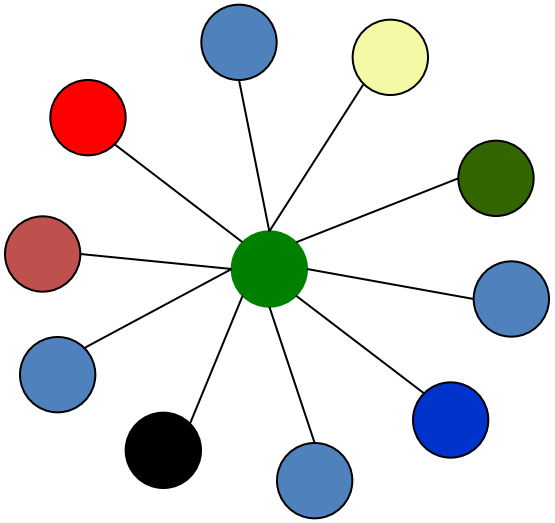
Economics of Networks II



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"Commerce is a pacific system, operating to cordialise mankind, by rendering... individuals useful to each other... The invention of commerce... is the greatest approach towards universal civilisation that has yet been made." **Thomas Paine, 1792**

"[The] legacy [of social morality] has diminished with time and with the corrosive contact of the active capitalist values - and more generally with the greater anonymity... of industrial society" **Fred Hirsch, 1976**

The Great Transformation

- The interaction between communities and markets remains a central theme in the social sciences.
  - markets crowd out social ties and aggravate inequality. Polanyi (1955), Scott(1976), Sandel (2011).
  - markets enhance welfare, reinforce reciprocity, and thereby strengthen social ties. Paine (1792), Hirschman (1977).
- Wide and conflicting empirical evidence.
- **Aim: Theoretical framework to understand this evidence.**

Reciprocity as a Self-Sustaining System

Kranton 1996, AER

- Community based exchange involves reciprocity: I do you a favor today and you reciprocate in kind at a later date.
- Individuals who do not fulfill their obligations are punished by termination of favor exchange relationship
- Seriousness of this punishment depends on the presence of alternatives.
- Alternative: a spot market where agents can anonymously exchange affects the enforceability of reciprocal exchange.

Trade-offs

- Size of the market is important because it shapes the costs of obtaining goods/services. Thin markets raise the costs of search, while thick markets reduce them.
- The more individuals engage in reciprocal exchange, the less they need to rely on markets to obtain goods and services and vice-versa. Thus there is a negative externality from markets to reciprocal exchange.

Informal exchange and markets

Theorem

Reciprocal-exchange and markets are substitutes, and they constitute self-sustaining systems.

Welfare

- Substitutability of goods. In reciprocal relations individuals are obliged to accept whatever their partner provides. This restricts the range of goods available.
- So if commodities are close substitutes then reciprocalexchange is efficient; if they are poor substitutes then markets are efficient.
- Inefficient outcomes possible.
  most people in reciprocal exchange: it persists as no one wishes to enter the market due to high search costs.
  similarly for large market.

Case study 1: Traditional Networks and Globalization Munshi and Rosenzweig 2006, AER.

- Liberalization of the Indian economy in the 1990s.
- Shift in Bombay's economy toward the corporate and finance sectors $\longrightarrow$ Raised returns from English language education (approx. 25%) in 2000.
- Working class boys adopted English much less than girls.
- Gap in English education between girls of high and low castes disappeared; the gap for boys remained intact.
- Inequality between men and women fell.

Case Study 2: Kerala Fisherman and Mobile Telephony Jensen 2007, QJE

- Cellphone adoption by Kerala fishermen in 1990's.
- Fishermen unable to observe prices in different markets. High transportation costs, limited duration of market, perishability.
- By 2001, 65% of fishing boats in Kerala owned a cellphone.
- Adopters are well connected large boats.
- Cellphone allows call to buyers before deciding on market.
- Use of phones $\longrightarrow$ increased profits for all fishermen.
- Price dispersion and waste fell.
- Inequality among fisherman rose.

Structure of the talk

1. **The model**
2. **Results:**
   - 2.1 Equilibrium characterisation: *the q-core*
   - 2.2 Market participation: *who adopts markets: "well" connected or marginalized individuals?*
   - 2.3 Inequality: *Who benefits the most from markets? When do markets increase inequality?*
   - 2.4 Welfare: *Do markets raise or lower welfare?*
3. **Applications**
4. **Concluding Remarks**

Literature

- Classical *doux-commerce* stance: markets reinforce durable and peaceful social relations (e.g. Montesquieu, 1748; Paine, 1792; Condorcet, 1795).
- Expansion of markets crowd out social ties (Polanyi 1955; Scott, 1977; Sandel, 2011).
- Conflicting views can be reconciled: markets reinforce social ties in case two activities are complements, undermine them in case of substitutes.

Literature

- Formal literature on the relation between social ties and anonymous exchange (e.g. Arnott and Stiglitz, 1991; Galeotti, 2010; Kranton, 1996; and Montgomery, 1991).
- This work abstracts from the details of network topology.
- Games on networks: Jackson and Zenou (2014) and Bramoull and Kranton (2015). Abstracts from markets.
- We propose a model that bridges two strands of work.

Literature

- Large literature on communities and economic development; see, survey by Munshi (2014)
- Exogenously specified community – caste, ethnicity.
- Focus is on empirical implications of variations in community size.
- Novel element: Heterogeneity in social connections.

Model

Gagnon and Goyal, 2017

- **Players**: $N = \{1, 2, ...n\}$, with $n \geq 3$.
- **Networks**: $\mathbf{g}$ is a graph, where $g_{ij} \in \{0, 1\}$ for all j, $i \in N$.
- **Actions**: Player i chooses two actions, "network action" x_i and "market action" y_i, where $x_i \in \{0, 1\}$ and $y_i \in \{0, 1\}$.
- Define

$$\chi_i(\mathbf{a}) = \sum_{j \in N_i(\mathbf{g})} x_j \tag{1}$$

Model

- Let $\Phi_i(\mathbf{a} \mid \mathbf{g})$ denote individual i's payoffs under action profile $\mathbf{a}$ in a network $\mathbf{g}$.
- Payoffs:

$$\Phi_i(\mathbf{a} \mid \mathbf{g}) = \begin{cases} 0, & \text{if } a_i = (0,0) \\ \pi_y, & \text{if } a_i = (0,1) \\ \phi_0(\chi_i(\mathbf{a})), & \text{if } a_i = (1,0) \\ \phi_1(\chi_i(\mathbf{a})), & \text{if } a_i = (1,1) \end{cases} \tag{2}$$

Network action is complementary

- Following Kranton (1996), we suppose that (bilateral) reciprocal exchange between two individuals takes place only if both individuals chose $x = 1$.

  Assumption 1 Both $\phi_0(\cdot)$ and $\phi_1(\cdot)$ are strictly increasing and unbounded in $\chi_i(\mathbf{a})$.

Network and market

- Market action y affects the marginal returns from network activity, x.

$$\xi\left(\chi_i\left(\mathbf{a}\right)\right) = \phi_1\left(\chi_i\left(\mathbf{a}\right)\right) - \phi_0\left(\chi_i\left(\mathbf{a}\right)\right) - \pi_y. \tag{3}$$

- *Substitutes* if $\xi\left(\cdot\right)$ is negative and (weakly) decreasing in $\chi_i\left(\mathbf{a}\right)$. *Complements* if $\xi\left(\cdot\right)$ is positive and (weakly) increasing in $\chi_i\left(\mathbf{a}\right)$.

  Assumption 2 $\xi\left(0\right) = 0$ and $\xi(.)$ is unbounded in $\chi_i\left(\mathbf{a}\right)$. Network and market actions are either substitutes or complements.

Examples

Example

Player i's payoffs are given by:

$$\Pi_i(\mathbf{a}|\mathbf{g}) = (1 + \theta y_i) x_i \chi_i(\mathbf{a}) + y_i - p_x x_i - p_y y_i \tag{4}$$

$\theta \in [0, 1]$: Substitutes for $\theta < 0$ and complements for $\theta > 0$.

Example

Player i's payoffs are given by:

$$\Pi_i(\mathbf{a}|\mathbf{g}) = (x_i \chi_i^{\alpha}(\mathbf{a}) + y_i)^{\theta} - p_x x_i - p_y y_i \tag{5}$$

$\theta \in [0, \infty)$: Substitutes for $\theta \in (0, 1)$ and complements for $\theta > 1$.

Equilibrium and welfare

Definition

An equilibrium $(\mathbf{x}^*, \mathbf{y}^*)$ is *maximal* if there does not exist another equilibrium $(\mathbf{x}', \mathbf{y}') \in \mathcal{A}^n$ that Pareto-dominates it.

Definition

Given a network $\mathbf{g}$ aggregate welfare from a strategy profile $(\mathbf{x}, \mathbf{y})$ is given by:

$$W(\mathbf{x}, \mathbf{y}|\mathbf{g}) = \sum_{i \in N} \Pi_i(\mathbf{x}, \mathbf{y}|\mathbf{g}). \tag{6}$$

Equilibrium Existence and Uniqueness

Theorem

Suppose Assumptions 1-2 hold. Then there exists a unique maximal equilibrium, generically.

- Steps in proof:
  1. Complements: start with $(0, 0)$ and iterate through best responses. As strategy set is bounded, there exists an equilibrium. As strategy set is finite, there exists a maximal equilibrium.
  2. Substitutes: consider separately case where market action is attractive or not.
  3. Uniqueness: argument from contradiction.

Characterization: q-core

Individual chooses between $x_i = 1$ and $x_i = 0$: will choose $x_i = 1$ if χ_i is high enough. Similarly, her neighbors will choose $x = 1$ if a sufficient number of their own neighbors choose $x = 1$.

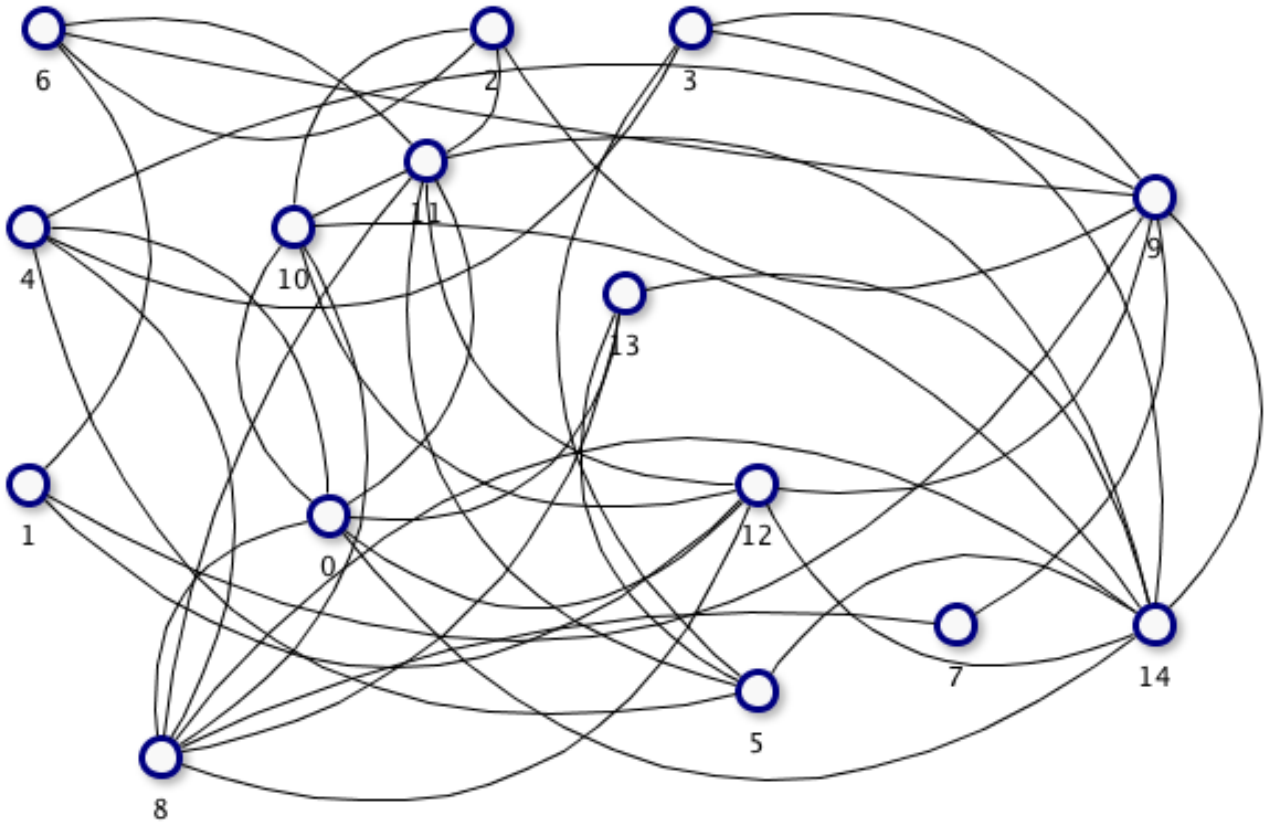
Definition

Bollobas, 1984 The q-core of $\mathbf{g}$, denoted by $\mathbf{g}^q$, is the largest collection of players that have strictly more than q links to other players in $\mathbf{g}^q$.

This set is unique. Note that $\mathbf{g}^{q+k} \subseteq \mathbf{g}^q$, for any $q, k \geq 0$.

The q-core in a network

- Suppose $q = 4$.
- Step 1: eliminate all nodes with $k \leq 4$.
- Step 2: iterate.



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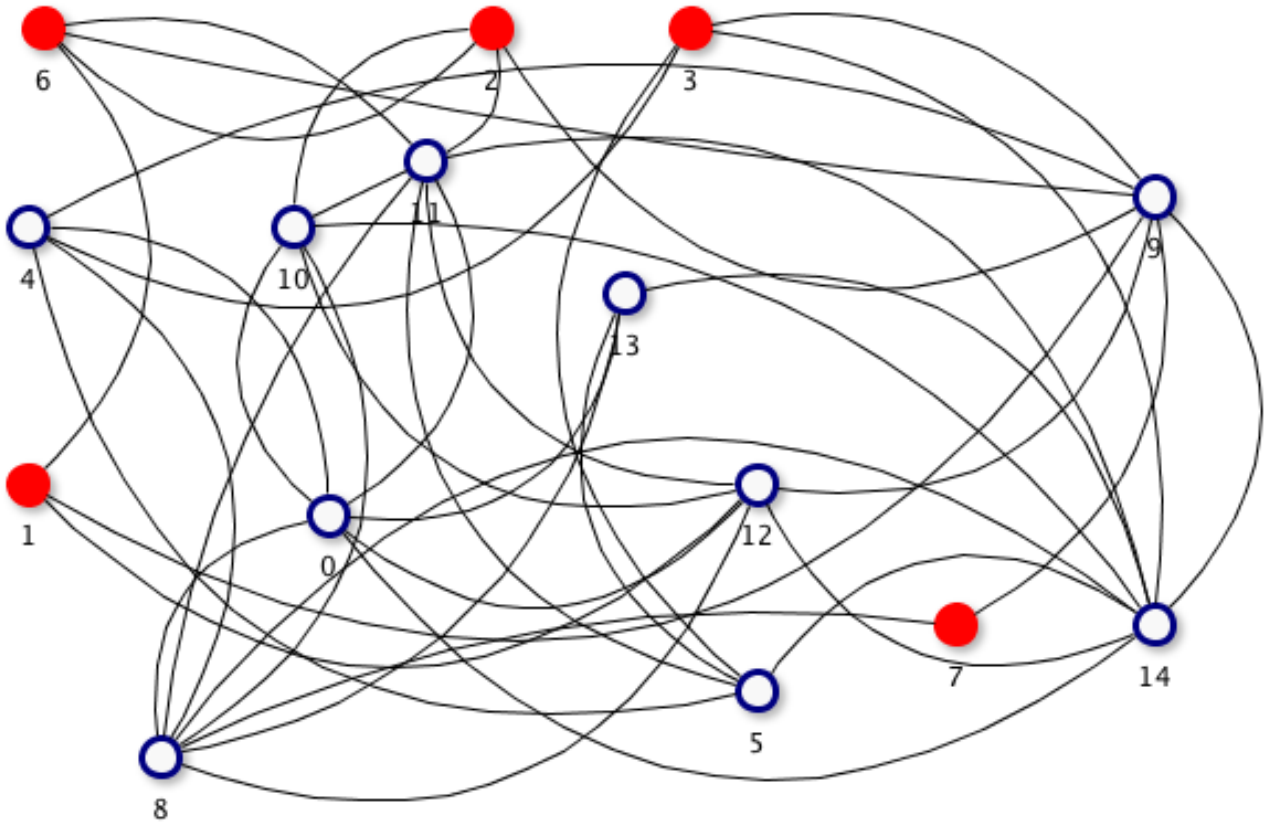

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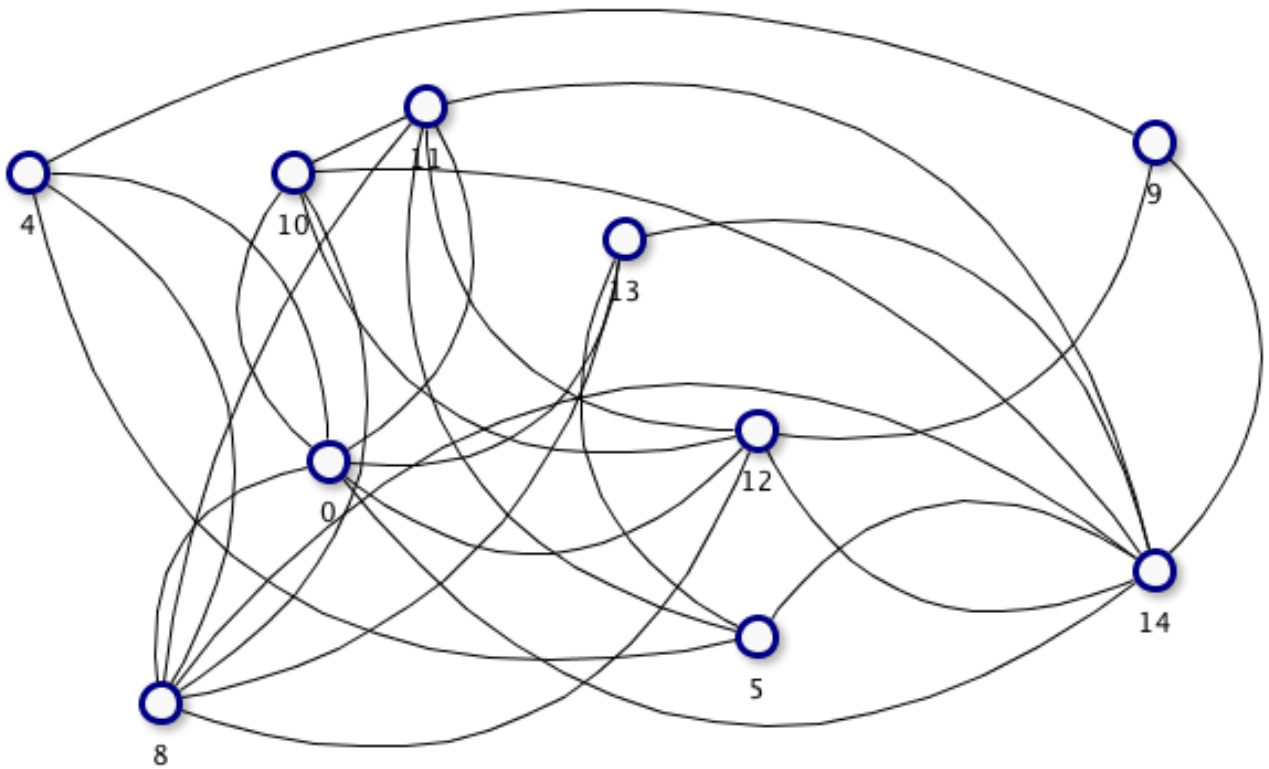

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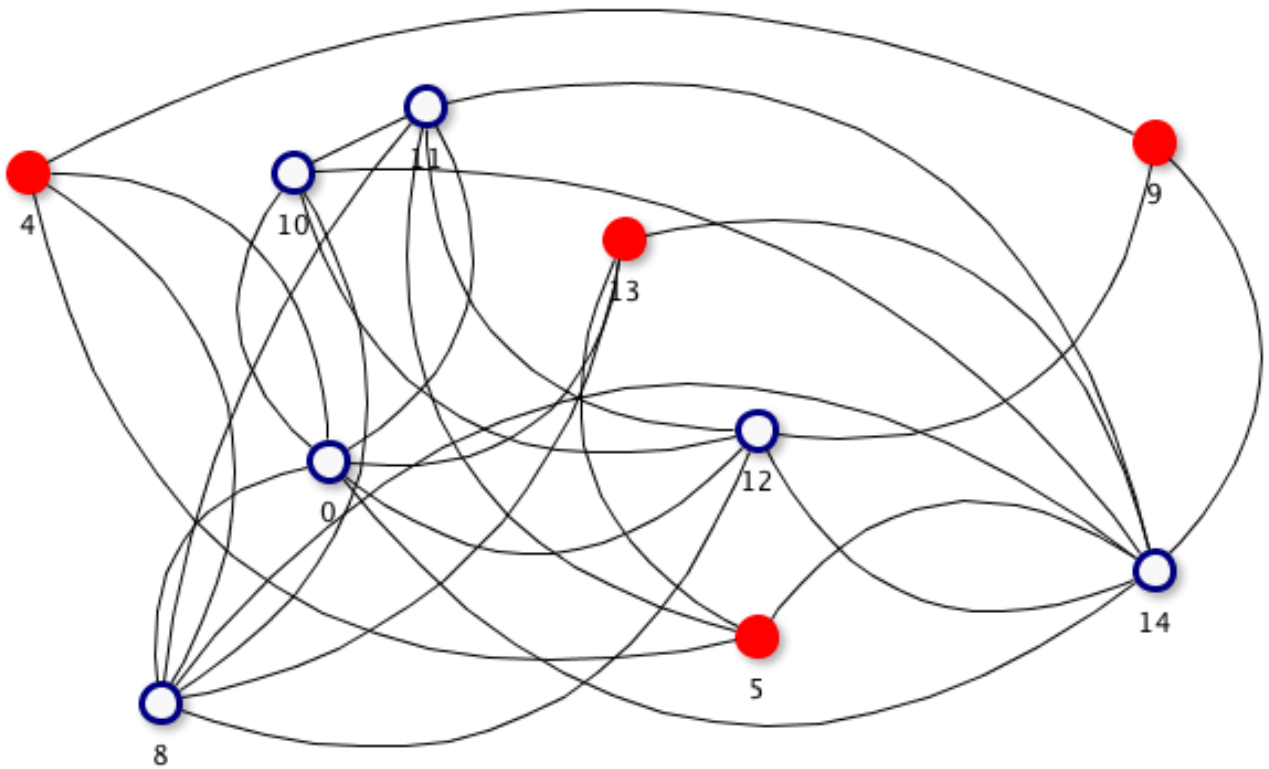

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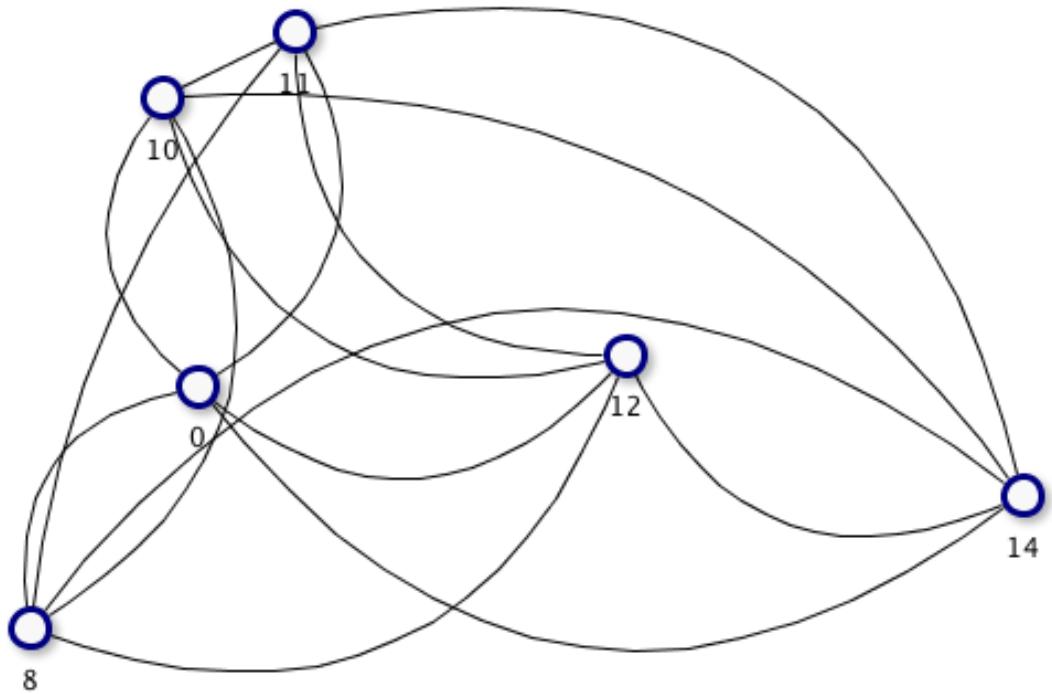

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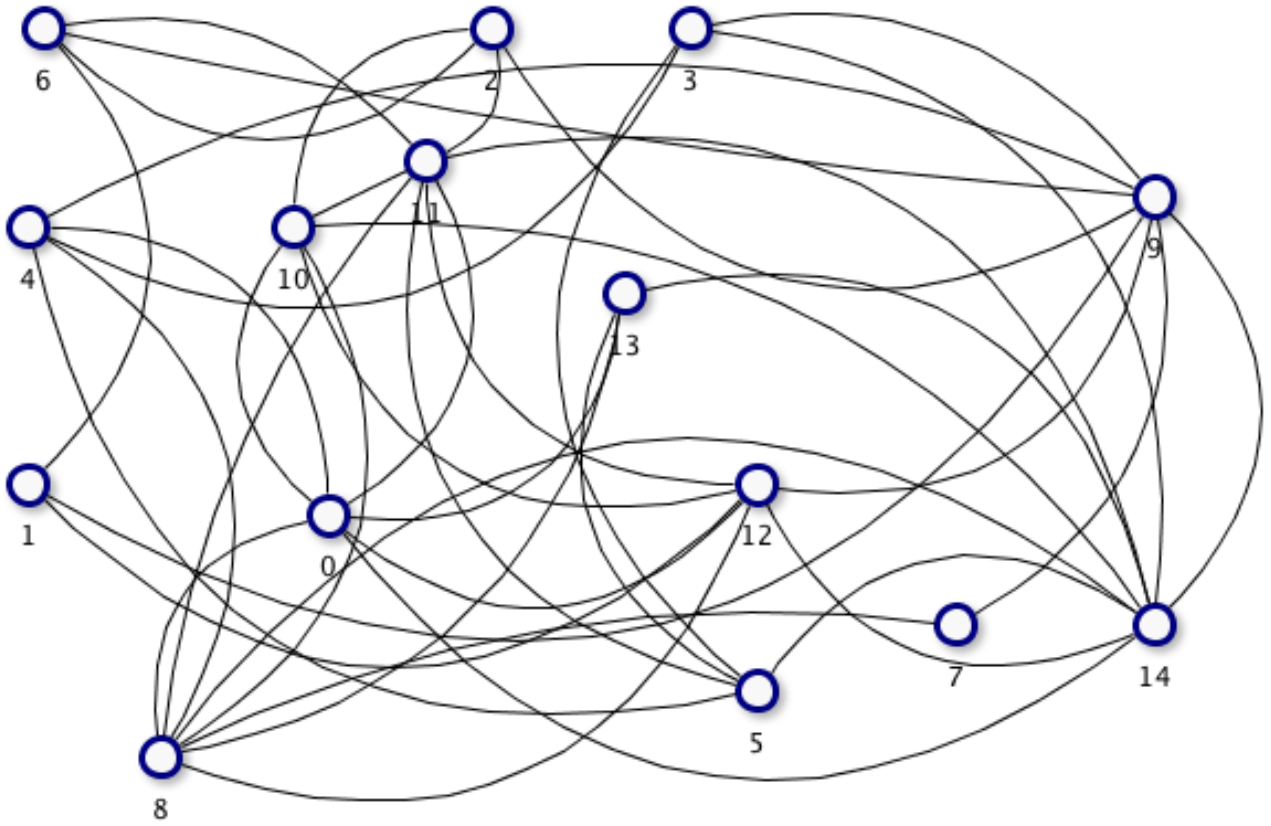

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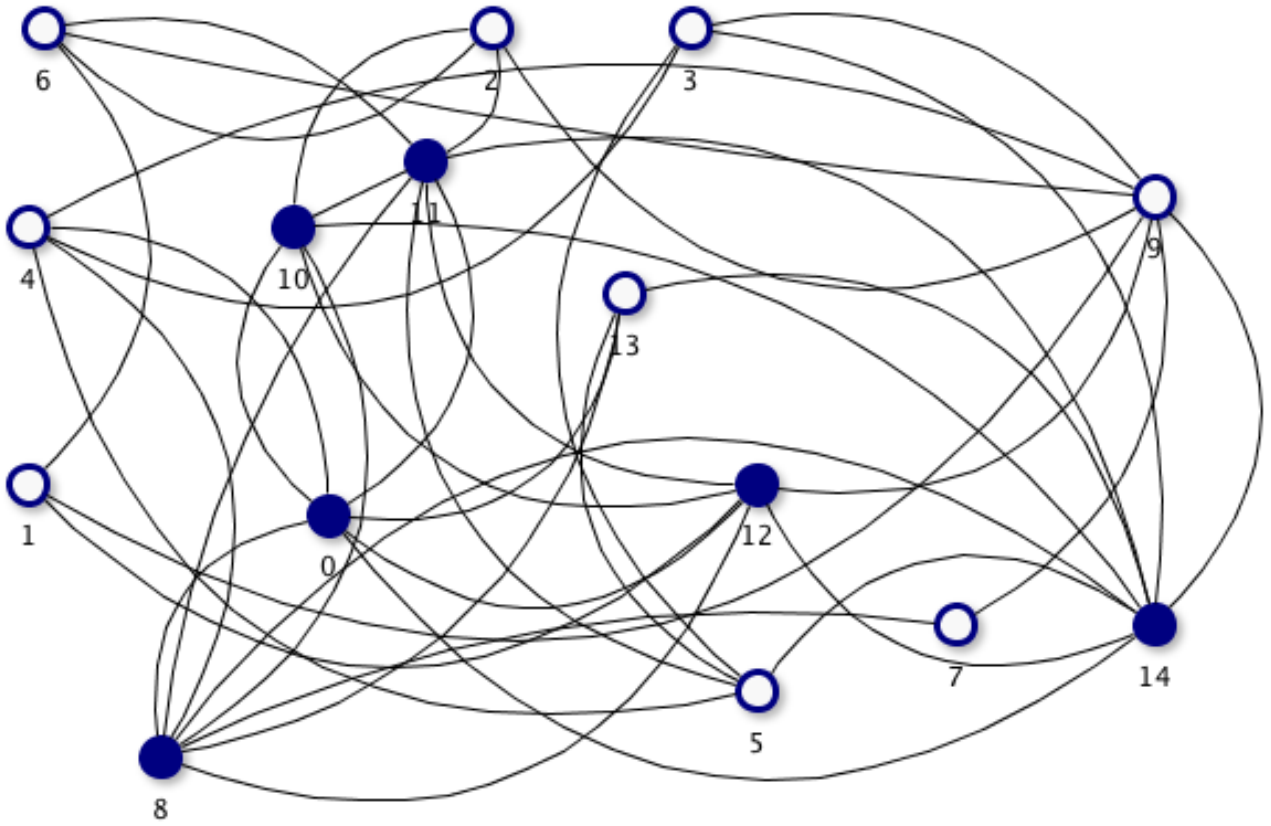


Thresholds for q-core

- An individual chooses between $(0,0)$, $(1,0)$, $(0,1)$, and $(1,1)$.
- Develop thresholds χ_i that characterize optimal choice.
- First, from Assumption 2 there exist $q_1 \geq 0$ and $q_2 \geq 0$:

$$\phi_0(\chi_i) > \max\{0, \pi_y\} \text{ if and only if } \chi_i > q_1 \quad (7)$$

$$\phi_1(\chi_i) > \max\{0, \pi_y\} \text{ if and only if } \chi_i > q_2 \quad (8)$$

- For simplicity in exposition, we rule out both x and y in the substitutes case and solely action x in the complements case.

Equilibrium Characterization

Theorem

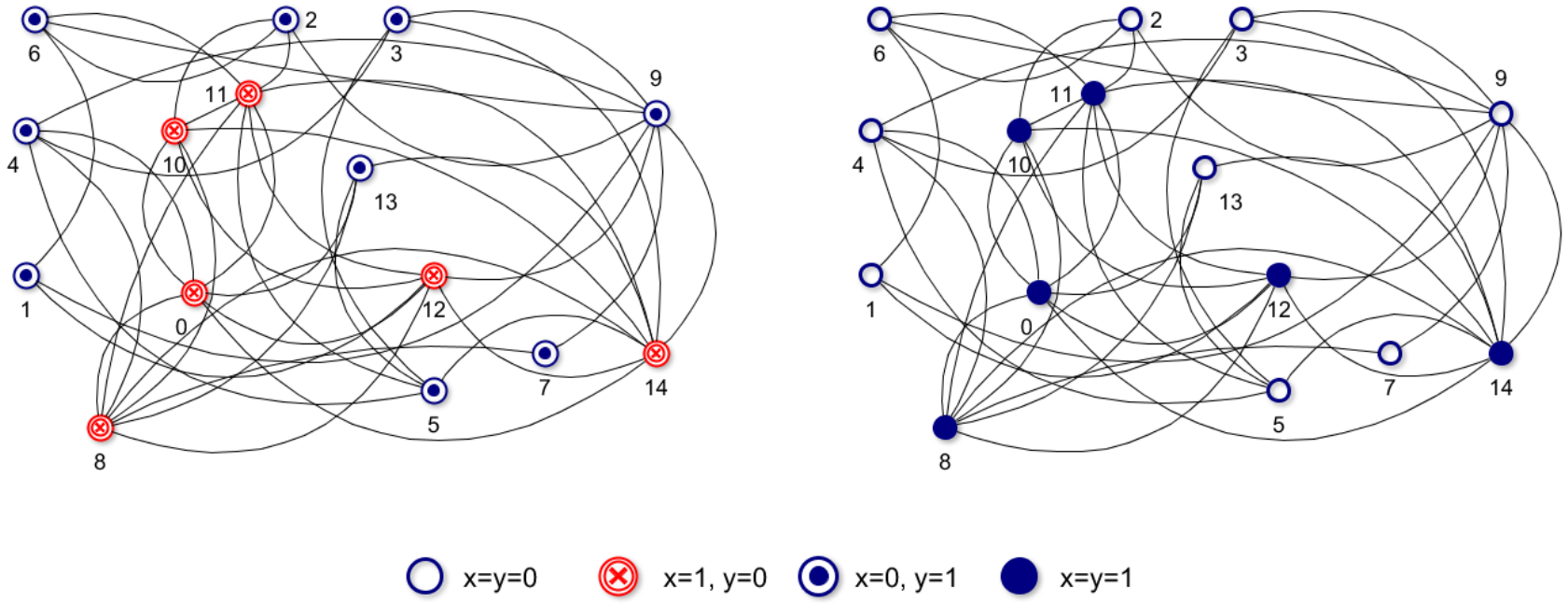
Suppose that Assumptions 1 and 2 hold. Let $\mathbf{a}^*$ *be the maximal equilibrium.*

1. **Strong Substitutes.** $a_i^* = (1,0)$ *if and only if* $i \in \mathbf{g}^{q_1}$. *If* $i \notin \mathbf{g}^{q_1}$, *then* $a_i^* = (0,0)$ *in case* $\pi_y \leq 0$, *and* $a_i^* = (0,1)$ *in case* $\pi_y > 0$.
2. **Strong Complements.** $a_i^* = (1,1)$ *if and only if* $i \in \mathbf{g}^{q_2}$. *If* $i \notin \mathbf{g}^{q_2}$, *then* $a_i^* = (0,0)$ *in case* $\pi_y \leq 0$, *and* $a_i^* = (0,1)$ *in case* $\pi_y > 0$.

Connections and markets

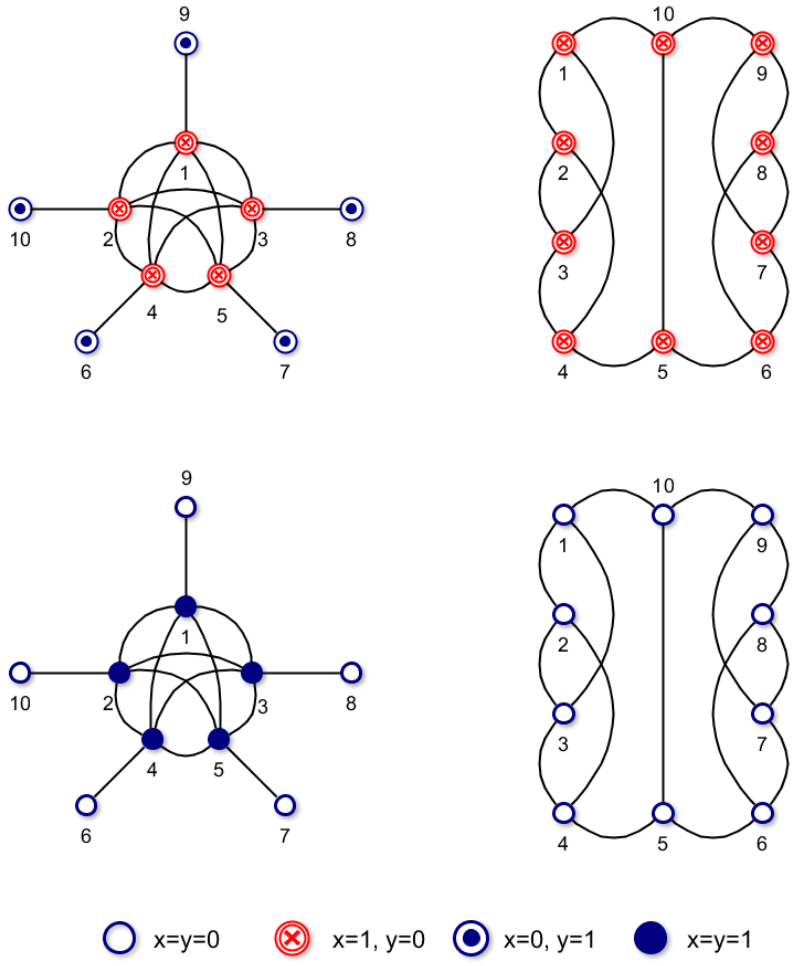
- q-core: Intuition that highly connected nodes adopt the network action, less connected nodes adopt the market action. Our analysis goes beyond this intuition. The connections of neighbors and their neighbors matter...
- Strategic structure: In the substitutes case, nodes lying *outside* the relevant q-core choose market action, in the complements case it is the nodes *within* the relevant q-core that choose this action!

Substitutes and complements



Left: $(\theta = -0.9)$, $p_y = 0.5$ and $p_x = 4.1$. **Right**: $(\theta = 1)$, $p_y = 1.1$ and $p_x = 5.1$.

Core-periphery vs regular networks



Top: Substitutes (with $\theta = -0.9$), $p_y = 0.5$ and $p_x = 1.5$.

Bottom: complements (with $\theta = 1$), $p_y = 1.5$ and $p_x = 6.5$.

Market Participation

- Receptive to markets: sparse or dense networks?
- Individuals and markets: "well" connected or marginalized?
- Theorem 1: in any network, there is a unique maximal equilibrium $(\mathbf{x}^*, \mathbf{y}^*)$.
- We define market penetration

$$\mathcal{M}(\mathbf{g}) \equiv \frac{\sum_{i \in N} y_i^* (\mathbf{g})}{N} \tag{9}$$

Who participates in markets?

Proposition

Suppose payoffs satisfy assumptions 1 and 2.

1. *Market participation is (weakly) lower in denser networks with substitutes, and (weakly) larger in case of complements.*
2. *Markets adopted by 'less' connected in case of substitutes, by 'well' connected in case of complements;*
3. *Market participation (weakly) increases with π_y.*

Do markets raise welfare?

Proposition

Suppose payoffs satisfy assumptions 1 and 2. In the case of complements, the introduction of the market always (weakly) increases aggregate welfare. In the case of substitutes, the introduction of the market may lower aggregate welfare.

- Intuition: In the case of complements, markets reinforce social ties and this raises payoffs. In the case of substitutes, marginal poorly connected individuals may move out of social exchange to markets. This weakens social ties, and could lower aggregate welfare.

Do markets increase inequality?

Given $\mathbf{g}$, equilibrium inequality is denoted by $\mathcal{R}(\mathbf{p})$:

$$\mathcal{R}(\mathbf{g}) \equiv \frac{1 + \max\{\Pi_i(\mathbf{a}^*)\}_{i \in N}}{1 + \min\{\Pi_i(\mathbf{a}^*)\}_{i \in N}} \tag{10}$$

$\mathcal{R}(\mathbf{g})$ are payoffs of the "wealthiest" players compared to those of the "poorest". It is close to other traditional metrics of inequality, including the *range*, the *20:20 ratio* or the *Palma ratio*.

Markets and Inequality

Proposition

Suppose payoffs satisfy assumptions 1 and 2. In the case of substitutes, the introduction of the market (weakly) decreases inequality.
In case of complements if $\mathcal{M}(\mathbf{g}) \in (0,1)$ *then markets strictly increase inequality, while if* $\mathcal{M}(\mathbf{g}) = 1$, *its effect on inequality is ambiguous.*

Similar findings also obtain for Gini-coefficient.

Markets and Inequality

- When x and y are substitutes, markets offer an outside option to those players who benefit the least from x before its introduction.
- When x and y are complements, the opposite logic obtains. Indeed, in many cases, only the best-off players can afford y or both y and x, therefore benefiting from the complementarity between x and y. In such cases, y clearly increases inequality.

Other Applications

1. Tourism markets as **complements** for local cultures and languages Kroshus Medina (2003) De Azeredo Grunwald (2002).
2. Online social networks (e.g. Facebook) as **substitutes** to traditional markets (newspapers) Newman (2009); Currah, (2009).

Remarks

- The dynamics between markets and social networks exhibit interesting non-linearities. One technology can lead to the relative decline of social networks, while a subsequent technology can lead to a revival and expansion of social networks. This suggests that social networks are very malleable.
- Through much of human history, news was passed on through private communication.
- The Royal Society was set up in London in 1660, in an attempt to formalize such private communication (of the invisible college) through weekly meetings.
- Newspapers, television and radio magazines dominate communication through 19th and 20th century.

Online Social Ntworks

- Explosive growth of online social networks in last decade.
- Reuters reports that more than half the population of many countries (e.g. Brazil, Spain, Italy and Finland) use Facebook for news purposes.
- The use of online social networks strongly related to age: roughly 40% of $18-24$ age group find news via online social networks; only 17% for people over 55.
- A sharp decline of traditional media, print newspapers.

Online social networks

- Instance of a reversal of the ‘normal’ sequence: a disruptive technology weakens the market and strengthens social networks.

Remarks

- Heterogeneity in other dimensions matters: the model can be generalized.
- Indirect benefits of connections: possible to generalize model.
- Evolving networks: how social networks evolve as they interact with markets is an important subject for future work.
- Market activity yields exogenous payoffs: the performance of markets is affected by institutions whose quality may depend on social networks.

Summary

- A parsimonious framework to study the relation between networks and markets.
- Two ingredients – complementarity in network exchange and the strategic relationship between networks and market activity – help us reconcile evidence.
- Third ingredient – social networks – helps understand market participation and inequality.

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