Globelics Academy 2008
Ph.D. School on National Systems of Innovation
and Economic Development

Factors that determine the impact of innovation policies in a sectoral innovation system in Colombia: A methodological approach from Applied Evolutionary Economics and Complex Systems

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Tampere, Finland
June 6th 2008

Outline

- The Motivation
- The Questions
- The Methodological Approach
  - The conceptual basis
  - The basics of the model
- Next steps

NIS and Productivity in Colombia

- In 1990 the National System of Science and Technology was formally created.
- In the mid 90's the idea of a National Innovation System was introduced as concept for articulating the elements of the System
- Nowadays, there are evidences of low growth levels in terms of productivity and productive diversification
- This suggest that the impact of the Colombian National Innovation System on economic competitiveness is still not significant
- System's capacities are still in their early stages

There is a need for revising Technical Change Policies

- Colombia undertook during the early 1990s a market-opening processes
- At that time, priority was given to transversal (or functional) policies on:
  - macro-economic and legal stability;
  - physical infrastructure;
  - the financial system;
  - ensuring free competition
- But functional policies, although necessary, were not sufficient to allow for improving firms' competitiveness
- Horizontal and sectoral (vertical) policies are also required. The experience in East Asian countries confirms this (Lall and Teubal, 1998).

The Importance of Micro-level Policies

- There is a need of an adequate and realistic understanding of firms' learning processes.
  - Firms have imperfect knowledge of the relevant options in front of them,
  - Tend to be myopic in searching for relevant information, suggestions, and solutions
  - They are entities with a "particular personality": they are idiosyncratic
- Then, vertical/sectoral policies must ensure the efficient access by firms and sectors to the specific factors that condition their capacities and performance.
- In sum, the public policy agenda for the promotion of innovation in firms should include a combination of functional, horizontal and vertical policies. (Lall and Teubal, 1998)

Market and Non-market Relationships: The need for coordination

- The market is not, in all cases, the most efficient way in which technological activity is organized and in which good practices and knowledge are distributed
- Non-market mechanisms play a crucial complementary role since:
  - Strategies involve not only economic but non-economic objectives (cooperation)
  - They allow for catalyzing market forces, by promoting “endogenization” of those activities necessary for diffusion of new organizational and management routines among firms
- And it requires a high degree of coordination with bureaucratic, professional and political components
- Then, firms' learning requires policy interventions, as there are failures in coordination

The Questions

- Which are the most important factors that, at micro-economical level, determine the impact of policies to promote innovation in a specific sector in Colombia

- What criteria, strategies and measures must be implemented as part of a public policy agenda, for effectively promoting a better performance by firms on the selected sector.

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The Systemic Nature of Innovation

- I focus, based on Teubal (2002), on three sub-systems of the innovation systems at a meso and micro levels:
  - the business sector (BS);
  - the supporting structure (SS): Government, financial and research institutions
  - the interactions and links: the connections
- The transformation of a system is cumulative and comprises the co-evolution of its elements in a circular causality process
- Changes in the system can take place through:
  - Learning processes within the elements of the system
  - Changes in its architecture, such as:
    - the incorporation of new elements, be the firms or institutions in the SS
    - the appearance of new connections.

The Importance of Connections within the Economic System(Potts, 2000)

- Concepts such as uncertainty, bounded rationality and incomplete information, from heterodox economics can be unified around the concept of “geometry of the economic space”.
- As opposed to the orthodox assumption, is not one of an integrated space, but rather one of a complex system
- Connections are incomplete and determine the structure and dynamics of the economic system.
- Institutions and actors change as much as connections change, provided that these generate new behaviors, routines and social structures. And vice versa.
- Knowledge creation and diffussion, information and coordination are closely associated to the geometry of the connections in the economic system.

The Complexity of Innovation Systems: In the search of new Analytical Representations

- Complexity: systems with multiple elements adapting and reacting to the patterns these elements create (Arthur, 2004)
- Complex systems arise naturally in the economy and can not be understood through reductionism of standard economics (Colander, 2004)
- Economic theory has not been especially successful at finding structural laws (ibid)
- Computer technology offers a means to gain for far more insight into complex systems of dynamic equations:
  - Does not provide analytic solutions but provide numerical ones by using “brute force”
  - Allows for the construction of Analytical Tools which can be connected with empirical research (Colander, 2004)

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The model by Grebel, Pyka and Hanusch (2004):

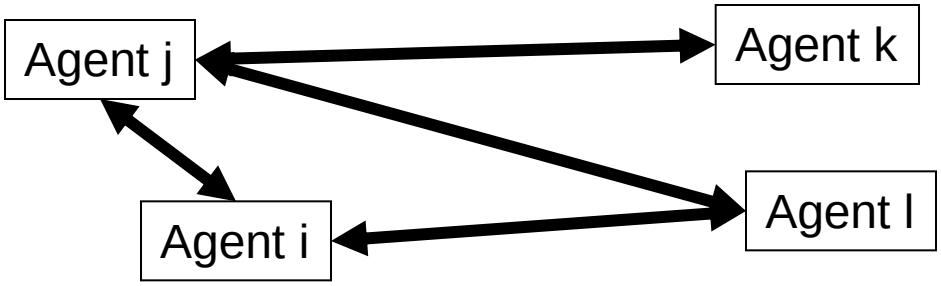
- An evolutionary approach to entrepreneurial behaviour that uses a computational simulation model
- Draw on an actor-centered perspective.
- Does not assume optimal behaviour, nor an equilibrium concept
- Its core elements:
  - The heterogeneity of actors and behaviours
  - Their bounded rational behaviour to make myopic decision (which may eventually lead to suboptimal outcomes)
  - The feedback effects from the micro- to the macro level and vice versa
  - The historicity of events

Objective

To model a specific sector for understanding its structure, patterns of change and historical evolution

- How firms compete, cooperate and co-evolve with other actors
- What factors determine its evolution: their capacities, strategies and interactions
- Which institutions govern the interaction between the agents: norms, routines, habits

A simplified view of an Economic System: Agents and Connections



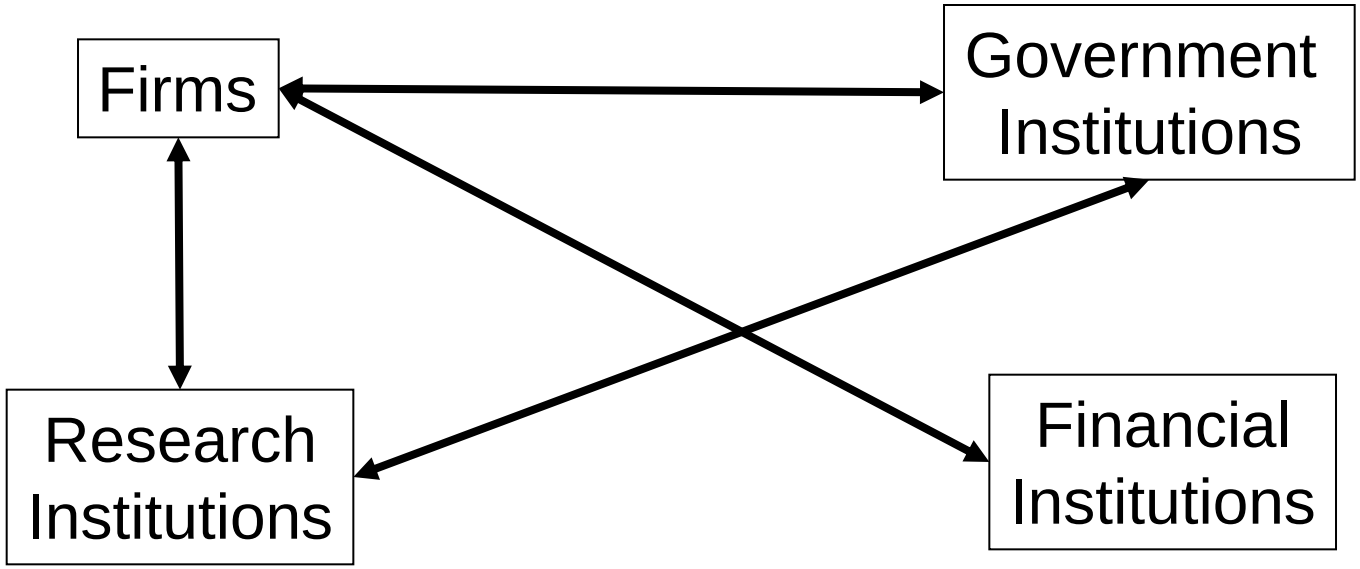
Agents

- In this case, for example: firms, consumers, banks, etc..
- They have attributes, associated with their capacities
- Attributes determine:
  - How agents make decisions
  - How external factors influence agents decisions
  - The agents' performance
- Attributes change in time

Connections

- Connections are incomplete among agents in a system
- Changes in connections may affect:
  - agents attributes and vice versa
  - As well as the architecture of the system
- Exist in the form of, v. gr.:
  - Contracts
  - Technology
  - Flows of information
  - Competition
  - Cooperation

The Elements of the Model



Firms

- Are heterogeneous and differ in their attributes
- Face uncertainty
- Make decisions on the basis of environmental factors such as economic and sectoral indicators, public policies and incentives (Feedback effects)

- Make alliances with other firms and actors (non-market relations)
- Compete (market relations)
- Firms attributes can be associated to
  - Organizational capacities
  - Human Capital
  - Innovation capacities
  - Interaction capacities
  - Financial Capital

$f_i^t = \{cf_{1i}^t, ..., cf_{ki}^t\}$ describes the firm *i* as having *k* attributes or characteristics in time *t*.

For example:

cf_1^t = organizational capacities

cf_2^t = human capital

cf_3^t = financial capital

Where cf_i^t, cf_2^t , cf_3^t are randomly created for the *n* firms of the system and uniformly created for the interval

$$F^t = \left\{ f_i^t \right\}_{i \in \{1,...n\}}$$

Government Institutions

- Comprise such government institutions devoted to promote directly firms' innovation capacities
- For the model:
  - Establish relation with firms and operators
  - Eventually with banks

- Their attributes could be associated to:
  - Public policies quality and scope
  - Financial resources to allocate
  - Coordination and networking capacities
  - Capacities for providing relevant public goods

$g_i^t = \{cg_{1i}^t, ..., cg_{li}^t\}$ describes the government institution *i* as having *l* attributes or characteristics in time *t*.

For example:

cg_1^t = Public policies quality and scope

cg_2^t = Human capital

cg_3^t = Coordination capacities

Where cg_1^t, cg_2^t, cg_3^t are randomly created for the *m* government institutions of the system and uniformly created for the interval

$$G^t = \left\{ g_i^t \right\}_{i \in \{1,...m\}}$$

Research Institutions

- In the case of Colombia are:
  - Research Centers
  - Technological Development Centers
  - Universities
  - Providers of Scientific and Technological Services

- The attributes can be associated with:
  - Human capital
  - Experience
  - Scientific and technological capacities
  - Interaction capacities

$r_i^t = \{cr_{1i}^t, ..., cr_{pi}^t\}$ describes the research institution *i* as having *p* attributes or characteristics in time *t*.

For example:

cr_1^t = Human capital qualifications

cr_2^t = Experience of its members

cr_3^t = Scientific and Technological Capacities

Where cr_1^t, cr_2^t, cr_3^t are randomly created for the *v* research institutions of the system and uniformly created for the interval

$$R^t = \{r_i^t\}_{i \in \{1,...v\}}$$

Financial Institutions

- Provide financial capital
- May be not only banks but capital markets

- Its attributes for the sake of the model:
  - Availability of capital
  - Quality of its financial products
  - Supporting clients capacities

$b_i^t = \{cb_{1i}^t, ..., cb_{qi}^t\}$ describes the operator *i* as having *q* attributes or characteristics in time *t*.

For example:

cb_1^t = Financial capital for innovation initiatives

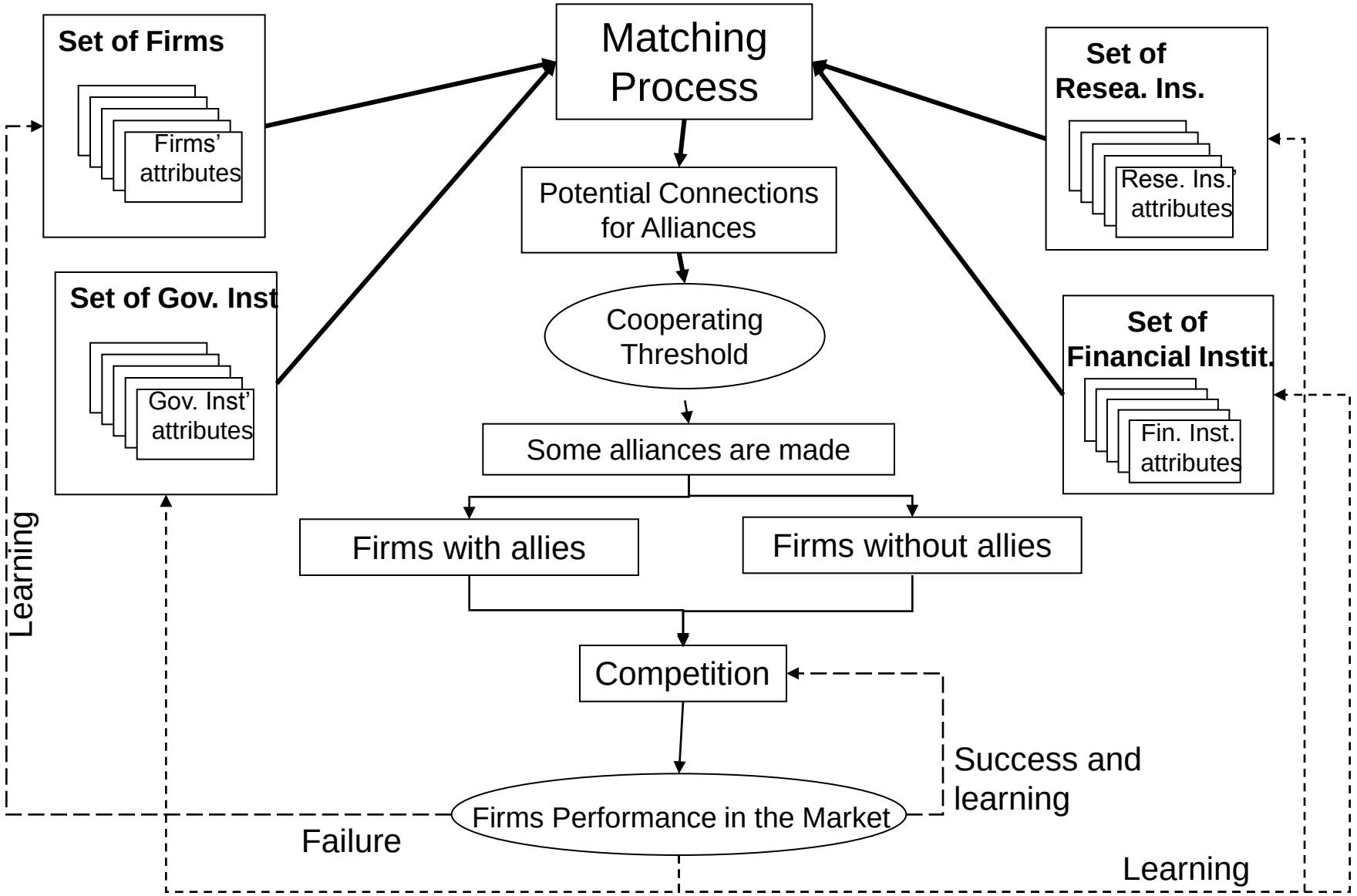
cb_2^t = Quality of its financial products

cb_3^t = Supporting clients' capacities

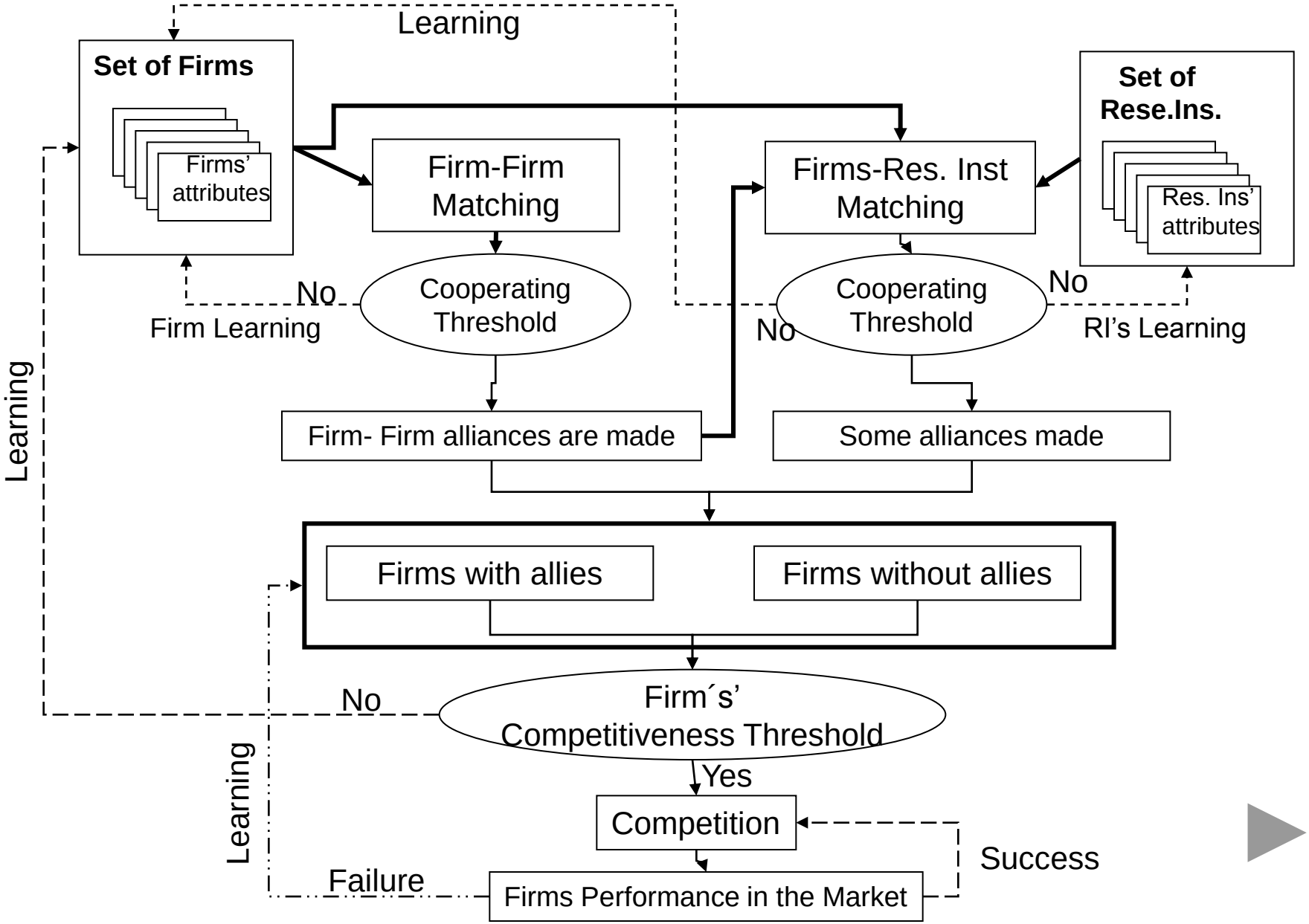
Where cb_1^t, cb_2^t, cb_3^t are randomly created for the *s* financial institutions of the system and uniformly created for the interval

$$B^t = \{b_i^t\}_{i \in \{1,...s\}}$$

The Basic Structure of the Model



The case for Firms-Research Inst. Alliances



The Matching Process

- For each iteration:
  - The population of agents, not yet connected, is permuted and a number of agents are randomly brought together.
  - The chances of making alliances are evaluated on the basis of specific attributes of each agent
  - That is, for each match, a function β , based on the information and analysis of the sector and the policy incentives, operates the attributes of the agents that have been brought together and calculates a value for the potential of creating an alliance
- For example, the potential of an alliance between two firms would be:

$$pa_q^{\,t} = \beta\left(f_i^{\,t}, f_j^{\,t}\right) \forall i \neq j$$

Where:

$q \in \{1,\ldots m\}$ denotes the specific potential alliance between firms

$f_i = \{cf_{1i},\ldots,cf_{ki}\}$ describes the firm i , that has k attributes or characteristics

And the set of potential alliances between firms at time t is:

$PA^t = \left\{pa_q^t\right\}_{q\in\{1,\ldots,m\}}$ m is the number of potential alliances between firms

The Cooperation Threshold

- For modelling reasons a Cooperation Threshold φ is introduced, a 'meso-macroeconomic signal' which, as a hypothesis, depends on:
  c_t = Level of competence on the sector at time *t*
  e_t = Economic indicators at time *t*
  i_t = Public policy incentives to create alliances at time *t*
- Continuing with the previous example of two firms

$$\varphi^t = \varphi(c^t, e^t, i^t)$$

The set of newly created alliances in period *t* is

$$A^t_{new} = \left\{ pa^t_q : pa^t_q > \varphi^t \right\} \text{ where } pa^t_q \in PA^t$$

Next Steps

- To decide which sector to model (availability of information). Probably de Agro-industry sector
- To determine and validate each agent's attributes and the probabilistic functions to be used in allocating attributes among the various agents' populations
- To formulate the functions for:
  - The matching process
  - The thresholds
- To model, based on stochastic tools, the competition process

Thanks