MOSIPS AGENT-BASED MODEL FOR PREDICTING AND SIMULATING THE IMPACT OF PUBLIC POLICIES ON SMES

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ABSTRACT

This paper presents MOSIPS (MOdel of Simulation of Impacts of Public Policies on SMEs), a multi-agent model of an open economy. It is part of a user-friendly object-oriented interactive intelligent policy simulation system allowing forecasting and visualizing the socio-economic potential impact of public policies for supporting SMEs. MOSIPS model specifies the characteristics of every agent, and its particular feature is that it locates agents in a spatial raster, using this information to precisely determine the interaction network. It represents the dynamic behaviour of people and enterprises, analysing their decisions and interactions in the social networks. It can be used to model macro-economic features of a system and permits focusing on a specific part of the economy, at sector and spatial level.

Keywords: agent-based model, prediction and simulation, policy evaluation

1. INTRODUCTION

Recently, agent-based models (ABM) have increased their importance in economics. In particular, the last financial crisis was not predicted by standard macroeconomic models. Due to several of their assumptions, they were not able to represent that significant deviation from the equilibrium growth path predicted. In contrast, if the approach is bottom-up, starting with the specification of the agents involved in the economy, it appears and emergent behaviour of the system which cannot be explained from the behaviour of the representative agent. This allows the appearance of bubbles, followed by a sharp reduction in prices and a lowering in expectations. Multi-agent models have been used to study economic systems in several ways: we can find examples of conceptual works on agent-based economic models, such as Tesfatsion and Judd (2006); a variety of agent-based models focused on a part of the economy, for example, leverage effects in financial markets (Farmer and Foley 2009). Multi-agent models of the economy as a whole are infrequent, examples are the models by Gintis (2006), Dosi et al. (2008), Madel et al. (2009) and the EURACE model (Dawid et al., 2011).

MOSIPS model includes a number of features of the previous referred models, but it represents the economy making the emphasis in Small and Medium Enterprises (SMEs) and the factors faced in their creation and growth. Thus, entrepreneurship and access to finance appears as two major issues. These enterprises choose their location not only optimizing the place, but taking into account the residence of the owner. This characteristic makes necessary to locate the entrepreneurs. Moreover, the demand SMEs face is determined by their location and their size, which conditions their visibility. SMEs' suppliers, workers and consumers tend to be near their location. Then, it is crucial to locate every agent in its real place to allow determining realistic interaction networks and the correct performance of every firm. For our purposes, in order to truthfully represent a local, regional or national economy, both firms and people should be placed with their individual characteristics. In addition, public administration, financial sector and the external sector are represented as well, as they interact with SMEs establishing policies, giving access to finance, competing with them or allow selling part of their production abroad.

What is described here is the abstract model. The description follows partially the agent-based model documentation guidelines developed at the 100th Dahlem Conference "New Approaches in Economics after the Financial Crisis" (Wolf et.al. 2011). As specified by these guidelines, the first part provides an overview (Section 2) and the second one explains general concepts underlying the model's design (Section 3). The fourth part provides the specification of data needing and its treatment, as it requires a much more complex process than the majority of macroeconomic models. Then, there is a description about the introduction of policies in the model. Finally, a brief conclusion looks at the further developments of the model and summarizes its major characteristics.

2. OVERVIEW

The rationale behind MOSIPS model (Figure 1) is closely related to the purpose of the project for which is designed: to develop a policy simulation system allowing forecasting and visualizing the socio-economic potential impact of public policies for supporting SMEs.

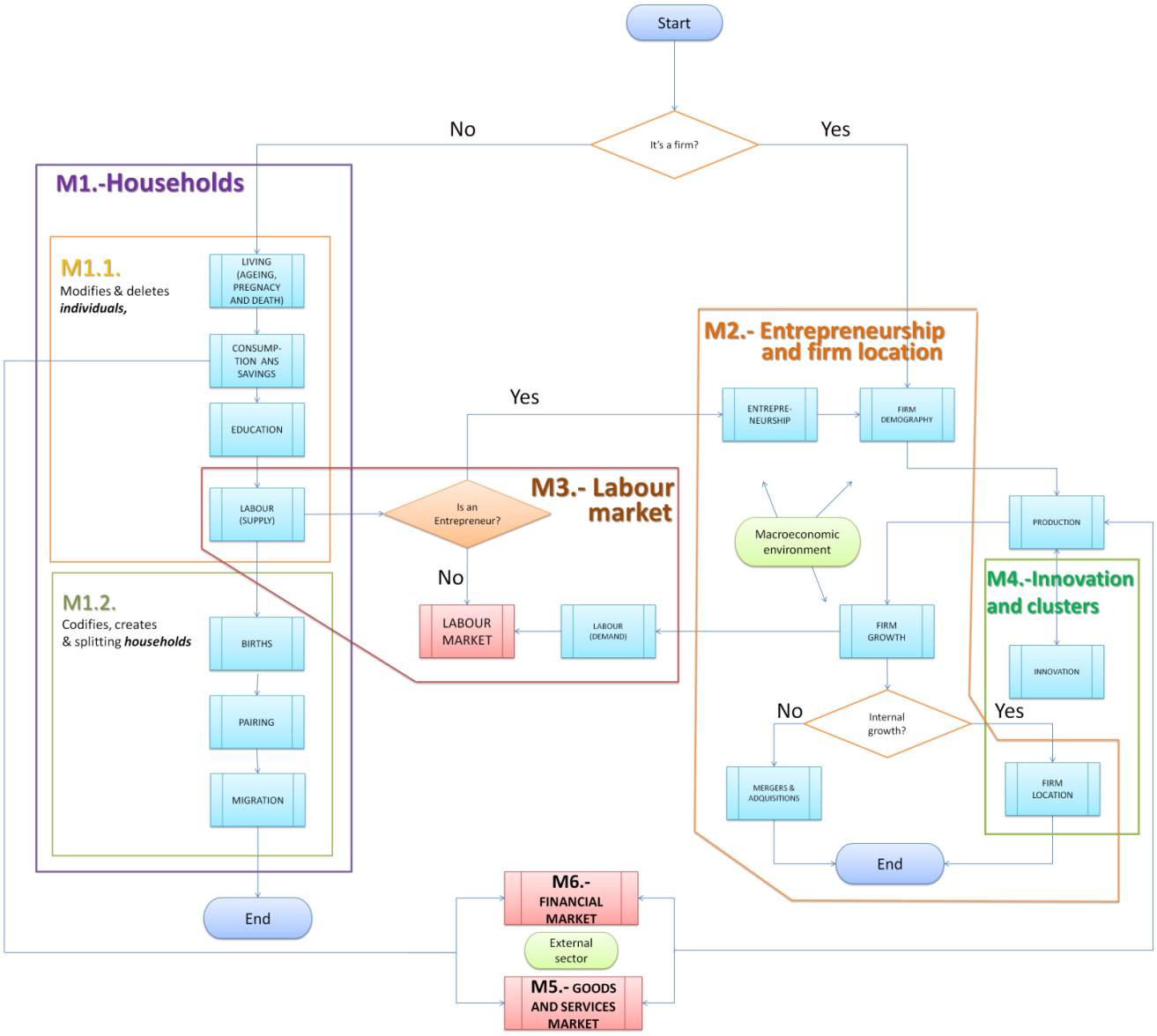

Figure 1: Diagram of modules included in MOSIPS model

2.1. Rationale

What is the object under consideration? What is the intended usage of the model? Which issues can be investigated?

MOSIPS model represents the dynamics of behaviour and decisions of agents, and their interactions. It forecasts the evolution of an economic system over a time horizon of one quarter to several years. It is based on a multi-agent approach at the micro-economic level. It can be used to model macro-economic features of a system and allow focusing in a specific part of the economy, at sector and spatial level, evaluating the effects of a policy over the firms and the individuals, depending on their initial characteristics. The concept of industrial district arises as a leading figure in which there are combined concepts such as localization and innovation, key for the performance of the different actors that are part of the socio-economic reality.

MOSIPS model provides the framework to test the accuracy of micro-foundations specified outside the scope of the representative agent paradigm reproducing a virtual reality to evaluate the effects of economic policy. The obtained results have a range of error due to the randomness of individual processes and the building of the database. This approach can be seen as an extension to Arrow-Debreu general equilibrium theory (Arrow and Debreu 1954), as the unique result computed by standard models is one of the possible outcomes: the optimal trajectory excluding part of the heterogeneity of the agents, and not having into account spatial issues with a sufficient degree of accuracy.

The object of study is a local economic system, disaggregated by branches, which represents the economic system under consideration. Then, the effects of a policy are studied both at sector and at spatial level.

These effects also can be observed according to other characteristics such as the size of the firms, their innovative behaviour or their financial situation. The effects of policies can also affect to the population, and they can also be studied taking into account their location or the individual characteristics

2.2. Agents

What kinds of agents are considered in the model? Is there a refined taxonomy of agents? Are there agent groupings which are considered relevant?

The model includes two basic types of agents: individuals-families and entrepreneurs-firms. These agents, by means of commercial or social mechanisms, interact among themselves and with other entities within their environment but which are external to the agents' identity and decisions.

MOSIPS concerns particularly these two types of agents and their scope from the moment that a part of individuals chooses to become entrepreneurs with the intention to start up a firm. While such a choice is clearly influenced by the decisions they have made previously (Stam et al. 2008, Nielsen and Sarasvathy 2011, Aldrich and Cliff 2003) (e.g., their type of education, family influence, or acceptance of a firm as inheritance), as well as by the environment created by other entities or markets (Ardagna and Lusardi 2010) (i.e., government regulations or rate of interest required on a loan to an entrepreneur), the analysis underscores the behaviours and decisions of 'entrepreneurs-firms' agents.

Partnerships among firms are also possible, so that sometimes groups or conglomerates of firms aiming at achieving common goals (for innovation or export activities for example) can be formed. Therefore, in the proposed model, groups of agents are or may be relevant (Roessl 2005; Street and Cameron 2007).

In addition, each 'firm' agent can be considered from the perspective of the 'individuals' agents comprising such firm, that is, from the different degrees of responsibility and the ability to make decisions that individuals belonging to a firm have. In this way, one can include workers, technicians, managers, directors, and owners. According to this view, which rests upon the theories on human resources and knowledge management as well as the agency problem or theory, each individual who is part of the firm takes initiatives based on simple, or sometimes complex, management options, which may even be opportunistic or contradictory to the objectives of the firm or the interests of the owner (Brunet and Alarcón 2004). These behaviours, dealt with individually (each member of the firm is an individual), would lead to a deepening or specialisation of the proposed model, which eventually would bring new ideas and approaches on firm development and growth in the territory analysed (with the information and data warehouse used), as well as any possible imbalances.

Every agent has the characteristics pointed by Wooldridge and Jennings (1995). They decide their characteristics autonomously trying to maximize their expected profits/utility. The communication among agents takes place by market prices and social networks. Agents react to the changes in their environment, but sometimes anticipate these changes in order to define their decisions, showing a proactive behaviour.

2.3. Other entities

What are the other entities which are time-evolving but not decision-making

In addition to these two basic types of agents, there appear other complementary entities for their activities involved to a higher or lesser extent in the modelling process but which are pivotal in the composition of agents. These entities do not make decisions directly in the process, but the evolution of their behaviours in time clearly impacts on the creation of the expectations and decisions of firms (and individuals). Specifically, these entities are the public sector, the financial system, and the local environment.

2.4. Boundaries

What are additional inputs to the model at runtime? Which outside influences on the model are hence represented?

The model faces a major constraint in its development: the existence and behaviour of the agents which comprise the external sector. Agents and institutions that compose it (companies, public administrations, households...) incorporate permanent or sequential new inputs to the model in its running time, interacting with businesses in the analysed territory. For example, in trade relations between import and export companies, decisions are produced on both sides, in the country and abroad. Often, in business practice are taken decisions on capital investment out of the country. However, such decisions are not fully considered in the model. In turn, these decisions are based on the behaviour of other agents or external entities that have their own behaviours and different rules (for example, labour legislation, taxation of companies, the price of industrial land, or the difference productivity in the tradable good or service).

These external effects modify the behaviour of agents in the area to be analysed and, therefore, may be measured at least indirectly or by a method of approximation. Then, all the consumers of the exported goods and services, and firms that produce the imports are considered as several entities (one for each economic region), and their behaviour is only predicted in an aggregate way making use of several macroeconomic indicators. For the purposes of international trade, the model uses international exchange rates, which express fairly accurately the

strengths and weaknesses of different economies, or what is the same level of competitiveness of domestic and foreign companies. Likewise, in the case of investment in the country by foreign companies, there are several difficulties in the determination of the behaviour of foreign agents not individually and explicitly modelled.

2.5. Relations

What kinds of relationships structure the agents' interactions? To which extent do these represent institutions?

The types of relationships that structure the interactions among agents are of a diverse nature. These are developed based on the various activities conducted by entrepreneurs and firms in their processes of recruitment and procurement of inputs, human resources management, production, innovation and technology management, product development, financial management, and marketing and sales strategy. Also influential are the possible strategies for growth and territorial expansion of investments (within or outside the territory). Individuals on themself or grouped in households have relations with other individuals and with firms resulting from their labour, consumption and investment activities.

In general, the market itself sets a 'virtual' kind of network relationships among firms in their pursuit of needs/opportunities for personnel, intermediate inputs, production equipment and technology, and sales niches, which are provided by the different types of markets (labour, goods and services…) (Coviello and Munro 1995; Slotte-Kock and Coviello 2010). But the general market also establishes the relationship of rivalry and competition between them. In sum, these are network relations that provide information for cooperation or competition as appropriate (Gulati 1999, Meyer et al. 2004).

Contractual relationships on the labour market are structured between individuals and firms. They are based on search processes, where firms in a context of imperfect information choose the best candidates and individuals offer their work to firms that provide the most attractive terms. In general, these relationships are normative since they are based on labour legislation.

2.6. Activities

What kind of actions and interactions are the agents engaged into?

Individuals are born into households where they grow, consume, pursue an education, and, eventually, die. Households may change their location and increase or decrease the number of their members. Upon reaching working age, individuals choose in each period whether to join the workforce and, if so, become employees or entrepreneurs. Job seekers offer their work to firms in their environment recruiting workers, which take the decision regarding who to hire. Individuals who choose to become entrepreneurs create firms and choose the location.

Firms produce and sell their products on the market. They also choose the cheapest and most reliable suppliers. Additionally, they change in terms of size through internal growth or by acquiring other firms, provided they have adequate funding. They can apply for funding from the financial system, based on their repayment capacity and on the financial market conditions. Further, firms decide the level of their commitment to innovation, both in terms of processes and products. They modify their workforce by hiring or laying off workers according to their labour skills or to production needs. Firms disappear if they go bankrupt or if the businessperson so chooses.

The public sector incorporates its rules and policies by modifying the attributes and behaviours of agents. Banks procure funds from agents with a funding capacity, and they provide funds to those who require them. The financial resources available for firms and households can differ from the level of savings of agents due to the financial flows with other countries and the circumstances of the financial system. The local environment includes aspects that affect the agents from a territorial perspective such as closeness from infrastructures, the existence of firm clusters, or congestion problems.

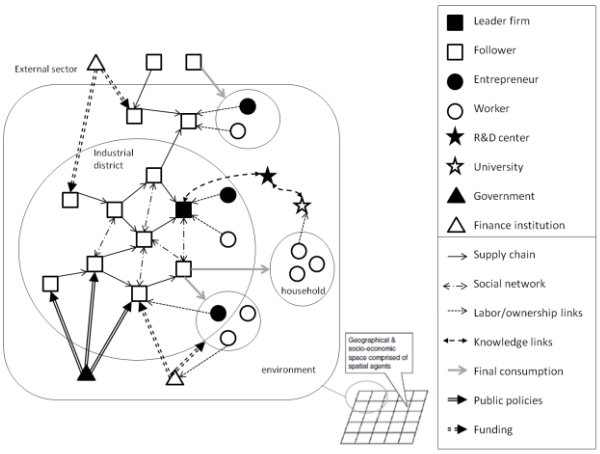

Figure 2. Agents and environment incorporated in MOSIPS. Based on Albino et.al (2007).

The kind of relations that structure the interactions between agents have different nature depending on the agents that form part of them, and the activity or characteristic that links them. These relations are developed based on the various activities undertaken by companies in their recruitment and procurement of inputs, human resources management, production, innovation and technology management, product development, financial management and business strategy sales. Individuals establish their relations with firms from their consumption and saving decisions, employment and ownership. Social relations with other

individuals take place through companies (co-owners, work colleagues, etc.) or with some of their relatives and neighbours.

In the modelling process, the properties of the protocols that govern the interaction between individuals and companies are based on relations of production and consumption, employment and lending, adopting a microeconomic perspective. In this sense, the price of competitors' products in relation to themselves constitutes one of the main signals received by the agents. They act taking the suitable decisions for the acquisition of inputs, recruitment of factors, production and sales. These relations take place in markets.

With respect to these factors and product markets, the model provides an approximation to local environments, on one side. But on the other side it also assumes the existence of other broader environments, at national or international level. That is, the analysis of interaction of agents is focused on their interest in a defined territorial space, such as a region. Relationships with agents from other areas are analysed in a more simplified approach. For example, the majority of goods are bought by large retailers in international markets, and then they sell them to small retailers. Final customers do not have access to a high number of sellers due to informational costs. Then, the appropriate scale of the first market is international, small retailers only have access to the regional market and final costumers tend to purchase goods at local level.

The same assumptions are made in the relation between firms and workers, who are unemployed or employed in other companies and they want to change their jobs. It could be considered that both companies and workers face the regional employment supply and demand, respectively. In most of the approaches, it is assumed that all the agents act against the market, the aggregate behaviour of the rest of agents, looking to optimize their interest. However, in most of the cases, every agent creates its own behaviour associated to the decisions of its neighbours. It arises from the information and expectations generated by the rest, weighted depending on their spatial and relational proximity. For example, a company located in a municipality is able to produce and sell its production with a slightly different price from a competitor of a neighbouring municipality, while in other part of the region prices can be lower. Then, agent actions and decisions are highly affected by the behaviours of agents in the proximity, but it also depends on the aggregate behaviour, emerged from the decisions of every agent.

Thus, all companies are somehow interconnected, but these links are stronger in environments which are closer. In any case, those behaviours associated with the environment may also depend on the sector, the concentration of supply and demand or the degree of public promotion of a product (e.g., which is derived from the impact of advertising).

Individuals face the same interaction protocols and information flows, but applied to their decisions. They obtain most of the information from firms which they are linked, but also from the aggregate behaviour (e.g. the unemployment rate, GDP growth, price index). Individuals also condition their decisions taking into account the performance of other agents who are linked with. Then, a potential entrepreneur will decide to create his own enterprise with a higher probability if both their acquaintances and the information she has about the general performance of the economy is promising for her success

3. DESIGN CONCEPTS

This section of the paper presents some of the highlights of the general approach of the model

3.1. Time, activity patterns and activation schemes

What is the basic sequence of events in the model? Are activities by agents triggered by a central clock or by actions respectively messages sent by other agents?

Time is modelled discretely. Each period consists of several steps. The length of the period determines the temporal resolution of the model and is determined largely by the characteristics and temporal reference of the data used. The model can consider any time interval without affecting its characteristics. However, the quarter has been taken as the primary reference since it is considered that most of the decisions of the agents have a maturation period around this length.

Actions are triggered instantly at the time when the 'central clock' determines each period. They, however, do not need to be carried out in each period. The user can choose a different periodicity for some of them.

By observing this basic temporal sequence of events, the model is fed with information and data proposed in the system architecture for the years 2007 to 2011. This means that the simulation system starts from 2007 and forecasts of the modelling can be developed from 2012.

3.2. Interaction protocols and information flows

What are the general properties of the protocols governing the interaction between agents? How is determined which agents can interact with each other

Matching interactions and business activities are bilateral. These are gravitational interactions where intensity depends on "visibility", which, for an agent, means the expected relevance of its interaction with the counterpart.

In the case of matching of individuals, each individual selects a group of people with whom s/he

interacts and who s/he subjectively evaluates based on its attributes. In the case of firms, sellers offer their product to the market and buyers choose their supplier from a group of sellers who are selected according to their closeness and to the size of their firms.

Each firm demands workers featuring certain characteristics. Among the firms seeking a worker's profile, workers choose the most "attractive" ones in terms of salary and distance. Matching occurs when the best possible combination for both parties is achieved.

3.3. Forecasting

Are agents in the model forward looking or purely backward looking? If agents are forward looking, what is the basic approach to modelling forecasting behaviour?

Agents base their forecasts on their past experience, within a context of incomplete information. Households determine their levels of consumption and savings from their income experience in prior periods following a scheme inspired by the life cycle and permanent income hypotheses. Firms make their decisions based on the experience gained with clients and competitors.

3.4. Behavioural assumptions and decision making

Based on which general concepts is decision making behaviour of the different types of agents modelled?

Agents have bounded rationality and act in an environment of imperfect information. Interactions take place predominantly in the close environment of the agents. The chances of interaction among agents depend on their "visibility", understood as indicated in section 3.2. A possibility to model it is the following:

$$V_i(t) = \left(\sum_{0}^{j} (1-\delta_3)^j \, (size_i(t-j) + adv_i(t-j)) \right) + \left(\sum_{1}^{k} size_k(t) \, SP_{i,k}^2 \right)$$

The visibility of each firm is determined by its current and past size, and its advertisement effort. Agglomeration increases the value of this variable, adding the size of the k nearest firms, weighted by the spatial proximity.

Firms select their suppliers and their workers. Consumers choose the firm in which they work and their consumptions elections. In all the situations the process is the same. Firstly, the agent evaluates its performance. For this purpose, it examines not only its results, but also receives information about other agents. It can be biased and incomplete. If the performance is sufficiently good, the agent does not search for new agents (suppliers, workers, etc.), whereas if its performance is not sufficiently good, according to the expectations of the agent, or worse than the average perceived performance, the firm will look for better agents to work with (Figure 3).

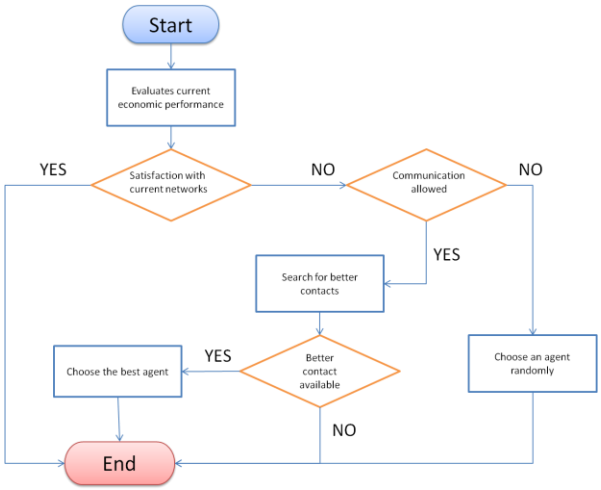

Figure 3: Social links formation and updating process. Based on Giardini et.al. (2008)

3.5. Learning

Are decision rules of agents changed over time? If yes, which types of algorithms are used to do this?

The structural characteristics of households and firms evolve through learning. This is done by imitation and mutation procedures. The structural characteristics of individuals are modified in each period either due to random factors or by imitation of the behaviour of the agents regarded as displaying more appropriateness (like benchmarking).Thus, by means of a selection evolution process, agents get adapted to the circumstances through learning, as it happens, for instance, in the case of the initial reservation wage, or the choice of distance when seeking suppliers.

These learning processes are represented by the changing of several structural characteristics (consumption patterns, mark-ups or technology) of households and firms.

Agents tend to imitate other ones of their same kind which are in their network and show a better behaviour. Not always the adoption of a new behaviour is positive, every so often the better result obtained could have happened by chance. Thus, imitation has not always the desired effects. Additionally, previous behaviour does not warranty current or future success because of the unforeseen or unexpected sharp changes in the economy. A good example is found in the real estate sector during bubbles. It shows high profits during a certain amount of time, but the last starters only achieve losses.

3.6. Population Demography

Can agents drop out of the population and new agents enter the population during a simulation run? If yes, how are exit and entry triggered?

In the model, entries and exits of households and firms occur in each period.

Within households, there are births and deaths. Births depend on the location and personal circumstances of the mother, while deaths hinge on the individual's age as well as other factors. Individuals can change their location when appropriate in a cost-benefit scheme.

Some individuals are entrepreneurs, and they emerge as such when, from a subjective point of view, it is convenient for them to be entrepreneurs. Similarly, they stop being entrepreneurs when it no longer suits them. Entrepreneurs with one or more firms are businessmen.

The birth and death of firms follow the decisions taken by businessmen, who are dependent on economic or personal factors. They also make decisions about the location of their firms.

3.7. Level of randomness

How do random events and random attributes affect the model?

There are two main sources of randomness. The major one is generated in the creation of agents. There is available a certain information, but it is incomplete, and agents are created following random rules, accordingly and conditioned to their known characteristics. For example, an employed person who works in a given sector is matched to a firm of that sector with an establishment near his residence, but there is a possibility of make incorrectly this process. Then, if the actual firm has a good performance and the matched firm goes bankrupt, this individual will lose his job, while in the reality, he continues working. The counterpart is an actual unemployed will continue be working in the modelled reality. As we can see, part of these random possibilities cancel at aggregate level, but can have huge effects at the micro level, making unfeasible to obtain accurate micro information.

Another significant source of randomness is the creation of networks, as this is the part of the model for which there is a lower level of data available. Networks are extremely important for learning processes and changing behaviours. Thus, the model increases its randomness along periods of simulation, leading to stochastic dynamics for a large number of variables (household characteristics, prices, amounts, innovation, location, etc.).

3.8. Miscellaneous

Any important aspects of the used modelling approach that do not yet any of the items above should be explained here

The MOSIPS model is inspired by the circular pattern of income where the financial field is explicitly integrated. This is crucial in the current crisis process given the serious financial constraints of firms.

Additionally, MOSIPS provides a highly precise spatial outlook since agents are located individually using GIS techniques, which makes it possible to observe the impact of policies at a micro-spatial level.

4. DATA BASES FOR THE MODEL

In order to represent the society it is necessary to build two databases, one for individuals and families and other for firms and establishments. They are complemented with the macroeconomic environment, and public, financial and foreign sector, taken as a whole.

The variables for the macroeconomic environment and public policies, allow the agents information creating their expectations and it is added to the information they have from themselves and other individuals and firms whom they have connections.

We make use of two techniques that allow achieve a great grade of accuracy in the process: statistical matching and downscaling. Thus, the model has a high degree of scalability, and allows the user focusing from individual effects up to total variation or putting the focus in the agents of a specific area or a group of SMEs with similar characteristics.

4.1. Statistical Matching

Statistical matching is used to fusion information from different microdata sources (Diorazio 2006)

In the model the main one for individuals is the Population Census, which informs about the number of the total population and the main individual characteristics: age, gender, location at regional level, family composition, level of studies, etc. It is complemented with the Labour Force Survey to become acquainted labour status of individuals. The EU Labour Force Survey is a large household sample survey providing quarterly results on labour participation of people aged 15 and over as well as on persons outside the labour force. All definitions apply to persons aged 15 years and over living in private households. The Global Entrepreneurship Monitor explores the role of entrepreneurship in national economic growth, unveiling detailed national features and characteristics associated with entrepreneurial activity. It is used to value the chances of developing new enterprises. Mobility surveys make possible to know patterns of mobility of individuals, and allow creating demand functions spatially defined (Schenk et.al. 2007).Tax Income Panel is the best indicator of income and Household Budget Survey permits identify the consumption in every sector and the savings as the remaining part of the income. It allows us to ascertain the consumption expenditure of households residing, as well as the distribution of said expenditure among the different consumption divisions. Other sources are used to acquire information not present in the previous presented sources. The main one is mortgage duration

and amount, present in the Annual Report of Property Registers.

Enterprises data base is built in a similar way, starting from the Business Directory, which contains information about the number of enterprises, the sector they belong and their size. However, is a poor source with respect to the Population Census and only includes aggregate information. Then, it must be fulfilled with the microdata exhaustive information enclosed in other statistical source called Amadeus.

This data base should be enlarged including characteristics from the Survey on Access to Finance and Technical Innovation Panel. The Survey on Access to Finance covers micro, small, medium-sized and large firms and it provides evidence on the financing conditions faced by SMEs compared with those of large firms every six months. In addition to a breakdown into firm size classes, it provides evidence across branches of economic activity, euro area countries, firm age, financial autonomy of the firms, and ownership of the firms. The Technological Innovation Panel is a statistical instrument for studying the innovation activities of firms over time. It takes into account the heterogeneity in the firms' decisions (such as different shares of intramural R&D and external R&D in total innovation expenditures) or in the effects (such as the different impacts on productivity).

The statistical matching process is taken in several stages. For individuals is necessary to start from the Population Census, and then add labour information though a microsimulation model that is built in order to obtain accurate data. Then, we are sure that every individual is coherent with himself across the time periods. For example, a civil servant cannot be fired. Then, it is possible to link information about income and consumption at household level, due to the available microdata information. Finally, entrepreneurial activity is compute for every adult. Enterprises data base is constructed following the same scheme, starting with the census (business directory) and adding information about their characteristics (number of workers, financial statements...) and access to finance, which is a major issue for the growth and overall performance of SMEs.

4.2. Downscalling

In order to accurately define the placement of agents, a raster of locations must be included, with information of land price, demography, uses of land and transport networks. This raster is built making use of downscaling techniques. From information at local level or other (e.g. per Ha or per Km2) we arrive to the level of each cell included in the raster. (Gallego 2010)

After making the statistical matching process, both firms and households are located into the raster. Finally, networks are built between individuals, firms and among individuals and firms. These relations are related to the information provided by markets of factors, goods and services.

5. PUBLIC POLICIES

The model permits the study of almost any policy that the public administration implements which has effects on SMEs, not only the policies designed specifically to encourage business activity. All the principles included in the Small Business Act (European Commission, 2008) have been taken into account and turned into a concrete set of policy domains. Then, the model allows the inclusion of any policy related to entrepreneurial activity, infrastructure, innovation, internal managing, inter-firm relations, labour market, funding, relations with the administration, environment and macro-economic environment such as changes in taxation or trade restrictions.

These policy domains can affect the agents in three different ways, as it is shown in Figure 4. They can change their cost function, their characteristics (data) or their behaviour. They affect the performance, development and decay of every industrial district present in the economy, as well as the processes undertaken between the components of the district such as cooperation, competition, innovation and knowledge dissemination.

Figure 4: Illustration of policy domains included in MOSIPS model.

Policies can be integrated in the model as appears in the above figure as it is shown in the following example.

It is possible to think about two kinds of subsidies that affect innovation: a grant intended to increase the potential of SMEs in order to acquire high-tech machinery and another one that is granted for training their employees in a R&D course. In the first case, it affects the cost function by reducing the costs of producing a certain amount of product. Instead, the second measure affects the behaviour of SMEs, making them more able to produce and adopt innovations, but in the next period they will produce with the same cost function and data (employees, machinery…) as if the policy had not taken place. However, in the following periods, it would behave in a more pro-innovative way, adapting and developing new procedures that will reduce costs.

6. CONCLUSIONS AND OUTLOOK

We have discussed the characteristics of agent-based models. Agents, other entities, relationships, activities and decision rules within the model MOSIPS have been described. This allows to predict and to simulate public policies on SMEs.

The opportunity to deal with real data makes the model a powerful tool to predict the real functioning of the economy at individual level. Consequently, it is necessary to develop complex databases that include the agents heterogeneity.

ACKNOWLEDGMENTS

The work presented in this document has been conducted in the context of the EU Framework Programme project with Grant Agreement 288833 MOSIPS (Modeling and Simulation of the Impact of public Policies on SMEs). MOSIPS is a 36 months project started on September 1st, 2011.

REFERENCES

Albino, V., Carbonara, N. and Giannoccaro, I. 2007. Supply chain cooperation in industrial districts: A simulation analysis. *European Journal of Operational Research*, 177, 261-280.

Aldrich, H. E. and Cliff, J. E. 2003. The pervasive effects of family on entrepreneurship: toward a family embeddedness perspective, *Journal of Business Venturing*, 18(5), 573-596.

Ardagna, S. and Lusardi, A. 2010. Explaining International Differences in Entrepreneurship: The Role of Individual Characteristics and Regulatory Constrains". In Lerner, J. and Schoar, A., eds. *International Differences in Entrepreneurship*, University of Chicago Press, 17- 62.

Arrow, K.J. and Debreu, G. 1954. The existence of an equilibrium for a competitive economy. *Econometrica*, 22, 265-290.

Brunet, I. and Alarcón, A. 2004. Teorías sobre la figura del emprendedor, *Papers: revista de sociología*, 73, 81- 103.

Coviello, N. and Munro, H. 1995. Growing the entrepreneurial firm: networking for international market development, *European Journal of Marketing*, 29(7), 49-61.

Dawid, H., Gemkow, S., Harting, P., van der Hoog, S., and Neugart, M. 2011. The Eurace@Unibi Model: An Agent-Based Macroeconomic Model for Economic Policy Analysis. Available from www. wiwi.uni-bielefeld.de/vpl1/projects/eurace/eurace-unibi.html.

DíOrazio, M., DiZio, M. and Scanu, M. 2006. *Statistical Matching: Theory and Practice*, Wiley, New York.

Dosi, G., Fagiolo, G., and Roventini, A. 2008. Schumpeter Meeting Keynes: A Policy-Friendly Model of Endogenous Growth and Business Cycles. Laboratory of Economics and Management, SantAnna School of Advanced Studies, LEM Working Paper Series, 21.

European Commission. 2008. Think small first: A Small Business Act for Europe, DG Enterprise, Brussels, Belgium.

Farmer, J. and Foley, D. 2009. The economy needs agent-based modelling. *Nature*, 460, 685-686.

Gallego, F.J. 2010. A population density grid of the European Union, *Population and Environment*, 31, 460–473.

Giardini, F., Di Tosto G. and Conte, R. 2008. A model for simulating reputation dynamics in industrial districts. *Simulation Modelling Practice and Theory*, 16, 231-41.

Gintis, H. 2006. The emergence of a price system from decentralized bilateral exchange. *B. E. Journal of Theoretical Economics*, 6, 1302-1322.

Gulati, R. 1999, Network location and learning: The influence of network resources and firm capabilities, *Strategic Management Journal*, 20(5), 397-420.

Mandel, A., Fürst, S., Lass, W., Meissner, F., and Jaeger, C. C. 2009. *Lagom generiC: an agent-based model of growing economies*. ECF Working Paper, 1. Available from www.europeanclimate-forum.net/index.php?id=ecfworkingpapers.

Meyer, M., Aderhold, J. and Duschek, S. 2004. Organizing social complexity in production networks, *Journal of Academy of Business and Economics*, 3(1), 1.

Nielsen, K., and Sarasvathy, S. 2011. Who Re-enters Entrepreneurship? And Who Ought to? An Empirical Study of Success After Failure, in Dime-Druid Academy, *Winter Conference in Aalborg*, 20-22 Jan, Aalborg, Denmark.

Roessl, D. 2005. Family Businesses and Interfirm Cooperation. *Family Business Review*, 18, 203-214.

Schenk T., Löffler G., Rauh J. 2007. Agent-based simulation of consumer behaviour in grocery shopping on a regional level. *Journal of Bussiness Research*, 60, 894-903.

Slotte-Kock, S. and Coviello, N. 2010. Entrepreneurship Research on Network Processes: A Review and Ways Forward. Entrepreneurship Theory and Practice, 34(1), 31-57.

Stam, E., Audretsch, D. and Meijard, J. 2008. Renascent entrepreneurship. *Journal of Evolutionary Economics*, 18 (3-4), 493-507.

Street, C. T. and Cameron, A.-F. 2007. External Relationships and the Small Business: A Review of Small Business Alliance and Network Research, *Journal of Small Business Management*, 45(2), 239- 266.

Tesfatsion, L. and Judd, K. 2006. Agent-Based Computational Economics. 2 in *Handbook of Computational Economics*. Elsevier, North-Holland.

Wolf, S., Bouchaud, J-P., Cecconi, F., Cincotti, S., Dawid, D., Gintis, H., Hoog, S. Jaeger, C.C.,

Kovalevsky, D.V., Mandel, A., Paroussos, L. (2011). Describing economic agent-based models, Dahlem ABM documentation guidelines. Proceedings of the 100th Dahlem Conference, New Approaches in Economics after the Financial Crisis, 2010 Aug 28-31.

Wooldridge, M. and Jennings, N.R. 1995. Intelligent agents: theory and practice. *Knowledge Engineering Review*, 10, 115-152.

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