

Feri, Francesco

Working Paper

Network Formation with Endogenous Decay

Nota di Lavoro, No. 35.2005

Provided in Cooperation with:

Fondazione Eni Enrico Mattei (FEEM)

Suggested Citation: Feri, Francesco (2005) : Network Formation with Endogenous Decay, Nota di Lavoro, No. 35.2005, Fondazione Eni Enrico Mattei (FEEM), Milano

This Version is available at:

<https://hdl.handle.net/10419/74100>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Network Formation with Endogenous Decay

Francesco Feri

NOTA DI LAVORO 35.2005

MARCH 2005

CTN – Coalition Theory Network

Francesco Feri, *Dipartimento di Scienze Economiche, Ca' Foscari University*

This paper can be downloaded without charge at:

The Fondazione Eni Enrico Mattei Note di Lavoro Series Index:
<http://www.feem.it/Feem/Pub/Publications/WPapers/default.htm>

Social Science Research Network Electronic Paper Collection:
<http://ssrn.com/abstract=681084>

The opinions expressed in this paper do not necessarily reflect the position of
Fondazione Eni Enrico Mattei
Corso Magenta, 63, 20123 Milano (I), web site: www.feem.it, e-mail: working.papers@feem.it

Network Formation With Endogenous Decay

Summary

This paper considers a communication network characterized by an endogenous architecture and an imperfect transmission of information as in Bala and Goyal (2000). We propose a similar network's model with the difference that it is characterized by an endogenous rate of information decay. Endogenous decay is modelled as dependent on the result of a coordination game, played by every pair of directly linked agents and characterized by 2 equilibria: one efficient and the other risk dominant. Differently from other models, where the network represents only a channel to obtain information or to play a game, in our paper the network has an intrinsic value that depends on the chosen action in the coordination game by each participant. Moreover the endogenous network structure affects the play in the coordination game as well as the latter affects the network structure. The model has a multiplicity of equilibria and we produce a full characterization of those that are stochastically stable. For sufficiently low link costs we find that in stochastically stable states network structure is ever efficient; individuals can be coordinated on efficient as well as on risk dominant action depending on the decay difference among the two equilibria in the single coordination game. For high link costs stochastically stable states can display networks that are not efficient; individuals are never coordinated on the efficient action.

Keywords: Network, Decay, Strategical interaction

JEL Classification: A14, D20, J00

I am very grateful for their advice to Sergio Currarini, Matt Jackson, Giovanni Ponti, Fernando Vega Redondo, Claudio Mezzetti.

This paper was presented at the 10th Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.

Address for correspondence:

Francesco Feri
Dipartimento di Scienze Economiche
Ca' Foscari University
San Giobbe 873
Venezia
Italy
E-mail: francesco.feri@tin.it

1. Introduction

In recent years there is a growing interest about social and economic networks. The reason is that these models fit better the real environment to explain many economic phenomena. For example, we remember the diffusion of new technologies, products and conventions, labor search, diffusion of information and social learning, internal and external firm's relations, customized equipment between a group of firms, and so on. The fundamental idea is that, against the assumption that agents in an economic system are anonymous, there is the empirical evidence that agents must have a link to do any kinds of transaction and that in an economic system interaction among agents (or the collection of information) has a cost. These costs together with the relative benefits influence the interaction structure that, in her turn, affects the final result. Indeed in a market two agents can exchange the goods if and only if they are in touch (or they are linked) and the pattern of links affects the competition for goods and profits. For these reasons many authors have examined the role of interaction structure and its evolution in an economic contest.

The literature on social networks concentrates on the one hand, upon the contrast between efficiency and stability of various possible structures and, on the other, upon the cost-benefit relation deriving from those networks. Jackson and Wolinsky [14] show how efficiency and stability do not always coincide. Their model considers a situation where each individual transmits a value into the network which is discounted according to the number of links involved. Moreover, they study those allocation rules which permit both efficiency and stability simultaneously. Later Bala and Goyal [1] consider a similar model, but with the differences that the links can also be one-sided. They study both those cases in which the benefit flows in one direction only, and those in which the benefit flows in two directions. Furthermore, they consider the dynamics of the link formation. Concerning this last is a work by Watts [21] that considers the dynamics of network formation in the case of the connection model of Jackson and Wolinski [14].

An open question in these papers is that the generated payoff is independent of any other action that is different from the creation or deletion of links in the networks. In detail decay is always considered exogenous or, from another point of view, independent of any action of the agents. We try to solve this problem considering a network characterized by an imperfect transmission of information as in the Bala and Goyal [1] but assuming that the rate of decay into the network is endogenous: the rate of decay in a given link depends on the

results of a social game between the 2 (directly) linked agents. There are 2 possible actions: the first one produces a zero decay if both players choose it and a maximum decay if the players choose different actions; the second one produces an intermediate value of decay indifferently from the partner's choice. In this way we model a trade off between complexity (and efficiency) and compatibility. This trade off is illustrated by the following example: an individual has to pass a message and can write it in word format or ascii format. The first choice is more efficient only if the reader has the Word software. The second choice is less efficient but all the people can read it. This model has other two important features: the value of each individual depends on her position inside the network and the interaction between two agents affects all agents in the network. We are able to produce a full characterization of stochastically stable states: the networks characterized by the efficient action are stochastically stable for relatively low link cost, otherwise are stochastically stable those networks characterized by the risk dominant action.

Other related papers are those of Jackson and Watts [12], Goyal and Vega [9], Droste, Gilles and Johnson [4]. These consider the payoff generated by links as determined by the interaction strategy between individuals directly or indirectly linked. The fundamental idea in these papers is that individuals establish links to play a coordination game. As in our paper, to the choice as to whether to link or not is added the choice as to which interaction strategy to use with other individuals. Differently from our paper, these models have in common the idea that the payoff is generated only from the direct link or, as in the paper of Vega and Goyal [9], the payoff is also generated from the indirect link, but by means of a simplification, namely that the benefit deriving from the interaction of two individuals is independent of the kind of link (direct or indirect).

The paper is organized in the following way: in section 2 we describe the model. Section 3 contains the main results. Section 4 concludes the discussion and provide possible directions for futher research.

2. The Model

Let $N = \{1, 2, \dots, n\}$ be a set of agents where $n \geq 3$. We assume that every agents is endowed with one unit of private information of value 1 as well as of a quantity of information deriving from other agents in the network. Each agent can choose a subset of other players with whom to establish links and to play a bilateral game. Let $\mathbf{g}_i = (\mathbf{g}_{i,1}, \dots, \mathbf{g}_{i,i-1}, \mathbf{g}_{i,i+1}, \dots, \mathbf{g}_{i,n})$ be the set of links supported by

player i where $\mathbf{g}_{ij} \in \{0,1\}$ for each $j \in N \setminus \{i\}$. We say agent i supports a link with agent j if $\mathbf{g}_{ij} = 1$. The set of all players link decisions, denoted by $\mathbf{g} = (\mathbf{g}_1, \mathbf{g}_2, \dots, \mathbf{g}_n)$, defines a direct graph $\{N, \Gamma\}$ called network. The network will be denoted by g . Specifically, the network g has the set of players N , as its set of vertices, and its set of arrows, $\Gamma \subset N \times N$, is defined as follows:

$$(2.1) \quad \Gamma = \{(i, j) \in N \times N : \mathbf{g}_{ij} = 1\}$$

Given a network g , we say that 2 players are directly linked if at least one of them has established a link with the other one, i.e. $\max\{\mathbf{g}_{ji}, \mathbf{g}_{ij}\} = 1$. To describe the direct links with no regard who support them, we define the closure $\bar{\mathbf{g}}_{ij} = \max\{\mathbf{g}_{ij}, \mathbf{g}_{ji}\}$. Let $\bar{\mathbf{g}}_i = (\bar{\mathbf{g}}_{i,1}, \dots, \bar{\mathbf{g}}_{i,i-1}, \bar{\mathbf{g}}_{i,i+1}, \dots, \bar{\mathbf{g}}_{i,n})$ be the set of direct links of agent i . Then $\bar{\mathbf{g}} = (\bar{\mathbf{g}}_1, \bar{\mathbf{g}}_2, \dots, \bar{\mathbf{g}}_n)$ describes the graph with no regard who support the links. Let $N^d(i; g) \equiv \{j \in N : \mathbf{g}_{i,j} = 1\}$ be the set of players in network g with whom player i has established links, while $v^d(i; g) \equiv |N^d(i; g)|$ is its cardinality. In a similar way, let $N^d(i; \bar{g}) \equiv \{j \in N : \bar{\mathbf{g}}_{i,j} = 1\}$ be the set of players in network g with whom player i is connected, while $v^d(i; \bar{g}) \equiv |N^d(i; \bar{g})|$ is its cardinality. We say there is a path in g between i and j if either $\bar{\mathbf{g}}_{ij} = 1$ or there exists a set of agents $\{j_1, j_2, \dots, j_m\} \in N \setminus \{i, j\}$ such that $\bar{\mathbf{g}}_{ij_1} = \bar{\mathbf{g}}_{j_1 j_2} = \dots = \bar{\mathbf{g}}_{j_m j} = 1$. By T_{ij} we denote the set of all paths between agents i and j . The distance in g between agents i and j , denoted as $d(i, j; g)$, is defined as the number of links of the shorter path in T_{ij} . The shorter path is that with the lower number of direct links. A sub-network $g' \subset g$ is called a component of g if for all $i, j \in g'$, $i \neq j$, there exists a path in g' connecting i and j , and there does not exist a path between an agent in g' and one in $g \setminus g'$. A network with only one component is called connected. Given any g , the notation $g + ij$ denotes the network obtained with the formation of a new link between i and j in the network g . Similarly, $g - ij$ refers to the network obtained deleting the link \mathbf{g}_{ij} in g . By minimally connected we denote a connected network g such that $g - ij$ is a no connected network for all $i, j \in g$ such that $\mathbf{g}_{ij} = 1$. Finally we introduce the following notation. A network is called:

- empty and denoted by g^e if $\bar{g}_{i,j} = 0$ for $\forall i, j \in N$;
- star and denoted by g^s if there exists some $i \in N$ such that, for all $k, j \in N \setminus \{i\}$, $j \neq k$, $\bar{g}_{i,j} = 1$ and $\bar{g}_{k,j} = 0$;
- complete and denoted by g^c if $\bar{g}_{i,j} = 1$ for $\forall i, j \in N$;
- essential if $g_{ij} \cdot g_{ji} = 0$ for $\forall i, j \in N$

Among the star networks we denote with g^{cs} the star with all the links supported by the central agent, with g^{ps} the star with all links supported by peripheral agents and with g^{ms} all the intermediate cases. The links are costly: every agent pays a cost $k > 0$ for each link she supports. In our model, as in Bala and Goyal [1] or Goyal and Vega Redondo [9], link formation is one-sided and non-cooperative: the formation of a link requires only the consensus of the supporting player.

In our model decay is endogenous. We assume that every pair of directly linked agents plays a 2×2 symmetric game in strategic form with a common action set given by $A = \{\mathbf{a}, \mathbf{b}\}$. For each pair of actions $a, a' \in A$, the share of information received by a player choosing a when the partner plays a' is denoted by $\mathbf{d}(a, a')$ and is given by the following table:

(2.2)

	\mathbf{a}	\mathbf{b}
\mathbf{a}	l	0
\mathbf{b}	e	e

where $0,5 \leq e \leq 1$

Then, the quantity of information received by a player choosing a when the partner plays a' is given by $\mathbf{d}(a, a') \cdot x$, where x is the information owned by the partner. There are 2 Nash equilibria in pure strategies: (\mathbf{a}, \mathbf{a}) and (\mathbf{b}, \mathbf{b}) . The first one is efficient, the second one is risk dominant. Each agent plays the game with all directly linked agents and have to use the same action in all engaged bilateral games. In the following we indicate an agent(s) choosing action a by a -agent(s) where $a \in \{\mathbf{a}, \mathbf{b}\}$.

For a generic agent i the strategy space is identified with $S_i = G_i \times A$, where G_i is the set of possible link decisions and A is the common action space of the underlying bilateral game. In the following we consider that $G_i = G \quad \forall i \in N$.

Then, given the strategies of other players, $s_{-i} = (s_1, \dots, s_{i-1}, s_{i+1}, \dots, s_n)$, the payoff of player i deriving from her participation to the game playing some strategy $s_i = (g_i, a_i)$ is given by:

$$(2.3) \quad \Pi(s_i, s_{-i}) = \sum_{j \in N_i} \left[\prod_{l, k \in \bar{t}_{ij}} d(a_l, a_k) \right] - k \cdot v^d(i; g)$$

where $N_i = \{j : T_{ij} \neq \emptyset\}$ and \bar{t}_{ij} represents the path between players i and j such that $\bar{t}_{ij} = \underset{t_{ij}}{\operatorname{argmax}} \prod_{l, k \in t_{ij}} d(a_l, a_k)$.

Time is modelled discretely, $t = 1, 2, 3, \dots$. At time t the state of the system will be given by strategy profile $s(t) = \{g(t), a(t)\}$ specifying the action chosen and links established by each player ($s_i(t) = \{g_i(t), a_i(t)\}$). At every period t one agent obtains, by a probability p , a chance to revise her strategy. When an agent receives this opportunity, she select a best response to strategy profile in the previous periods:

$$(2.4) \quad s_i(t) \in \operatorname{argmax}_{s_i \in S} \Pi[s_i, s_{-i}(t-1)];$$

If there are several best responses, then any one of them is chosen with equal probability. This strategy revision process defines a Markov chain on $S \equiv S_1 \times S_2 \times \dots \times S_n$. As we will see, in our framework, this Markov chain could be characterized by several absorbing states. Then, the equilibria are depending on the initial conditions.

To select among all possible equilibria, we employ the standard techniques used by Kandory, Mailath and Rob [15] and Young [21]. We suppose, conditional on the chance to revise her strategy, players make mistakes. In this case, player chooses her strategy at random with some small probability $\epsilon > 0$. For any $\epsilon > 0$, the process defines an aperiodic and irreducible Markov chain that has a unique invariant probability distribution \mathbf{m}_ϵ . We analyze the structure of \mathbf{m}_ϵ as the probability of mistakes ϵ converges to zero. We define $\lim_{\epsilon \rightarrow 0} \mathbf{m}_\epsilon = \hat{\mathbf{m}}$, then a state s is called stochastically stable if $\hat{\mathbf{m}}(s) > 0$.

3. Results

In this section we characterize the efficient states, study the characteristics of equilibria when dynamic is not perturbed by mistakes and, finally, examine the stochastic stability of different configurations.

3.1 Efficiency

We use the utilitarian concept of efficiency: the efficient state is that producing the higher total net payoff (gross payoff less cost of links).

Proposition 1: *If $k \leq n$, in all efficient states all agents are coordinated on action \mathbf{a} and networks are minimally connected. If $k > n$, only empty networks are efficient.*

As the intuition provided below is simple, a formal proof is omitted. Any network architecture with agents coordinated on action \mathbf{b} is dominated by an equal network with agents coordinated on action \mathbf{a} . When all agents are coordinated on \mathbf{a} , from proposition 4.3 in Bala and Goyal [1] follows that for $k \leq n$ minimally connected networks are efficient otherwise, if $k > n$, the efficient networks are empty.

There are several efficient network architectures : all kinds of star, the line and, more in general, all architectures minimally connected and with minimum number of links: to connect n agents are necessary at least $n-1$ links. This is possible because there are not differences in payoff between a direct link and an indirect one, when all individuals are coordinated on action \mathbf{a} (remember $p(\mathbf{a}, \mathbf{a}) = 1$). If $p(\mathbf{a}, \mathbf{a}) < 1$, we could restrict the set of efficient networks because the share of information arriving from a player to another is decreasing with the number of links that have to pass through. In according to proposition 1 in Jackson and Wolinsky [13], we find efficient networks are complete or star or empty depending on the link cost k .

3.2 Static equilibria.

The following proposition describes the general characteristics of strict Nash equilibria in a network with endogenous decay.

Proposition 2: *Let $\bar{s} = \{\mathbf{g}, \mathbf{a}\}$ be a strict Nash equilibrium. Then the network is essential, connected and all agents are coordinated on the same action. Moreover if $k < 1$ the chosen action could be \mathbf{a} or \mathbf{b} , otherwise only \mathbf{b} can be chosen.*

The proposition describes two important features of strict Nash equilibria: aggregation and conformity. A state with two or more separated components is not a strict Nash equilibrium as well as a state with agents coordinated on different actions. Note that we do not exclude the existence of Nash equilibria in which agents are choosing different actions in the same component (aggregation without conformity). We only say that these equilibria are not strict Nash. More in detail, for $k < 1$, networks with agents coordinated on **a** could be strict Nash equilibria as well as networks with agents coordinated on **b**. On the contrary, for $k > 1$ only networks with agents coordinated on **b** could be strict Nash. A sub-network $g' \subset g$ is called *a*-group, where $a \in \{\mathbf{a}, \mathbf{b}\}$, if $\forall i \in g'$ is an *a*-agents and, for all $i, j \in g'$, $i \neq j$, there exists a path in g' connecting i and j and does not exist a direct link between an agent in g' and one *a*-agent in $g \setminus g'$. With this definition in hand we can prove the proposition.

Proof: The proof goes in two steps. In the first one we prove that all strict Nash equilibria with conformity are essential and connected. In the second step we show that a strict Nash equilibrium without conformity does not exist. Step 1. Assume a strict Nash equilibrium where all agents are choosing action **a**. From proposition 4.2 in Bala and Goyal [1] we know that when $k < 1$ only g^{cs} is a strict Nash equilibrium. In this state every agents obtain a strictly positive payoff. Changing action an agent could obtain a payoff's proportional reduction at least of $1 - e$. Then the considered state is a strict Nash equilibrium. For $k > 1$, from proposition 4.2 in Bala and Goyal [1] we know that the unique candidate to be a strict Nash equilibrium is g^e . But in our model this network is never strict Nash because the player can switch to other action obtaining the same (zero) payoff. Now, assume a strict Nash equilibrium where all agents are choosing action **b**. The proof for essentiality and connecteness derives directly from proposition 5.3 in Bala and Goyal [1]. If an agent switches to action **a**, she obtain a zero payoff. Then the considered state is a strict Nash equilibrium. Step 2 Consider any strategy profile without conformity where n' agents are choosing action **a**, n'' agents are choosing **b** and $n' > 1$ ⁴. Using the same arguments as in proposition 4.2 in Bala and Goyal [1] we know that, if $k < 1$, in a

⁴ The special case with $n' = 1$ cannot be a strict Nash equilibrium because the unique **a**-agent obtains zero payoff: she could change action obtaining at least a zero payoff (for example, if she changes action and does not link with anyone obtain zero payoff).

strict Nash equilibrium, all \mathbf{a} -agents have to link among themselves in a g^c . Suppose that \mathbf{b} -agents are in one or more separated components. This state cannot be a strict Nash equilibrium because any \mathbf{b} -agent, forming a link with an \mathbf{a} -agent, could obtain a payoff of $n' \cdot e - k$ that is strictly positive given (2.2). All connected states where \mathbf{a} -agents support links with \mathbf{b} -agents cannot be strict Nash equilibrium either because \mathbf{a} -agents obtain a negative net payoff from their links with \mathbf{b} -agents⁵. Finally, all connected states where \mathbf{b} -agents support links with \mathbf{a} -agents cannot be strict Nash equilibrium because \mathbf{b} -agents are indifferent among which \mathbf{a} -agent to be tied. In the case for $k \geq 1$, in a strict Nash all agents must be \mathbf{b} -agents because a strict Nash equilibrium for \mathbf{a} -agents does not exist. QED.

3.3 Dynamic

In this section we describe the dynamic properties of different equilibria. First we study the no-perturbed dynamic in the complete game. After we provide a complete description of all equilibria that are stochastically stable.

Proposition 3: *There exists a $\bar{n}(k, e)$ such that for $n > \bar{n}(k, e)$ the dynamic process converges with probability 1 to a state characterized by an essential and connected network and with all agents coordinated on the same action or to a state with an empty network.*

If $k < 1$ the system goes in a state where all agents are coordinated on \mathbf{a} and the network is essential and minimally connected or in a state with all agents coordinated on \mathbf{b} and connected network. If $k > 1$ the system goes in an empty network or in a state with all agents coordinated on \mathbf{b} and connected network.

Proof: The proof relies on showing that from any network there is a positive probability to transit to an absorbing set in a finite time. The results will follow from the standard theory of Markov chains. The proof goes on two steps. In the first one we show as, starting from any initial state, the process transits to a connected network or to g^e in finite time. In the second step we show as, starting from any connected network with heterogeneity, the system goes in a state with conformity.

Step 1: In this step we use the result stated in the following lemma.

⁵ an \mathbf{a} -agent supporting one link with a \mathbf{b} -agent obtains a negative payoff of $-k$.

Lemma 1: Let be $k > e$. Consider any initial state in which all agents chose action **b**. Then if:

- a) $e < k < 1$ the dynamic process converges to a connected state with all agents coordinated on action **a** or **b**;
- b) if $k > 1$ the dynamic process converges to a connected state with all agents coordinated on action **b** or to g^e ;

The proof is in appendix.

Assume $k < e$. In any state the best response for **b**-agents is to be tied, directly or indirectly, with all others, while for **a**-agents is to be tied with all other **a**-agents. Then a no-connected network cannot be an absorbing state. Assume a network with h components ($h \geq 1$), n' agents choosing action **a** and n'' agents choosing action **b**. If $n' \geq 2^6$ and $e < k < 1$ the best response of **a**-agents is to be tied in unique **a**-group or to switch to action **b**. If the case is the first one the best response of **b**-agents is to be directly or indirectly tied to the **a**-group (switching action or not) and the system goes in a connected network. If the case is the second the system could go in a state with only **b**-agents. Using the result stated in the part a of lemma 1 we are able to demonstrate the convergence in a connected state. Assume $k > 1$. Giving repeatedly the chance to revise the strategy only to **a**-agents, they delete their links between them. The proof of this result is omitted because use similar arguments than in theorem 4.1 in Bala and Goyal [1]. Then, from the result stated in part b of lemma 1 we know that the system will go in connected state with all agents coordinated on action **b** or in g^e .

Step 2: In this step we use the result stated in the following lemma.

Lemma 2: Let be $e - e^2 < k < e$. Then in a **b**-group of an absorbing state, the maximum distance between 2 player is bounded above by the minimum integer value of l such that $k < e - e^{l+1}$.

The proof is in appendix.

Now we prove as, starting from a connected network g with n' **a**-agents and n'' **b**-agents, the system converges towards the conformity for different levels

⁶ In the special case with $n' = 1$, the unique **a**-agent has in the set of her best responses to switch action, given that her payoff is zero and that switching action obtain at least zero payoff; therefore the proof follows lemma 1.

of link cost with positive probability. Then we show that the probability to go from a state with conformity to another without, is zero. From step 1 results that only if $k < l$ the system could converge to a connected network characterized by no conformity. Therefore we discuss only the case for $k < l$. Assume that $k < e - e^2$. The dynamic process converges in a state where every **b**-agent is directly linked with all other **b**-agents and with the **a**-group. We note that **b**-agents are indifferent to choose a specific **a**-agents or another to form a link and any **a**-agent is chosen with equal probability. Therefore exists a positive probability that best response dynamic converges to a state where all **b**-agents are linked to the same **a**-agent. The payoff of an **a**-agent receiving links from all **b**-agents and supporting x links, from choosing action **a** is:

$$(2.5) \quad \Pi(\mathbf{a}) = (n' - l) - x \cdot k$$

while choosing action **b** obtains:

$$(2.6) \quad \Pi(\mathbf{b}) = (n' + n'' - l) \cdot e - x \cdot k$$

From the stability condition, $\Pi(\mathbf{a}) > \Pi(\mathbf{b})$, we obtain:

$$(2.7) \quad n' > \frac{n'' \cdot e}{l - e} + l$$

Now we consider a **b**-agent. Among all complete network architectures the larger possible payoffs is:

$$(2.8) \quad \Pi(\mathbf{b}) = (n' + n'' - l) \cdot e - k$$

Switching to action **a** the payoff is:

$$(2.9) \quad \Pi(\mathbf{a}) = n' - k$$

From the stability condition, $\Pi(\mathbf{b}) > \Pi(\mathbf{a})$, we obtain:

$$(2.10) \quad n' < \frac{(n'' - l) \cdot e}{l - e}$$

that is incompatible with the conditions (2.7). Finally we note how in a state with conformity to switch action is never a best response because it decrease the payoff (from **a** to **b**) or produce a zero payoff (from **b** to **a**).

Assume that $e - e^2 < k < e$. In this case the dynamic process converges in a state characterized from only one **b**-group given that to form a link with a no connected agent yields a positive payoff. The network architecture of **b**-group is not well defined. The stability condition for a generic **b**-agent i , such that she has no incentive to switch action, is:

$$(2.11) \quad \Pi_i(\mathbf{b}) + d \cdot n' > n' - 1$$

where $\Pi_i(\mathbf{b})$ is the net payoff deriving from the \mathbf{b} -group and $d \leq e$ depending on i is directly or indirectly linked with the \mathbf{a} -group. Follows that n' is bounded above by:

$$(2.12) \quad n' < \frac{\Pi_i(\mathbf{b}) + 1}{1 - d}$$

The stability condition for a generic \mathbf{a} -agent j such that she has no incentive to switch action, is:

$$(2.13) \quad n' - 1 > (n' - 1) \cdot e + \Pi_j(\mathbf{b})$$

where $\Pi_j(\mathbf{b})$ is the better possible net payoff deriving from the \mathbf{b} -group.

Then, n' is bounded below by:

$$(2.14) \quad n' > 1 + \frac{\Pi_j(\mathbf{b})}{1 - e}$$

Increasing the number of agents in the network have to increase both n' and n'' . We note that it is impossible to increase n'' without increase n' . Indeed from lemma 2 we know that in an absorbing set payoff deriving from the \mathbf{b} -group due to an agent more is bounded below by⁷ $e - k$. Then increasing n'' , to satisfy condition (2.14), n' have to increase too. Viceversa, increasing n' , to satisfy condition (2.12), n'' have to increase too. Using this consideration we find that exists a value of n , denoted by $\bar{n}(k, e)$, such that (to satisfy the equilibrium

conditions) must be $n' > \frac{k}{e - e^2}$ for all $n > \bar{n}(k, e)$. In this situation all \mathbf{b} -

agents have as best response to form a direct link with \mathbf{a} -group. The stability condition for an \mathbf{a} -agent receiving links from all \mathbf{b} -agents and that for a \mathbf{b} -agent with the greater possible payoff are the same than in previous case, (2.7) and (2.10), that are not compatible.

Finally we have to consider the case $e < k < 1$. Using the same argumentation of previous case, we can say that exists a value of n , denoted by $\hat{n}(k, e)$, such that

for all $n > \hat{n}(k, e)$ to satisfy the equilibrium conditions must be $n' > \frac{k}{e - e^2}$. In

⁷ From lemma 2, adding an agent more at a distance larger than l from agent i , this can improve her payoff at least of $e - k$ supporting a new link. If the new agent stays at a distance smaller than l from agent i , this receive a payoff larger than $e - k$.

this state all \mathbf{b} -agents have as best response to form a direct link with \mathbf{a} -group. Then, computing as in previous case the equilibrium conditions, we obtain the incompatible conditions (2.7) and (2.10). QED.

The system converges to an equilibrium state in according to initial conditions. But for a given interval of relevant parameters (k, e, n) we are not able to produce a full description of equilibrium states. To select among all possible equilibria, we use the concept of stochastic stability: conditional on the chance to revise their strategy, players make mistakes and choose their strategy at random with some small probability $\epsilon > 0$.

We denote a minimally connected network by g^m . The state characterized by a g^x network with all agents coordinated on action a , $a \in \{\mathbf{a}, \mathbf{b}\}$, is denoted by $g^x(a)$. We describe the result regarding the stochastically stable states in the following theorem.

Theorem 1: *There exists a \hat{n} such that for all $n > \hat{n}$:*

- a) *If $k < e - e^2$ there exists a $\hat{k}_1(e, n)$ such that for $k > \hat{k}_1$ only $g^m(\mathbf{a})$ are stochastically stable and for $k < \hat{k}_1$ only $g^e(\mathbf{b})$ are stochastically stable.*
- b) *if $e - e^2 < k < e$, there exists $\hat{k}_2(e, n)$ such that for $k > \hat{k}_2$ only $g^m(\mathbf{a})$ are stochastically stable and for $k < \hat{k}_2$ only $g^{cs}(\mathbf{b})$, $g^{ms}(\mathbf{b})$ and $g^{ps}(\mathbf{b})$ are stochastically stable.*
- c) *If $e < k < 1$ there exists $\hat{k}_3(e, n)$ such that for $k > \hat{k}_3$ both $g^{cs}(\mathbf{a})$ and $g^{ps}(\mathbf{b})$ are stochastically stable and for $k < \hat{k}_3$ only $g^{cs}(\mathbf{a})$ are stochastically stable.*
- d) *If $k > 1$ there exists $\hat{k}_4(e, n)$ such that for $k > \hat{k}_4$ only g^e is stochastically stable, and for $k < \hat{k}_4$ both g^e and $g^{ps}(\mathbf{b})$ are stochastically stable.*

To demonstrate this theorem we use the definition of recurrent set in the sense of Samuelson (Def. 7.4 pag 220). Then we use the result of proposition 7.7 of Samuelson (pag 221): when an absorbing state belonging to a recurrent set is stochastically stable so are all other states in the recurrent set. This result permits us to simplify the computation of stochastic potential needs to find the set of stochastically stable states: we can consider only the states belonging to a recurrent set; then if exists only one recurrent set, all states belonging to it are stochastically stable otherwise, if more than one recurrent set exists, we have to

compute the stochastic potential considering only the transition from any state in a recurrent set to any other state in the other recurrent set that requires the minimum number of mutation. Let S_a and S_b be 2 recurrent sets. The stochastic potential of a state $s \in S_a$ is given by $|S_a| - 1 + m_{ba} + |S_b| - 1$ where m_{ba} denotes the minimum number of mutations needs to induce a transitions from S_b to S_a and $|S_x|$ denotes the number of elements in S_x . The stochastic potential of a state $s \in S_b$ is given by $|S_a| - 1 + m_{ab} + |S_b| - 1$. Therefore, to determine the stochastically stable states is enough to consider only the terms m_{ab} and m_{ba} .

Before to continue the proof of Theorem 1 we introduce some convenient notation. Given any agent in a network g , we denote by q_h the number of active links she supports to players choosing action h , where $h \in \{\mathbf{a}, \mathbf{b}\}$. Similarly, r_h stands for the number of passive links received from players choosing action h where $h \in \{\mathbf{a}, \mathbf{b}\}$.

Consider part a of Theorem 1, that is $k \leq e - e^2$. In this range of link cost, using the result stated in proposition 3, we identify 2 candidates to be recurrent sets: S_b characterized by $g^c(\mathbf{b})$ and S_a characterized by $g^m(\mathbf{a})$.

1. Now we compute the minimum number of mutations needs to move the system from S_a to S_b and denote it by m_{ab} . The payoff from choosing action \mathbf{b} for a player i is given by:

$$(2.15) \quad \Pi_i(\mathbf{b}) = (n - l) \cdot e - (L + q_b) \cdot k$$

where: L denotes the number of \mathbf{a} -groups do not linked to agent i . On the other hand, the payoff from choosing \mathbf{a} is equal to:

$$(2.16) \quad \Pi_i(\mathbf{a}) = (n - l - m_{ab}) - L \cdot k$$

The agent i prefers action \mathbf{b} only if the following is true:

$$(2.17) \quad \Pi_i(\mathbf{b}) - \Pi_i(\mathbf{a}) = m_{ab} - q_b \cdot k - (n - 1) \cdot (1 - e) \geq 0$$

The more favorable condition to induce the transition is when all \mathbf{b} -agents are supporting a link with agent i , that is $q_b = 0$. Solving (2.17) in m_{ab} as an equality we find the minimum number of \mathbf{b} -agents (mutants) needs to induce the transition to S_b that is given by:

$$(2.18) \quad m_{ab} = (n - 1) \cdot (1 - e)$$

2. Now we compute the minimum number of mutations to lead the system from S_b to S_a and denote it by m_{ba} . The payoff from choosing action \mathbf{b} for a player i is given by (2.15). The payoff from choosing \mathbf{a} is equal to:

$$(2.19) \quad \Pi_i(\mathbf{a}) = m_{ba} - L \cdot k$$

The agent i prefers action \mathbf{a} only if the following is true:

$$(2.20) \quad \Pi_i(\mathbf{a}) - \Pi_i(\mathbf{b}) = m_{ba} - (n-1) \cdot e + q_b \cdot k \geq 0$$

The more favorable condition to induce the transition is for $q_b = n - l - m_{ba}$, that is when agent i supports links with all \mathbf{b} -agents.

Solving (2.20) in m_{ba} we obtain the minimum number of mutations needs to induce the transition to S_a that is given by:

$$(2.21) \quad m_{ba} = (n - l) \cdot \frac{(e - k)}{l - k}.$$

The states in S_a are stochastically stable if and only if $m_{ab} > m_{ba}$. Using expressions (2.18) and (2.21), we write this condition as:

$$(2.22) \quad k > 2 - \frac{1}{e}$$

Otherwise the stochastically stable states are those in S_b . The necessary condition for only one of these sets to be stochastically stable is a sufficiently large number of agent such that the minimum number of mutation to lead the system from a recurrent set to another is greater than one and $|m_{ab} - m_{ba}| > l$.

Consider part *b* of Theorem 1, that is $e - e^2 \leq k \leq e$. In this case, using the result stated in proposition 3 and that in Theorem 1 in Feri (2003)⁸, if n is sufficiently large, we identify two candidates to be recurrent sets: S_a defined in point a , and S_b characterized by $g^s(\mathbf{b})$.

1. Now we compute the minimum number of mutation to lead the system from S_a to S_b and denote it by m_{ab} . The payoff from choosing action \mathbf{b} for a player i is given by:

$$(2.23) \quad \Pi_i(\mathbf{b}) = (r_a + r_b + q_a + q_b + x) \cdot e + (y + z) \cdot d - (q_a + q_b) \cdot k$$

⁸ by this we are able to concentrate our attention only on star networks.

where x denotes the number of **a**-agents indirectly linked with agent i through others **a**-agents, y is the number of **a**-agents indirectly linked with agent i through **b**-agents, z is the number of **b**-agents indirectly linked with agent i through **b**-agents and $e - k \leq d \leq e^2$. On the other hand, the payoff from choosing **a** is equal to:

$$(2.24) \quad \Pi_i(\mathbf{a}) = n - l - m_{ab} - (q_a + L_y) \cdot k$$

where L_y denotes the number of **a**-groups do not linked to agent i (or linked through **b**-agents). The agent i prefers action **b** only if the following is true:

$$(2.25) \quad \Pi_i(\mathbf{b}) - \Pi_i(\mathbf{a}) =$$

$$(r_a + q_a + x) \cdot e + y \cdot d + L_y \cdot k + r_b \cdot e + q_b \cdot (e - k) + z \cdot d - (n - 1 - m_{ab}) \geq 0$$

The more favorable condition to induce this transition is for $q_b = 0$, $z = 0$, $d = e^2$, $L_y = y$ and $r_a + q_a + x = 0$. Then (2.25) becomes:

$$(2.26) \quad r_b \cdot e + y \cdot (e^2 + k) - (n - 1 - m_{ab}) \geq 0$$

Note that $r_b = m_{ab}$ and $y = n - l - m_{ab}$. Then, solving (2.26) in m_{ab} we find the minimum number of **b**-agents (mutants) needs to induce the transition to S_b that is given by:

$$(2.27) \quad m_{ab} = (n - l) \cdot \frac{l - e^2 - k}{l + e - e^2 - k}$$

We note that for $k \geq l - e^2$ it is not possible to find a sufficiently large value of n such that $m_{ab} > 1$.

3. Now we compute the minimum number of mutations to lead the system from S_b to S_a and denote it by m_{ba} . The payoff from choosing action **b** for a player i is given by (2.23). The payoff from choosing **a** is equal to:

$$(2.28) \quad \Pi_i(\mathbf{a}) = m_{ba} - (q_a + L_y) \cdot k$$

The agent i prefers action **a** only if the following is true:

$$(2.29) \quad \Pi_i(\mathbf{a}) - \Pi_i(\mathbf{b}) =$$

$$= m_{ba} - (r_a + q_a + x) \cdot e - L_y \cdot k - y \cdot d - r_b \cdot e - q_b \cdot (e - k) - z \cdot d \geq 0$$

We note that in (2.23) agent i is optimally indirectly tied with the y \mathbf{a} -agents if $y \cdot e - L_y \cdot k \leq y \cdot d$. Therefore $y \cdot e \leq L_y \cdot k + y \cdot d$. Then the more favorable condition for the transition is given by $y = 0$, $r_b = 0$ and $z = 0$. In this case, noting that $r_a + q_a + x = m_{ba}$ and $q_b = n - 1 - m_{ba}$, we find that the minimum number of \mathbf{a} -agents (mutants) needs to induce the transition to S_a is given by:

$$(2.30) \quad m_{ba} = (n - 1) \cdot \frac{e - k}{1 - k}$$

The states in S_a are stochastically stable if and only if $m_{ab} > m_{ba}$. Using expressions (2.27) and (2.30), we write this condition as:

$$(2.31) \quad k > \frac{e + 2 \cdot e^2 - e^3 - 1}{2 \cdot e - 1}$$

Otherwise the stochastically stable states are those in S_b . The necessary condition for only one of these sets to be stochastically stable is a sufficiently large number of agent such that the minimum number of mutations to lead the system in an equilibrium out of the recurrent set is greater than one and $|m_{ab} - m_{ba}| > 1$.

Consider part c of Theorem 1 that is for $e \leq k \leq 1$. In this case, using the result stated in proposition 3 and that in Theorem 1 in Feri (2003)⁹, for a sufficiently large value of n , we have 2 possible recurrent sets: S_a defined in point a and S_b characterized by $g^{ps}(\mathbf{b})$.

1. To lead the system out of S_b is sufficient only one mutation of a peripheral agent i that chooses to form links with all others. If all other agents have the chance to revise before i , the system converges towards a $g^{cs}(\mathbf{b})$. This structure is unsustainable and the dynamic process leads the system to a g^e . From this state there is a positive probability that system goes in S_a .
2. Now we compute the range of link cost such that is sufficient only one mutation to lead the system from S_a to S_b . First we consider the

⁹ by this we are able to concentrate our attention only on star networks with links supported by peripheral agents.

conditions to lead the system from S_a to S_b . The payoff from choosing action \mathbf{b} for a player i is given by:

$$(2.32) \quad \Pi_i(\mathbf{b}) = (r_a + r_b + q_a + q_b + x) \cdot e + (y + z) \cdot d - (q_a + q_b) \cdot k$$

On the other hand, the payoff from choosing \mathbf{a} is equal to:

$$(2.33) \quad \Pi_i(\mathbf{a}) = (n - l - m_{ab}) - (q_a + L) \cdot k$$

where L denotes the number of \mathbf{a} -groups do not tied with i or indirectly linked through \mathbf{b} -agents. The agent i prefers action \mathbf{b} only if the following is true:

$$(2.34)$$

$$\begin{aligned} \Pi_i(\mathbf{b}) - \Pi_i(\mathbf{a}) = \\ = (r_a + q_a + x) \cdot e + y \cdot d + L \cdot k - (n - 1 - m_{ab}) + r_b \cdot e + q_b \cdot (e - k) + z \cdot d \geq 0 \end{aligned}$$

The more favorable condition for the transition is when $q_b = 0$, $z = 0$, $d = e^2$, $L = y$, $r_a + q_a + x = 0$. Inserting these conditions in (2.34) and arranging for $L = n - 1 - m_{ab}$ and $r_b = m_{ab}$, we obtain:

$$(2.35) \quad (n - 1 - m_{ab}) \cdot (e^2 + k - 1) + m_{ab} \cdot e \geq 0$$

Solving (2.35) in k assuming $m_{ab} = l$ we find the range of link cost where to induce the transition to S_b is sufficient only one mutation, that is given by:

$$(2.36) \quad k \geq l - e^2 - \frac{e}{n - 2}$$

That for large values of n can be approximated by $k \geq l - e^2$.

Follows that if the condition (2.36) is not satisfied only states in S_a are stochastically stable, while when this condition is satisfied are stochastically stable either states in S_a and S_b .

Consider part d of Theorem 1 that is for $k \geq l$. In this case, using the result stated in proposition 3 and that in Theorem 1 in Feri (2003)¹⁰, for a sufficiently large value of n , we have 2 possible recurrent sets: S_e characterized by g^e and S_b characterized by $g^{ps}(\mathbf{b})$. To lead the system from a state in S_b to an empty network is sufficient only one mutation (see part c). On the contrary to conduce

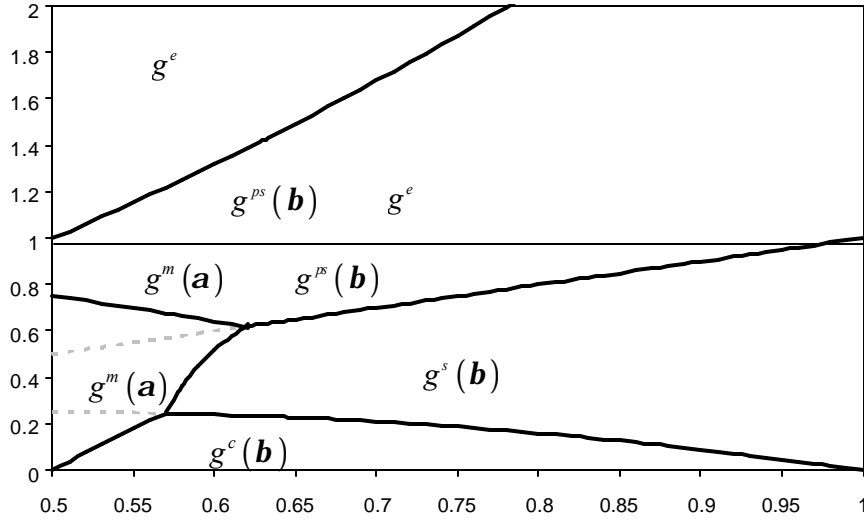
¹⁰ by this we are able to concentrate our attention only on star networks.

the system from an empty network to a state in S_b needs only one mutation if and only if the cost k is relatively lower. Consider an empty network. A mutating agent i chooses action \mathbf{b} and forms links with n_i agents. If $n_i \geq \frac{k-e}{e^2}$ all no connected agents will choose to form a link with agent i as soon as possible. If there are at least other n_i agents without links revising their strategy before than the central agent will do, the system will have a star network with at least n_i links supported by peripheral agents. From this state the no perturbed dynamic leads the system to a star network with links supported by peripheral agents. The condition on the link cost k that permits this transition with only one mutation is:

$$(2.37) \quad k \leq e + \frac{n-1}{2} e^2.$$

Therefore if (2.37) is satisfied, both $g^{ps}(\mathbf{b})$ and g^e are stochastically stable states, otherwise only g^e are stochastically stable states.

We consider the stochastically stable states as the states where the system spends most of the time. With this consideration in hand we explain the main characteristics of the model using the following figure where we display the stochastically stable states in according to the levels of e and k (x-axis displays e and y-axis displays k).



We note as efficient states are stochastically stable mainly for small values of e . Intuition is that if the premium to play efficient action is small the rational individuals spend most of the time on the risk dominant action or that is more probable that the system converges in a state characterized by individuals coordinated on risk dominant action. The second feature of the model is that, given a sufficiently low value of e , efficient states are stochastically stable only for intermediate values of k . Indeed for small values of k , the advantage to be coordinated on the efficient states, deriving from a smaller number of links, is lower. On the other side for large values of k coordination problems seem to play an important role to rule out the efficient states.

4. Conclusion

In this paper we have analyzed in a stylized form a social network characterized by an endogenous network architecture. We have considered the variety of networks with decay and we have modeled this as endogenous. The main result regard the analysis of equilibria. In our frameworks decay is assumed to depend on the actions chosen by agents participating to the network. We assume that agents can choose among two actions: one is efficient while the other is risk dominant. The empirical counterpart is the trade off between efficient technologies and compatible technologies.

In this model we have a greater number of equilibria and we are not able to produce a full description of them; on the contrary we are able to produce a full characterization of the subset of stochastically stable states. Differently from the results in Jackson and Watts [12] and Goyal and Vega Redondo [9], in our model the network structure depends on which action individuals coordinate. Moreover efficient states are stochastically stable for intermediate levels of link cost and not for high levels. The first difference in the results is due to the fact that the social game determines the decay level and not only the payoff. Therefore this result follows those in Jackson and Wolinsky [13] and Bala and Goyal [1]. The fact to have different network structures in according to the action on which individuals coordinate, affects the dynamic selection given that every network structure produces different externalities on the participants. This explains the difference in the results regarding the stochastically stable states too.

Further development can be made in many directions. First, we might consider a model with two-side link formation: this is more similar to real world and it may change the result on stochastic stability. Second, we might use a setting where small deviations from the best response are more probable that

the large ones. Third, we can model the endogenous decay with different social game that can be more respondent to different empirical situations. Finally, we could study applications regarding the diffusion of technologies and the hierarchical and social structure in the enterprises and firms.

Bibliografia

1. Bala and Goyal (2000): "A Non Cooperative Model of Network Formation", *Econometrica* 68.
2. Bhaskar and Vega Redondo (1998): "Migration and the Evolution of Conventions", mimeo.
3. Bramouille, Goyal, Lopez Pintado and Vega Redondo (2001): "Social Interaction in Anti-Coordination Games", mimeo.
4. Droste, Gilles, Johnson (2000): "Evolution of Conventions in Endogenous Social Networks ", mimeo.
5. Ellison (1993): "Learning, Local Interaction and Coordination", *Econometrica* 61
6. Ellison (2000): "Basins of Attraction, Long Run Stochastic Stability and the Speed of Step-by-step Evolution" *Review of Economic Studies*, 67.
7. Foster and Young (1991). "Cooperation in the Short and in the Long Run", *Games and Economic Behavior* 3.
8. Freidlin and Wentzell (1984): "Random Perturbations of Dynamical System", New York, Springer Verlag
9. Goyal and Vega Redondo (2000): "Learning, Network Formation and Coordination", mimeo.
10. Harsanyi and Selten (1988): "A General Theory of Equilibrium in Games", Cambridge MIT Press.
11. Jackson (2001): "The Stability and Efficiency of Economic and Social Networks", in "Models of the Formation of Networks and Groups" (B. Dutta and M. O. Jackson, Eds.), Springer-Verlag, Heidelberg.
12. Jackson and Watts (2002): "On the Formation of Interaction Networks in Social Coordination Games", *Games and Economic Behavior* 41.
13. Jackson and Watts (2002): "The Evolution of Social and Economic Networks" *Journal of Economic Theory* 106.
14. Jackson and Wolinsky (1996): "A Strategic Model of Social and Economic Networks", *J.E.T.* 71.
15. Kandori and Rob (1995): "Evolution of Equilibria in the Long Run: A General Theory and Applications", *J.E.T.* 65.

16. Kandori, Mailath and Rob (1993): “Learning, Mutation and Long Run Equilibria in Games”, *Econometria* 61.
17. Karandikar, Mookherjee, Ray and Vega Redondo (1998): “Evolving Aspirations and Cooperation”, *J.E.T.* 80.
18. Robson and Vega Redondo (1996): “Efficient Equilibrium Selection in Evolutionary Games with Random Matching”, *J.E.T.* 70.
19. Selten (1991): “Evolution, Learning and Economic Behavior”, *Games and Economic Behavior* 3.
20. Vega Redondo (2000): “Economics and the Theory of Games”, forthcoming, Cambridge University Press.
21. Watts (2001): “A Dynamic Model of Network Formation”, *Games and Economic Behavior* 34.
22. Young (1993): “The Evolution of Conventions”, *Econometria* 61.
23. Young (1996): “The Economics of Convention”, *J. of Economic Perspective* 10.
24. Feri (2003): “Stochastic Stability in Network With Decay”, mimeo

Appendix.

Proof of lemma 1.

Given any g , let be $M(i; g) = \{i \in N : g_{ij} = 1 \text{ at least for one } j \in N, j \neq i\}$ and $L(i; g) = \{i \in N : g_{ij} = 0 \forall j \in N\}$. Give the chance to revise only to agents $i \in M$. After each revision $|M|$ decreases or does not change while $|L|$ increases or does not change. Therefore the system goes in a state where M is empty (g^e) or in a state where $|M|$ and $|L|$ do not change. In this last case $\forall i \in M$ obtains a positive net payoff from her (link) strategy and if $|M| \geq 2$ all agents $i \in M$ are in the same component. Suppose more than 1 component; each agent in one given component can add to its current links the links supported by any player in another component and, by doing so, obtains an additional payoff. We note as g^e never is an equilibrium for $k < I$. In this state agents with the chance to revise choose the action randomly and when happen that one chooses action \mathbf{a} , all revising agents will have as best response to choose action \mathbf{a} and to be tied in an unique \mathbf{a} -group (connected network). On the contrary, when $k > I$ g^e is an equilibrium. QED.

Proof of lemma 2.

Suppose that in a generic state there are 2 agents indirectly linked through $l+1$ links. Then, one of two agents can improve her payoff forming a direct link with the other agent given that $e^{l+1} < e - k$. QED.

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

<http://www.feem.it/Feem/Pub/Publications/WPapers/default.html>

<http://www.ssrn.com/link/feem.html>

<http://www.repec.org>

NOTE DI LAVORO PUBLISHED IN 2004

IEM	1.2004	Anil MARKANDYA, Suzette PEDROSO and Alexander GOLUB: <u>Empirical Analysis of National Income and So2 Emissions in Selected European Countries</u>
ETA	2.2004	Masahisa FUJITA and Shlomo WEBER: <u>Strategic Immigration Policies and Welfare in Heterogeneous Countries</u>
PRA	3.2004	Adolfo DI CARLUCCIO, Giovanni FERRI, Cecilia FRALE and Ottavio RICCHI: <u>Do Privatizations Boost Household Shareholding? Evidence from Italy</u>
ETA	4.2004	Victor GINSBURGH and Shlomo WEBER: <u>Languages Disenfranchisement in the European Union</u>
ETA	5.2004	Romano PIRAS: <u>Growth, Congestion of Public Goods, and Second-Best Optimal Policy</u>
CCMP	6.2004	Herman R.J. VOLLEBERGH: <u>Lessons from the Polder: Is Dutch CO2-Taxation Optimal</u>
PRA	7.2004	Sandro BRUSCO, Giuseppe LOPOMO and S. VISWANATHAN (lxv): <u>Merger Mechanisms</u>
PRA	8.2004	Wolfgang AUSENNEGG, Pegaret PICHLER and Alex STOMPER (lxv): <u>IPO Pricing with Bookbuilding, and a When-Issued Market</u>
PRA	9.2004	Pegaret PICHLER and Alex STOMPER (lxv): <u>Primary Market Design: Direct Mechanisms and Markets</u>
PRA	10.2004	Florian ENGLMAIER, Pablo GUILLEN, Loreto LLORENTE, Sander ONDERSTAL and Rupert SAUSGRUBER (lxv): <u>The Chopstick Auction: A Study of the Exposure Problem in Multi-Unit Auctions</u>
PRA	11.2004	Bjarne BRENDSTRUP and Harry J. PAARSCH (lxv): <u>Nonparametric Identification and Estimation of Multi-Unit, Sequential, Oral, Ascending-Price Auctions With Asymmetric Bidders</u>
PRA	12.2004	Ohad KADAN (lxv): <u>Equilibrium in the Two Player, k-Double Auction with Affiliated Private Values</u>
PRA	13.2004	Maarten C.W. JANSSEN (lxv): <u>Auctions as Coordination Devices</u>
PRA	14.2004	Gadi FIBICH, Arie GAVIOUS and Aner SELA (lxv): <u>All-Pay Auctions with Weakly Risk-Averse Buyers</u>
PRA	15.2004	Orly SADE, Charles SCHNITZLEIN and Jaime F. ZENDER (lxv): <u>Competition and Cooperation in Divisible Good Auctions: An Experimental Examination</u>
PRA	16.2004	Marta STRYSZOWSKA (lxv): <u>Late and Multiple Bidding in Competing Second Price Internet Auctions</u>
CCMP	17.2004	Slim Ben YOUSSEF: <u>R&D in Cleaner Technology and International Trade</u>
NRM	18.2004	Angelo ANTOCI, Simone BORGHESI and Paolo RUSSU (lxvi): <u>Biodiversity and Economic Growth: Stabilization Versus Preservation of the Ecological Dynamics</u>
SIEV	19.2004	Anna ALBERINI, Paolo ROSATO, Alberto LONGO and Valentina ZANATTA: <u>Information and Willingness to Pay in a Contingent Valuation Study: The Value of S. Erasmo in the Lagoon of Venice</u>
NRM	20.2004	Guido CANDELA and Roberto CELLINI (lxvii): <u>Investment in Tourism Market: A Dynamic Model of Differentiated Oligopoly</u>
NRM	21.2004	Jacqueline M. HAMILTON (lxvii): <u>Climate and the Destination Choice of German Tourists</u>
NRM	22.2004	Javier Rey-MAQUIEIRA PALMER, Javier LOZANO IBÁÑEZ and Carlos Mario GÓMEZ GÓMEZ (lxvii): <u>Land, Environmental Externalities and Tourism Development</u>
NRM	23.2004	Pius ODUNGA and Henk FOLMER (lxvii): <u>Profiling Tourists for Balanced Utilization of Tourism-Based Resources in Kenya</u>
NRM	24.2004	Jean-Jacques NOWAK, Mondher SAHLI and Pasquale M. SGRO (lxvii): <u>Tourism, Trade and Domestic Welfare</u>
NRM	25.2004	Riaz SHAREEF (lxvii): <u>Country Risk Ratings of Small Island Tourism Economies</u>
NRM	26.2004	Juan Luis EUGENIO-MARTÍN, Noelia MARTÍN MORALES and Riccardo SCARPA (lxvii): <u>Tourism and Economic Growth in Latin American Countries: A Panel Data Approach</u>
NRM	27.2004	Raúl Hernández MARTÍN (lxvii): <u>Impact of Tourism Consumption on GDP. The Role of Imports</u>
CSRM	28.2004	Nicoletta FERRO: <u>Cross-Country Ethical Dilemmas in Business: A Descriptive Framework</u>
NRM	29.2004	Marian WEBER (lxvi): <u>Assessing the Effectiveness of Tradable Landuse Rights for Biodiversity Conservation: an Application to Canada's Boreal Mixedwood Forest</u>
NRM	30.2004	Trond BJORN DAL, Phoebe KOUNDOURI and Sean PASCOE (lxvi): <u>Output Substitution in Multi-Species Trawl Fisheries: Implications for Quota Setting</u>
CCMP	31.2004	Marzio GALEOTTI, Alessandra GORIA, Paolo MOMBRINI and Evi SPANTIDAKI: <u>Weather Impacts on Natural, Social and Economic Systems (WISE) Part I: Sectoral Analysis of Climate Impacts in Italy</u>
CCMP	32.2004	Marzio GALEOTTI, Alessandra GORIA, Paolo MOMBRINI and Evi SPANTIDAKI: <u>Weather Impacts on Natural, Social and Economic Systems (WISE) Part II: Individual Perception of Climate Extremes in Italy</u>
CTN	33.2004	Wilson PEREZ: <u>Divide and Conquer: Noisy Communication in Networks, Power, and Wealth Distribution</u>
KTHC	34.2004	Gianmarco I.P. OTTAVIANO and Giovanni PERI (lxviii): <u>The Economic Value of Cultural Diversity: Evidence from US Cities</u>
KTHC	35.2004	Linda CHAIB (lxviii): <u>Immigration and Local Urban Participatory Democracy: A Boston-Paris Comparison</u>

KTHC	36.2004	<i>Franca ECKERT COEN and Claudio ROSSI</i> (lxviii): <u>Foreigners, Immigrants, Host Cities: The Policies of Multi-Ethnicity in Rome. Reading Governance in a Local Context</u>
KTHC	37.2004	<i>Kristine CRANE</i> (lxviii): <u>Governing Migration: Immigrant Groups' Strategies in Three Italian Cities – Rome, Naples and Bari</u>
KTHC	38.2004	<i>Kiflemariam HAMDE</i> (lxviii): <u>Mind in Africa, Body in Europe: The Struggle for Maintaining and Transforming Cultural Identity - A Note from the Experience of Eritrean Immigrants in Stockholm</u>
ETA	39.2004	<i>Alberto CAVALIERE</i> : <u>Price Competition with Information Disparities in a Vertically Differentiated Duopoly</u>
PRA	40.2004	<i>Andrea BIGANO and Stef PROOST</i> : <u>The Opening of the European Electricity Market and Environmental Policy: Does the Degree of Competition Matter?</u>
CCMP	41.2004	<i>Micheal FINUS</i> (lxix): <u>International Cooperation to Resolve International Pollution Problems</u>
KTHC	42.2004	<i>Francesco CRESPI</i> : <u>Notes on the Determinants of Innovation: A Multi-Perspective Analysis</u>
CTN	43.2004	<i>Sergio CURRARINI and Marco MARINI</i> : <u>Coalition Formation in Games without Synergies</u>
CTN	44.2004	<i>Marc ESCRIHUELA-VILLAR</i> : <u>Cartel Sustainability and Cartel Stability</u>
NRM	45.2004	<i>Sebastian BERVOETS and Nicolas GRAVEL</i> (lxvi): <u>Appraising Diversity with an Ordinal Notion of Similarity: An Axiomatic Approach</u>
NRM	46.2004	<i>Signe ANTHON and Bo JELLES MARK THORSEN</i> (lxvi): <u>Optimal Afforestation Contracts with Asymmetric Information on Private Environmental Benefits</u>
NRM	47.2004	<i>John MBURU</i> (lxvi): <u>Wildlife Conservation and Management in Kenya: Towards a Co-management Approach</u>
NRM	48.2004	<i>Ekin BIROL, Ágnes GYÓVAI and Melinda SMALE</i> (lxvi): <u>Using a Choice Experiment to Value Agricultural Biodiversity on Hungarian Small Farms: Agri-Environmental Policies in a Transition al Economy</u>
CCMP	49.2004	<i>Gernot KLEPPER and Sonja PETERSON</i> : <u>The EU Emissions Trading Scheme. Allowance Prices, Trade Flows, Competitiveness Effects</u>
GG	50.2004	<i>Scott BARRETT and Michael HOEL</i> : <u>Optimal Disease Eradication</u>
CTN	51.2004	<i>Dinko DIMITROV, Peter BORM, Ruud HENDRICKX and Shao CHIN SUNG</i> : <u>Simple Priorities and Core Stability in Hedonic Games</u>
SIEV	52.2004	<i>Francesco RICCI</i> : <u>Channels of Transmission of Environmental Policy to Economic Growth: A Survey of the Theory</u>
SIEV	53.2004	<i>Anna ALBERINI, Maureen CROPPER, Alan KRUPNICK and Nathalie B. SIMON</i> : <u>Willingness to Pay for Mortality Risk Reductions: Does Latency Matter?</u>
NRM	54.2004	<i>Ingo BRÄUER and Rainer MARGGRAF</i> (lxvi): <u>Valuation of Ecosystem Services Provided by Biodiversity Conservation: An Integrated Hydrological and Economic Model to Value the Enhanced Nitrogen Retention in Renaturated Streams</u>
NRM	55.2004	<i>Timo GOESCHL and Tun LIN</i> (lxvi): <u>Biodiversity Conservation on Private Lands: Information Problems and Regulatory Choices</u>
NRM	56.2004	<i>Tom DEDEURWAERDERE</i> (lxvi): <u>Bioprospection: From the Economics of Contracts to Reflexive Governance</u>
CCMP	57.2004	<i>Katrin REHDANZ and David MADDISON</i> : <u>The Amenity Value of Climate to German Households</u>
CCMP	58.2004	<i>Koen SMEKENS and Bob VAN DER ZWAAN</i> : <u>Environmental Externalities of Geological Carbon Sequestration Effects on Energy Scenarios</u>
NRM	59.2004	<i>Valentina BOSETTI, Mariaester CASSINELLI and Alessandro LANZA</i> (lxvii): <u>Using Data Envelopment Analysis to Evaluate Environmentally Conscious Tourism Management</u>
NRM	60.2004	<i>Timo GOESCHL and Danilo CAMARGO IGLIORI</i> (lxvi): <u>Property Rights Conservation and Development: An Analysis of Extractive Reserves in the Brazilian Amazon</u>
CCMP	61.2004	<i>Barbara BUCHNER and Carlo CARRARO</i> : <u>Economic and Environmental Effectiveness of a Technology-based Climate Protocol</u>
NRM	62.2004	<i>Elissaios PAPYRAKIS and Reyer GERLAGH</i> : <u>Resource-Abundance and Economic Growth in the U.S.</u>
NRM	63.2004	<i>Györgyi BELA, György PATAKI, Melinda SMALE and Mariann HAJDÚ</i> (lxvi): <u>Conserving Crop Genetic Resources on Smallholder Farms in Hungary: Institutional Analysis</u>
NRM	64.2004	<i>E.C.M. RUIJGROK and E.E.M. NILLESEN</i> (lxvi): <u>The Socio-Economic Value of Natural Riverbanks in the Netherlands</u>
NRM	65.2004	<i>E.C.M. RUIJGROK</i> (lxvi): <u>Reducing Acidification: The Benefits of Increased Nature Quality. Investigating the Possibilities of the Contingent Valuation Method</u>
ETA	66.2004	<i>Giannis VARDAS and Anastasios XEPAPADEAS</i> : <u>Uncertainty Aversion, Robust Control and Asset Holdings</u>
GG	67.2004	<i>Anastasios XEPAPADEAS and Constadina PASSA</i> : <u>Participation in and Compliance with Public Voluntary Environmental Programs: An Evolutionary Approach</u>
GG	68.2004	<i>Michael FINUS</i> : <u>Modesty Pays: Sometimes!</u>
NRM	69.2004	<i>Trond BJØRNDAL and Ana BRASÃO</i> : <u>The Northern Atlantic Bluefin Tuna Fisheries: Management and Policy Implications</u>
CTN	70.2004	<i>Alejandro CAPARRÓS, Abdelhakim HAMMOUDI and Tarik TAZDAÏT</i> : <u>On Coalition Formation with Heterogeneous Agents</u>
IEM	71.2004	<i>Massimo GIOVANNINI, Margherita GRASSO, Alessandro LANZA and Matteo MANERA</i> : <u>Conditional Correlations in the Returns on Oil Companies Stock Prices and Their Determinants</u>
IEM	72.2004	<i>Alessandro LANZA, Matteo MANERA and Michael MCALEER</i> : <u>Modelling Dynamic Conditional Correlations in WTI Oil Forward and Futures Returns</u>
SIEV	73.2004	<i>Margarita GENIUS and Elisabetta STRAZZERA</i> : <u>The Copula Approach to Sample Selection Modelling: An Application to the Recreational Value of Forests</u>

CCMP	74.2004	<i>Rob DELLINK and Ekko van IERLAND</i> : <u>Pollution Abatement in the Netherlands: A Dynamic Applied General Equilibrium Assessment</u>
ETA	75.2004	<i>Rosella LEVAGGI and Michele MORETTO</i> : <u>Investment in Hospital Care Technology under Different Purchasing Rules: A Real Option Approach</u>
CTN	76.2004	<i>Salvador BARBERÀ and Matthew O. JACKSON (lxx)</i> : <u>On the Weights of Nations: Assigning Voting Weights in a Heterogeneous Union</u>
CTN	77.2004	<i>Àlex ARENAS, Antonio CABRALES, Albert DÍAZ-GUILERA, Roger GUIMERÀ and Fernando VEGA-REDONDO (lxx)</i> : <u>Optimal Information Transmission in Organizations: Search and Congestion</u>
CTN	78.2004	<i>Francis BLOCH and Armando GOMES (lxx)</i> : <u>Contracting with Externalities and Outside Options</u>
CTN	79.2004	<i>Rabah AMIR, Effrosyni DIAMANTOUDI and Licun XUE (lxx)</i> : <u>Merger Performance under Uncertain Efficiency Gains</u>
CTN	80.2004	<i>Francis BLOCH and Matthew O. JACKSON (lxx)</i> : <u>The Formation of Networks with Transfers among Players</u>
CTN	81.2004	<i>Daniel DIERMEIER, Hülya ERASLAN and Antonio MERLO (lxx)</i> : <u>Bicameralism and Government Formation</u>
CTN	82.2004	<i>Rod GARRATT, James E. PARCO, Cheng-ZHONG QIN and Amnon RAPOPORT (lxx)</i> : <u>Potential Maximization and Coalition Government Formation</u>
CTN	83.2004	<i>Kfir ELIAZ, Debraj RAY and Ronny RAZIN (lxx)</i> : <u>Group Decision-Making in the Shadow of Disagreement</u>
CTN	84.2004	<i>Sanjeev GOYAL, Marco van der LEIJ and José Luis MORAGA-GONZÁLEZ (lxx)</i> : <u>Economics: An Emerging Small World?</u>
CTN	85.2004	<i>Edward CARTWRIGHT (lxx)</i> : <u>Learning to Play Approximate Nash Equilibria in Games with Many Players</u>
IEM	86.2004	<i>Finn R. FØRSUND and Michael HOEL</i> : <u>Properties of a Non-Competitive Electricity Market Dominated by Hydroelectric Power</u>
KTHC	87.2004	<i>Elissaios PAPYRAKIS and Reyer GERLAGH</i> : <u>Natural Resources, Investment and Long-Term Income</u>
CCMP	88.2004	<i>Marzio GALEOTTI and Claudia KEMFERT</i> : <u>Interactions between Climate and Trade Policies: A Survey</u>
IEM	89.2004	<i>A. MARKANDYA, S. PEDROSO and D. STREIMIKIENE</i> : <u>Energy Efficiency in Transition Economies: Is There Convergence Towards the EU Average?</u>
GG	90.2004	<i>Rolf GOLOMBEK and Michael HOEL</i> : <u>Climate Agreements and Technology Policy</u>
PRA	91.2004	<i>Sergei IZMALKOV (lxxv)</i> : <u>Multi-Unit Open Ascending Price Efficient Auction</u>
KTHC	92.2004	<i>Gianmarco I.P. OTTAVIANO and Giovanni PERI</i> : <u>Cities and Cultures</u>
KTHC	93.2004	<i>Massimo DEL GATTO</i> : <u>Agglomeration, Integration, and Territorial Authority Scale in a System of Trading Cities. Centralisation versus devolution</u>
CCMP	94.2004	<i>Pierre-André JOUVET, Philippe MICHEL and Gilles ROTILLON</i> : <u>Equilibrium with a Market of Permits</u>
CCMP	95.2004	<i>Bob van der ZWAAN and Reyer GERLAGH</i> : <u>Climate Uncertainty and the Necessity to Transform Global Energy Supply</u>
CCMP	96.2004	<i>Francesco BOSELLO, Marco LAZZARIN, Roberto ROSON and Richard S.J. TOL</i> : <u>Economy-Wide Estimates of the Implications of Climate Change: Sea Level Rise</u>
CTN	97.2004	<i>Gustavo BERGANTIÑOS and Juan J. VIDAL-PUGA</i> : <u>Defining Rules in Cost Spanning Tree Problems Through the Canonical Form</u>
CTN	98.2004	<i>Siddhartha BANDYOPADHYAY and Mandar OAK</i> : <u>Party Formation and Coalitional Bargaining in a Model of Proportional Representation</u>
GG	99.2004	<i>Hans-Peter WEIKARD, Michael FINUS and Juan-Carlos ALTAMIRANO-CABRERA</i> : <u>The Impact of Surplus Sharing on the Stability of International Climate Agreements</u>
SIEV	100.2004	<i>Chiara M. TRAVISI and Peter NIJKAMP</i> : <u>Willingness to Pay for Agricultural Environmental Safety: Evidence from a Survey of Milan, Italy, Residents</u>
SIEV	101.2004	<i>Chiara M. TRAVISI, Raymond J. G. M. FLORAX and Peter NIJKAMP</i> : <u>A Meta-Analysis of the Willingness to Pay for Reductions in Pesticide Risk Exposure</u>
NRM	102.2004	<i>Valentina BOSETTI and David TOMBERLIN</i> : <u>Real Options Analysis of Fishing Fleet Dynamics: A Test</u>
CCMP	103.2004	<i>Alessandra GORIA e Gretel GAMBARELLI</i> : <u>Economic Evaluation of Climate Change Impacts and Adaptability in Italy</u>
PRA	104.2004	<i>Massimo FLORIO and Mara GRASSEN</i> : <u>The Missing Shock: The Macroeconomic Impact of British Privatisation</u>
PRA	105.2004	<i>John BENNETT, Saul ESTRIN, James MAW and Giovanni URG</i> : <u>Privatisation Methods and Economic Growth in Transition Economies</u>
PRA	106.2004	<i>Kira BÖRNER</i> : <u>The Political Economy of Privatization: Why Do Governments Want Reforms?</u>
PRA	107.2004	<i>Pehr-Johan NORBÄCK and Lars PERSSON</i> : <u>Privatization and Restructuring in Concentrated Markets</u>
SIEV	108.2004	<i>Angela GRANZOTTO, Fabio PRANOVI, Simone LIBRALATO, Patrizia TORRICELLI and Danilo MAINARDI</i> : <u>Comparison between Artisanal Fishery and Manila Clam Harvesting in the Venice Lagoon by Using Ecosystem Indicators: An Ecological Economics Perspective</u>
CTN	109.2004	<i>Somdeb LAHIRI</i> : <u>The Cooperative Theory of Two Sided Matching Problems: A Re-examination of Some Results</u>
NRM	110.2004	<i>Giuseppe DI VITA</i> : <u>Natural Resources Dynamics: Another Look</u>
SIEV	111.2004	<i>Anna ALBERINI, Alistair HUNT and Anil MARKANDYA</i> : <u>Willingness to Pay to Reduce Mortality Risks: Evidence from a Three-Country Contingent Valuation Study</u>
KTHC	112.2004	<i>Valeria PAPPONETTI and Dino PINELLI</i> : <u>Scientific Advice to Public Policy-Making</u>
SIEV	113.2004	<i>Paulo A.L.D. NUNES and Laura ONOFRI</i> : <u>The Economics of Warm Glow: A Note on Consumer's Behavior and Public Policy Implications</u>
IEM	114.2004	<i>Patrick CAYRADE</i> : <u>Investments in Gas Pipelines and Liquefied Natural Gas Infrastructure What is the Impact on the Security of Supply?</u>
IEM	115.2004	<i>Valeria COSTANTINI and Francesco GRACCEVA</i> : <u>Oil Security. Short- and Long-Term Policies</u>

ITEM	116.2004	<i>Valeria COSTANTINI and Francesco GRACCEVA: <u>Social Costs of Energy Disruptions</u></i>
ITEM	117.2004	<i>Christian EGENHOFER, Kyriakos GIALOGLOU, Giacomo LUCIANI, Maroeska BOOTS, Martin SCHEEPERS, Valeria COSTANTINI, Francesco GRACCEVA, Anil MARKANDYA and Giorgio VICINI: <u>Market-Based Options for Security of Energy Supply</u></i>
ITEM	118.2004	<i>David FISK: <u>Transport Energy Security. The Unseen Risk?</u></i>
ITEM	119.2004	<i>Giacomo LUCIANI: <u>Security of Supply for Natural Gas Markets. What is it and What is it not?</u></i>
ITEM	120.2004	<i>L.J. de VRIES and R.A. HAKVOORT: <u>The Question of Generation Adequacy in Liberalised Electricity Markets</u></i>
KTHC	121.2004	<i>Alberto PETRUCCI: <u>Asset Accumulation, Fertility Choice and Nondegenerate Dynamics in a Small Open Economy</u></i>
NRM	122.2004	<i>Carlo GIUPPONI, Jaroslav MYSLAK and Anita FASSIO: <u>An Integrated Assessment Framework for Water Resources Management: A DSS Tool and a Pilot Study Application</u></i>
NRM	123.2004	<i>Margaretha BREIL, Anita FASSIO, Carlo GIUPPONI and Paolo ROSATO: <u>Evaluation of Urban Improvement on the Islands of the Venice Lagoon: A Spatially-Distributed Hedonic-Hierarchical Approach</u></i>
ETA	124.2004	<i>Paul MENSINK: <u>Instant Efficient Pollution Abatement Under Non-Linear Taxation and Asymmetric Information: The Differential Tax Revisited</u></i>
NRM	125.2004	<i>Mauro FABIANO, Gabriella CAMARSA, Rosanna DURSI, Roberta IVALDI, Valentina MARIN and Francesca PALMISANI: <u>Integrated Environmental Study for Beach Management: A Methodological Approach</u></i>
PRA	126.2004	<i>Irena GROSFELD and Iraj HASHI: <u>The Emergence of Large Shareholders in Mass Privatized Firms: Evidence from Poland and the Czech Republic</u></i>
CCMP	127.2004	<i>Maria BERRITTELLA, Andrea BIGANO, Roberto ROSON and Richard S.J. TOL: <u>A General Equilibrium Analysis of Climate Change Impacts on Tourism</u></i>
CCMP	128.2004	<i>Reyer GERLAGH: <u>A Climate-Change Policy Induced Shift from Innovations in Energy Production to Energy Savings</u></i>
NRM	129.2004	<i>Elissaios PAPYRAKIS and Reyner GERLAGH: <u>Natural Resources, Innovation, and Growth</u></i>
PRA	130.2004	<i>Bernardo BORTOLOTTI and Mara FACCIO: <u>Reluctant Privatization</u></i>
SIEV	131.2004	<i>Riccardo SCARPA and Mara THIENE: <u>Destination Choice Models for Rock Climbing in the Northeast Alps: A Latent-Class Approach Based on Intensity of Participation</u></i>
SIEV	132.2004	<i>Riccardo SCARPA Kenneth G. WILLIS and Melinda ACUTT: <u>Comparing Individual-Specific Benefit Estimates for Public Goods: Finite Versus Continuous Mixing in Logit Models</u></i>
ITEM	133.2004	<i>Santiago J. RUBIO: <u>On Capturing Oil Rents with a National Excise Tax Revisited</u></i>
ETA	134.2004	<i>Ascensión ANDINA DÍAZ: <u>Political Competition when Media Create Candidates' Charisma</u></i>
SIEV	135.2004	<i>Anna ALBERINI: <u>Robustness of VSL Values from Contingent Valuation Surveys</u></i>
CCMP	136.2004	<i>Gernot KLEPPER and Sonja PETERSON: <u>Marginal Abatement Cost Curves in General Equilibrium: The Influence of World Energy Prices</u></i>
ETA	137.2004	<i>Herbert DAWID, Christophe DEISSENBERG and Pavel ŠEVČIK: <u>Cheap Talk, Gullibility, and Welfare in an Environmental Taxation Game</u></i>
CCMP	138.2004	<i>ZhongXiang ZHANG: <u>The World Bank's Prototype Carbon Fund and China</u></i>
CCMP	139.2004	<i>Reyer GERLAGH and Marjan W. HOFKES: <u>Time Profile of Climate Change Stabilization Policy</u></i>
NRM	140.2004	<i>Chiara D'ALPAOS and Michele MORETTO: <u>The Value of Flexibility in the Italian Water Service Sector: A Real Option Analysis</u></i>
PRA	141.2004	<i>Patrick BAJARI, Stephanie HOUGHTON and Steven TADELIS (lxxi): <u>Bidding for Incomplete Contracts</u></i>
PRA	142.2004	<i>Susan ATHEY, Jonathan LEVIN and Enrique SEIRA (lxxi): <u>Comparing Open and Sealed Bid Auctions: Theory and Evidence from Timber Auctions</u></i>
PRA	143.2004	<i>David GOLDREICH (lxxi): <u>Behavioral Biases of Dealers in U.S. Treasury Auctions</u></i>
PRA	144.2004	<i>Roberto BURGUET (lxxi): <u>Optimal Procurement Auction for a Buyer with Downward Sloping Demand: More Simple Economics</u></i>
PRA	145.2004	<i>Ali HORTACSU and Samita SAREEN (lxxi): <u>Order Flow and the Formation of Dealer Bids: An Analysis of Information and Strategic Behavior in the Government of Canada Securities Auctions</u></i>
PRA	146.2004	<i>Victor GINSBURGH, Patrick LEGROS and Nicolas SAHUGUET (lxxi): <u>How to Win Twice at an Auction. On the Incidence of Commissions in Auction Markets</u></i>
PRA	147.2004	<i>Claudio MEZZETTI, Aleksandar PEKEČ and Ilia TSETLIN (lxxi): <u>Sequential vs. Single-Round Uniform-Price Auctions</u></i>
PRA	148.2004	<i>John ASKER and Estelle CANTILLON (lxxi): <u>Equilibrium of Scoring Auctions</u></i>
PRA	149.2004	<i>Philip A. HAILE, Han HONG and Matthew SHUM (lxxi): <u>Nonparametric Tests for Common Values in First-Price Sealed-Bid Auctions</u></i>
PRA	150.2004	<i>François DEGEORGE, François DERRIEN and Kent L. WOMACK (lxxi): <u>Quid Pro Quo in IPOs: Why Bookbuilding is Dominating Auctions</u></i>
CCMP	151.2004	<i>Barbara BUCHNER and Silvia DALL'OLIO: <u>Russia: The Long Road to Ratification. Internal Institution and Pressure Groups in the Kyoto Protocol's Adoption Process</u></i>
CCMP	152.2004	<i>Carlo CARRARO and Marzio GALEOTTI: <u>Does Endogenous Technical Change Make a Difference in Climate Policy Analysis? A Robustness Exercise with the FEEM-RICE Model</u></i>
PRA	153.2004	<i>Alejandro M. MANELLI and Daniel R. VINCENT (lxxi): <u>Multidimensional Mechanism Design: Revenue Maximization and the Multiple-Good Monopoly</u></i>
ETA	154.2004	<i>Nicola ACOCELLA, Giovanni Di BARTOLOMEO and Wilfried PAUWELS: <u>Is there any Scope for Corporatism in Stabilization Policies?</u></i>
CTN	155.2004	<i>Johan EYCKMANS and Michael FINUS: <u>An Almost Ideal Sharing Scheme for Coalition Games with Externalities</u></i>
CCMP	156.2004	<i>Cesare DOSI and Michele MORETTO: <u>Environmental Innovation, War of Attrition and Investment Grants</u></i>

CCMP	157.2004	<i>Valentina BOSETTI, Marzio GALEOTTI and Alessandro LANZA: <u>How Consistent are Alternative Short-Term Climate Policies with Long-Term Goals?</u></i>
ETA	158.2004	<i>Y. Hossein FARZIN and Ken-Ichi AKAO: <u>Non-pecuniary Value of Employment and Individual Labor Supply</u></i>
ETA	159.2004	<i>William BROCK and Anastasios XEPAPADEAS: <u>Spatial Analysis: Development of Descriptive and Normative Methods with Applications to Economic-Ecological Modelling</u></i>
KTHC	160.2004	<i>Alberto PETRUCCI: <u>On the Incidence of a Tax on PureRent with Infinite Horizons</u></i>
IEM	161.2004	<i>Xavier LABANDEIRA, José M. LABEAGA and Miguel RODRÍGUEZ: <u>Microsimulating the Effects of Household Energy Price Changes in Spain</u></i>

NOTE DI LAVORO PUBLISHED IN 2005

CCMP	1.2005	<i>Stéphane HALLEGATTE: <u>Accounting for Extreme Events in the Economic Assessment of Climate Change</u></i>
CCMP	2.2005	<i>Qiang WU and Paulo Augusto NUNES: <u>Application of Technological Control Measures on Vehicle Pollution: A Cost-Benefit Analysis in China</u></i>
CCMP	3.2005	<i>Andrea BIGANO, Jacqueline M. HAMILTON, Maren LAU, Richard S.J. TOL and Yuan ZHOU: <u>A Global Database of Domestic and International Tourist Numbers at National and Subnational Level</u></i>
CCMP	4.2005	<i>Andrea BIGANO, Jacqueline M. HAMILTON and Richard S.J. TOL: <u>The Impact of Climate on Holiday Destination Choice</u></i>
ETA	5.2005	<i>Hubert KEMPF: <u>Is Inequality Harmful for the Environment in a Growing Economy?</u></i>
CCMP	6.2005	<i>Valentina BOSETTI, Carlo CARRARO and Marzio GALEOTTI: <u>The Dynamics of Carbon and Energy Intensity in a Model of Endogenous Technical Change</u></i>
IEM	7.2005	<i>David CALEF and Robert GOBLE: <u>The Allure of Technology: How France and California Promoted Electric Vehicles to Reduce Urban Air Pollution</u></i>
ETA	8.2005	<i>Lorenzo PELLEGRINI and Reyer GERLAGH: <u>An Empirical Contribution to the Debate on Corruption Democracy and Environmental Policy</u></i>
CCMP	9.2005	<i>Angelo ANTOCI: <u>Environmental Resources Depletion and Interplay Between Negative and Positive Externalities in a Growth Model</u></i>
CTN	10.2005	<i>Frédéric DEROLAN: <u>Cost-Reducing Alliances and Local Spillovers</u></i>
NRM	11.2005	<i>Francesco SINDICO: <u>The GMO Dispute before the WTO: Legal Implications for the Trade and Environment Debate</u></i>
KTHC	12.2005	<i>Carla MASSIDDA: <u>Estimating the New Keynesian Phillips Curve for Italian Manufacturing Sectors</u></i>
KTHC	13.2005	<i>Michele MORETTO and Gianpaolo ROSSINI: <u>Start-up Entry Strategies: Employer vs. Nonemployer firms</u></i>
PRCG	14.2005	<i>Clara GRAZIANO and Annalisa LUPORINI: <u>Ownership Concentration, Monitoring and Optimal Board Structure</u></i>
CSRM	15.2005	<i>Parashar KULKARNI: <u>Use of Ecolabels in Promoting Exports from Developing Countries to Developed Countries: Lessons from the Indian LeatherFootwear Industry</u></i>
KTHC	16.2005	<i>Adriana DI LIBERTO, Roberto MURA and Francesco PIGLIARU: <u>How to Measure the Unobservable: A Panel Technique for the Analysis of TFP Convergence</u></i>
KTHC	17.2005	<i>Alireza NAGHAVI: <u>Asymmetric Labor Markets, Southern Wages, and the Location of Firms</u></i>
KTHC	18.2005	<i>Alireza NAGHAVI: <u>Strategic Intellectual Property Rights Policy and North-South Technology Transfer</u></i>
KTHC	19.2005	<i>Mombert HOPPE: <u>Technology Transfer Through Trade</u></i>
PRCG	20.2005	<i>Roberto ROSON: <u>Platform Competition with Endogenous Multihoming</u></i>
CCMP	21.2005	<i>Barbara BUCHNER and Carlo CARRARO: <u>Regional and Sub-Global Climate Blocs. A Game Theoretic Perspective on Bottom-up Climate Regimes</u></i>
IEM	22.2005	<i>Fausto CAVALLARO: <u>An Integrated Multi-Criteria System to Assess Sustainable Energy Options: An Application of the Promethee Method</u></i>
CTN	23.2005	<i>Michael FINUS, Pierre v. MOUCHE and Bianca RUNDSHAGEN: <u>Uniqueness of Coalitional Equilibria</u></i>
IEM	24.2005	<i>Wietze LISE: <u>Decomposition of CO2 Emissions over 1980–2003 in Turkey</u></i>
CTN	25.2005	<i>Somdeb LAHIRI: <u>The Core of Directed Network Problems with Quotas</u></i>
SIEV	26.2005	<i>Susanne MENZEL and Riccardo SCARPA: <u>Protection Motivation Theory and Contingent Valuation: Perceived Realism, Threat and WTP Estimates for Biodiversity Protection</u></i>
NRM	27.2005	<i>Massimiliano MAZZANTI and Anna MONTINI: <u>The Determinants of Residential Water Demand Empirical Evidence for a Panel of Italian Municipalities</u></i>
CCMP	28.2005	<i>Laurent GILOTTE and Michel de LARA: <u>Precautionary Effect and Variations of the Value of Information</u></i>
NRM	29.2005	<i>Paul SARFO-MENSAH: <u>Exportation of Timber in Ghana: The Menace of Illegal Logging Operations</u></i>
CCMP	30.2005	<i>Andrea BIGANO, Alessandra GORIA, Jacqueline HAMILTON and Richard S.J. TOL: <u>The Effect of Climate Change and Extreme Weather Events on Tourism</u></i>
NRM	31.2005	<i>Maria Angeles GARCIA-VALIÑAS: <u>Decentralization and Environment: An Application to Water Policies</u></i>
NRM	32.2005	<i>Chiara D.ALPAOS, Cesare DOSI and Michele MORETTO: <u>Concession Length and Investment Timing Flexibility</u></i>
CCMP	33.2005	<i>Joseph HUBER: <u>Key Environmental Innovations</u></i>
CTN	34.2005	<i>Antoni CALVÓ-ARMENGOL and Rahmi İLKILIÇ(lxxii): <u>Pairwise-Stability and Nash Equilibria in Network Formation</u></i>
CTN	35.2005	<i>Francesco FERI (lxxii): <u>Network Formation with Endogenous Decay</u></i>

(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL), Venice, August 28-29, 2003

(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003

(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

(lxxi) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by Fondazione Eni Enrico Mattei and Consip and sponsored by the EU, Rome, September 23-25, 2004

(lxxii) This paper was presented at the 10th Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.

2004 SERIES

CCMP	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti)
GG	<i>Global Governance</i> (Editor: Carlo Carraro)
SIEV	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anna Alberini)
NRM	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
KTHC	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
IEM	<i>International Energy Markets</i> (Editor: Anil Markandya)
CSRM	<i>Corporate Social Responsibility and Sustainable Management</i> (Editor: Sabina Ratti)
PRA	<i>Privatisation, Regulation, Antitrust</i> (Editor: Bernardo Bortolotti)
ETA	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)
CTN	<i>Coalition Theory Network</i>

2005 SERIES

CCMP	<i>Climate Change Modelling and Policy</i> (Editor: Marzio Galeotti)
SIEV	<i>Sustainability Indicators and Environmental Valuation</i> (Editor: Anna Alberini)
NRM	<i>Natural Resources Management</i> (Editor: Carlo Giupponi)
KTHC	<i>Knowledge, Technology, Human Capital</i> (Editor: Gianmarco Ottaviano)
IEM	<i>International Energy Markets</i> (Editor: Anil Markandya)
CSRM	<i>Corporate Social Responsibility and Sustainable Management</i> (Editor: Sabina Ratti)
PRCG	<i>Privatisation Regulation Corporate Governance</i> (Editor: Bernardo Bortolotti)
ETA	<i>Economic Theory and Applications</i> (Editor: Carlo Carraro)
CTN	<i>Coalition Theory Network</i>