'} A_j =$$

$$\mathbf{A} = \boldsymbol{\alpha} + \mathbf{G}^{'} \boldsymbol{\beta} \mathbf{A}$$

Where:

$$\alpha_i = \frac{1 - p_i - \phi}{a \zeta_i} \{ a[\iota_h D_i + \iota_s \sum_{j \neq i} g_{ij} X_j - X_i] + b \}$$

$$\boldsymbol{\beta} = Diag(\iota_s)$$

$$g_{ij}^{'} = \frac{[1 - p_i - \phi][1 - p_j - \phi]}{\zeta_i} g_{ij}$$

BONACICH CENTRALITY AND AVOIDANCE

The nash equilibrium is then:

$$\mathbf{A} = [\mathbf{I} - \mathbf{G}^{'}\boldsymbol{\beta}]^{-1}\boldsymbol{\alpha} = b(\mathbf{G}^{'}, \boldsymbol{\beta}, \boldsymbol{\alpha})$$

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

$\mathbf{G}^{'}$	Edge weights scaled by agents' relative ER of A
$\boldsymbol{\beta}$	Scales weight of longer paths
$\boldsymbol{\alpha}$	Weights centrality by agent characteristics
$[\mathbf{I} - \mathbf{G}^{'}\boldsymbol{\beta}]^{-1}$	Well defined by row-scaling

TAXPAYERS' INTERACTION AS A GAME

The game arising from taxpayers interaction is:

Smooth Supermodular Game (Milgrom and Roberts 1990)

Bounds on strategies	$A_i \in (0, tW_i)$
Differentiability	$\mathbb{E}[U]_i$ is of class C^2
Strategic Complements	$\frac{\partial^2 \mathbb{E}[U]_i}{\partial A_i \partial A_j} \geq 0$

MONOTONE COMPARATIVE STATICS

Smooth Supermodular Games can be analyzed using **Monotone comparative statics**

Following Quah (2007) we exploit the **weaker** condition of **local supermodularity** around the Nash equilibrium point:

Then, for a given parameter z, it holds:

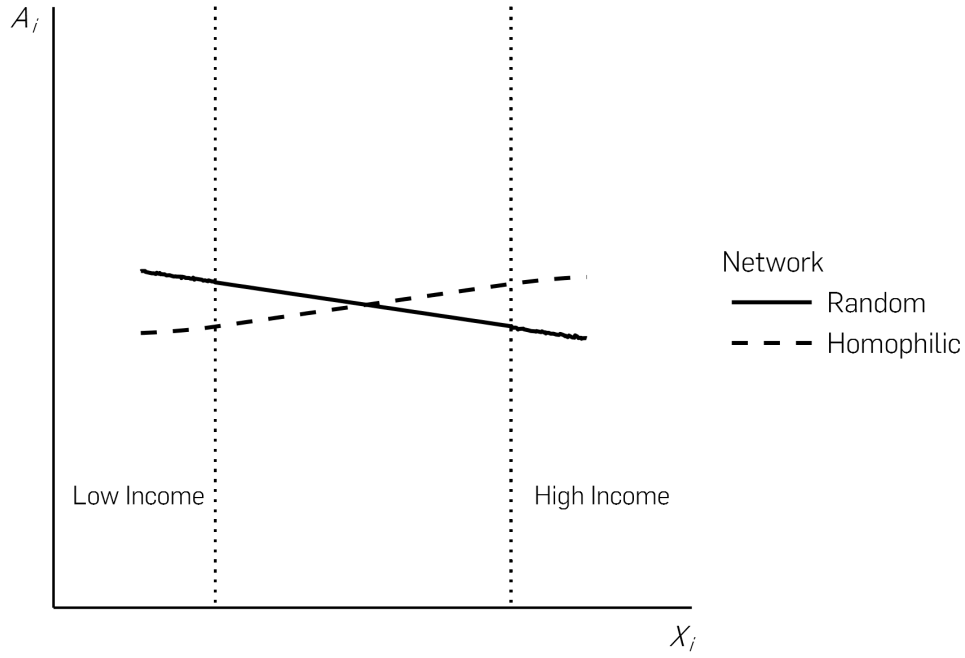
$$\left.\frac{\partial^2 \mathbb{E}[U]_i}{\partial A_i \partial z}\right|_{A_i=A_i^*} \geq 0 \Leftrightarrow \frac{\partial A_i^*}{\partial z} \begin{cases} > 0 \text{ if } \left.\frac{\partial^2 \mathbb{E}[U]_i}{\partial A_i \partial z}\right|_{A_i=A_i^*} > 0 \\ \geq 0 \text{ if } \left.\frac{\partial^2 \mathbb{E}[U]_i}{\partial A_i \partial z}\right|_{A_i=A_i^*} = 0 \end{cases}$$

MONOTONE COMPARATIVE STATICS

	A_i^*		A_i^*
a	$-$	t	$+$
b	$+$	ϕ	$+/-$
D_i	$+$	R_i	$+$
p_i	$-$	X_i	$-$
p_j	$-/0$	X_j	$+/0$
ι_h	$+$	ι_s	$+/0$

Monotone comparative statics for interior A_i^*

NETWORK STRUCTURE AND INCOME



The pure effect of X_i on A_i^* is negative

However, if:

→ X_j increases with X_i

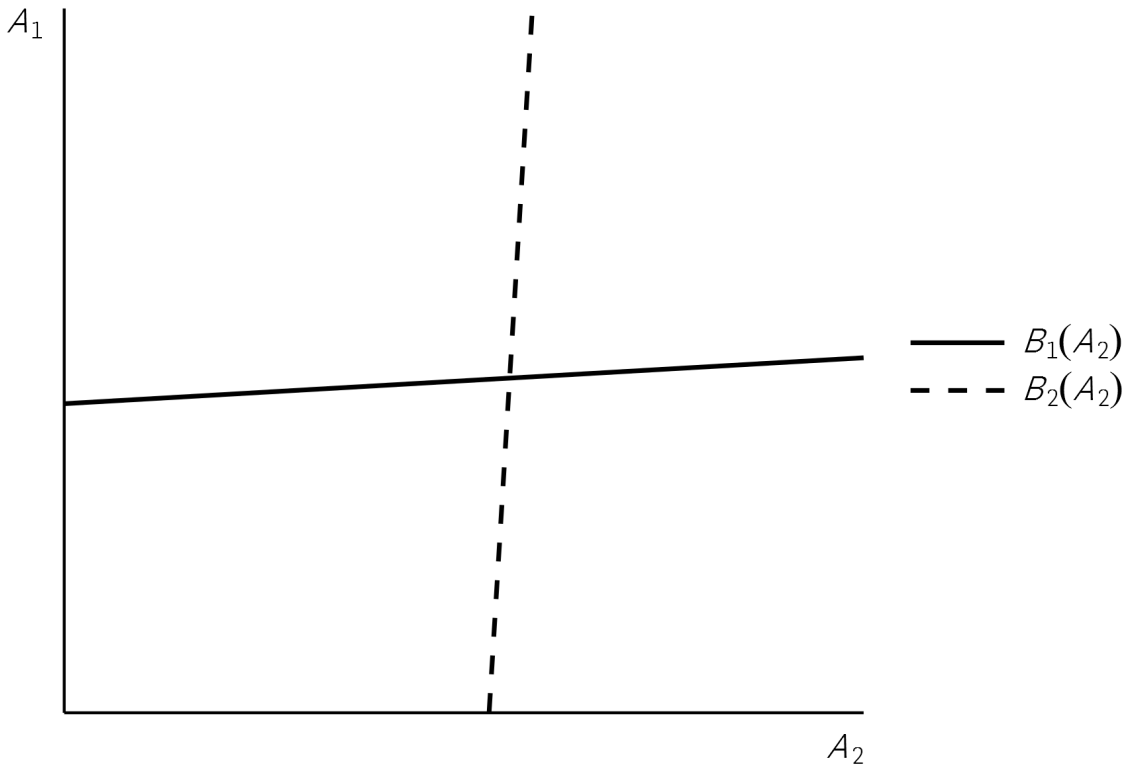
→ ι_s is high enough

The positive peer-effect may cause a reversal

If taxpayers with similar income tend to **group together** (homophily) and **social comparison plays a relevant role** in shaping reference income, the model predicts **avoidance to be increasing in income**

BEST RESPONSE

Quadratic utility leads to linear best response



Positive slope of best response functions follows from strategic complementarity in A_i, A_j