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"ENTREPRENEURSHIP AND FIRMS' MOBILITY"

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Abstract

Entrepreneurial activity is one of the major issues in regional economic analysis. Although its determinants and consequences are multiple and complex, most studies focus on individual factors or face the work from an aggregate level. These approaches assume that a representative agent —by maximising its utility— solves a social problem with which it is faced. However, this neglects the fact that the economy is a complex and evolving system made up of diverse and heterogeneous interacting agents. As a result, such models present major shortcomings, which justify the need to find a new methodology to model entrepreneurship and firms' dynamics that will make it possible to study in detail and forecast the effects that economic policies have on the business sector.

From the perspective of entrepreneurship and business activity, this paper introduces an agent-based model (ABM) in order to analyse the effects of policies within the behaviour, decisions and interactions dynamics of firms and individuals. Therefore, two basic types of agents are considered: individuals and firms. The individuals belong to a society made up of households and they act as entrepreneurs–businessperson that create firms. Firms have their own dynamics and adopt decisions as far as their approach of economic and business performance.

Building on the main trends and theories of entrepreneurship and business activity, this model analyses and forecasts, first, how the entrepreneurial spirit is shaped, which are the determinants that reinforce it, and what is the propensity to become an entrepreneur. And secondly, the choice of the characteristics of the firm and its development, taking into account the decisions on optimising in terms of location.

Key words: Entrepreneurship, agent-based model, actions and interactions, simulation.

JEL: L26, L52, R38

1. Introduction

Over the past few years, several models have been developed in the field of analysis of public policies in productive activity with a view to assessing the costs and effects of implementing such policies. These include traditional forecasting models, input-output models, production-possibility boundary, shift-share, or cost-benefit analyses.

These approaches assume that a representative agent—by maximising its utility—solves a social problem with which it is faced. However, this neglects the fact that the economy is a complex and evolving system made up of diverse and heterogeneous interacting agents (Wolf et al., 2011). As a result, such models present major shortcomings. One of the most important ones is that often, by their very nature, such models fail to provide an overview of the phenomenon studied, as they are concerned with analysing specific aspects of reality without factoring in the actions and interactions between the participating agents. Thus, these non-general models often involve considering many endogenous aspects as fixed variables.

Even those models that provide a general view, such as the dynamic stochastic general equilibrium (DSGE) models, often refer to global rather than local areas and reveal further important constraints such as the non-inclusion of the heterogeneity of agents (these models sometimes include various types of individuals but they do not capture individual differences) (Colander et. al, 2008). Other limitations include using the controversial assumptions of rationality and perfect information (Kirman, 2010) or, in a macroeconomic area, difficulties in incorporating the endogenous emergence of crises into the analysis (Committee on Science and Technology, 2010).

Moreover, the implementation of policies generally produces an impact that goes beyond the area of the analysis considered (e.g., spillover effects, both positive and negative) and such impact is not usually considered in the models or is considered just partially.

These reasons justify the need to find an ideal modelling of entrepreneurship and firms' dynamics that will make it possible to study in detail and forecast the effects that economic policies have on the business sector.

Firms' dynamics is determined by the availability of entrepreneurship capital (Audretsch & Keilbach, 2004), which is an endogenous factor within an economy where entrepreneurship develops. The usual approaches to this phenomenon come from two sides: industrial economics and the concept of entrepreneurship itself. Both are poorly interrelated and each focuses on partial aspects. Industrial economics models, usually more formal, consider that in business sectors where there exist exceptional profit margins and a lack of financial constraints new companies will automatically emerge. However, such models do not account for the fact that there must be individuals with specific characteristics to be able to start new business projects. From the viewpoint of entrepreneurship, which incorporates more realistic but less formal approaches, it is considered that the availability of entrepreneurship capital is a key aspect in the emergence of new companies and in economic growth in general.

The approach to this work attempts to bring both methods closer together and to provide an integrated framework whereby entrepreneurs come from an individual, household, and social environment where socio-economic circumstances will determine whether individuals become entrepreneurs and businesspeople or will stop to be so, with the corresponding implications on the opening and closing of firms. Thus, an integrated approach is proposed to close the circle of entrepreneurship, which fluctuates according

to firms' dynamics although firms' dynamics, in turn, hinges on the availability of entrepreneurs. Further, this process is closely linked to the conception and development of small and medium enterprises (SMEs), although at times the emergence of large companies also occurs *ex novo*. This latter case is not given specific attention herein since it is not too relevant in practice as most large firms stem from one or more growing SME.

This approach, which deals with the study of firms' dynamics as a result of the actions and interactions between agents, is the natural environment in which agent-based models (ABM) are developed. As noted by Wolf et al. (2011, a, p. 1) "an agent-based model implements agents at the micro-level on the computer, equipping them with rules for action and interaction. Simulation runs can then be used to study the evolution of the system at the macro-level. By considering trajectories of the system over time, ABMs have a dynamic perspective that is found wanting in standard equilibrium models which compute an optimal state without considering how society would get to this point".

The flexibility of agent-based simulations can generate complex models, even long term, through the successive performance by these agents, in each period, of the short-term models. Thus, the behaviour of the long-term model becomes the update, period by period, of the trajectories followed by agents in the short-term models. ABM simulations can be considered as substitutes for real-world experiments, which are very difficult to perform in the economic sphere.

Against this background, the aim of this paper is to present the module of entrepreneurship and firms' dynamics of the MOSIPS project.[1] This project focuses on simulating and evaluating policies for small and medium enterprises in a local or regional environment. It aims at conducting experiments on the implementation of policies according to different socio-economic scenarios. The results of these experiments allow citizens (and stakeholders) know how the measures proposed by governments affect them particularly and enable them to interact in the decision-making process by relying on first-hand information. Participation through social networks reinforces this interaction.

The MOSIPS model is inspired in many regards by the Lagom model family, developed within the Global Climate Forum (2012) and can be interpreted as a development aimed at analysing the impact of policies at the local level.

Therefore, the model presented here is part of a larger model (figure 1) which includes other basic elements of analysis. Thus, the full model consists of 6 modules: households (individuals-families), labour market, innovation and clusters, goods and services market, financial markets, and, lastly, entrepreneurship and firm location, which is the specific subject of this paper.

The model pertaining entrepreneurship and firms' dynamics (Module 2-M2) consists of 4 other sub-modules: entrepreneurship, firm demography, firm growth and firm location. This modular structure provides the model with great flexibility and broad development prospects. Each of the parts that make it up can be developed

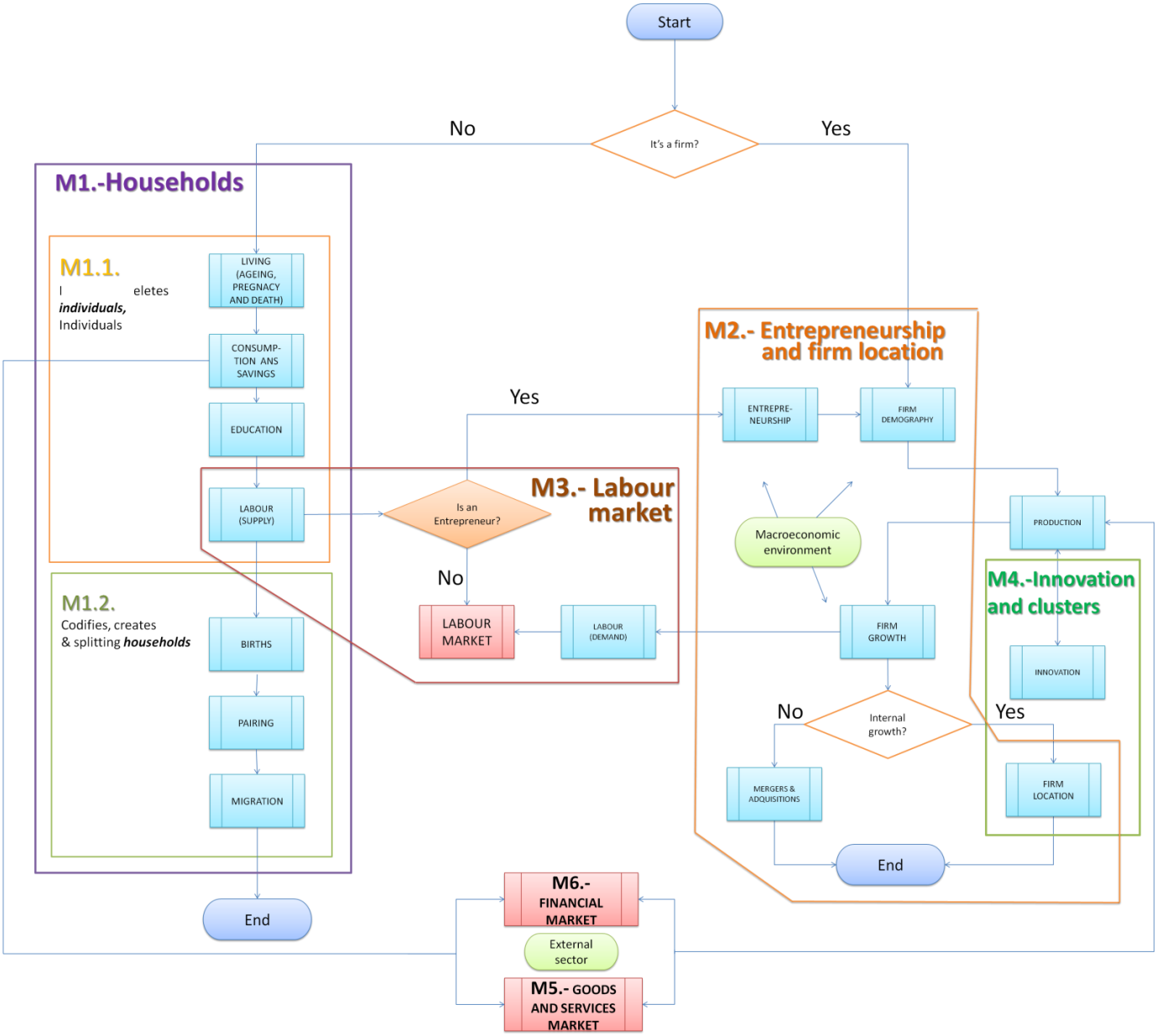
[1] This project, *Modeling and Simulation of the Impact of Public Policies on SMEs*, is funded by the 7th Framework Programme of the European Commission, Grant Agreement 288833 [FP7-ICT, ICT-2011.5.6, ICT Solutions for governance and policy modelling]. It is a 36 months project started on September 1st, 2011. The authors acknowledge the opportunity of this research to the EU and the other MOSIPS Consortium members.

independently without altering the overall structure of the model. This is therefore a theoretical paper that does not present the results of any simulation but offers innovative ideas regarding the modelling of economic systems and the agent-based models methodology that could be used as inspiration for future work in this area.

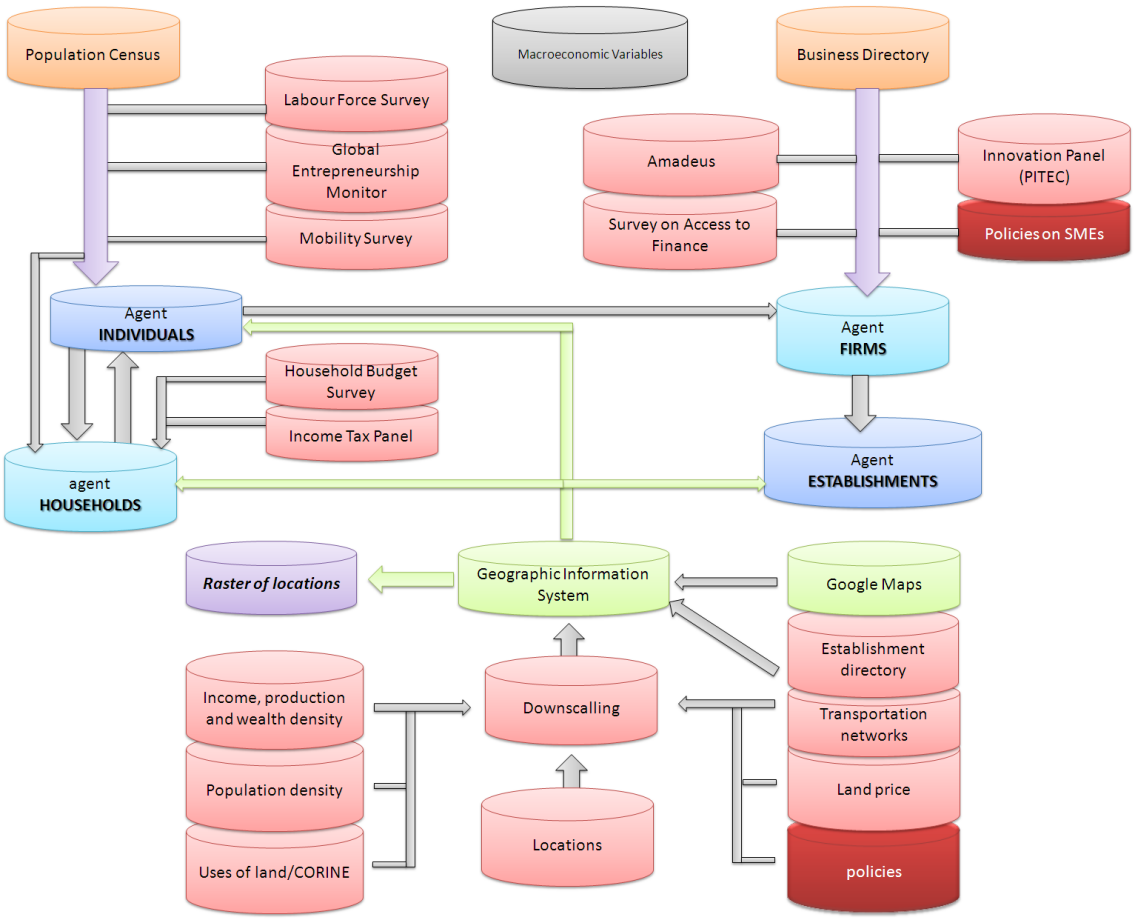
This paper incorporates in a coordinated, systematic, and comprehensive way many of the ideas derived from the literature on how to characterise and develop entrepreneurship, entrepreneurs, and firms' dynamics. It can be regarded as a kind of survey on the subject under consideration, except that the analysis chooses a specific structure, and although the specification can be flexible, it must be defined and must not give rise to contradictions. This provides the model with an additive capacity, that is, deficiencies or shortcomings can be remedied in later developments without having to modify the basic structure of the model.

The paper's structure follows the formal criteria and guide recommendations of the Dahlem Conference at the time of writing and presenting a work on new challenges for the development of agent-based models. It also takes as a methodological guide the multi-agent Lagom Regio model (Wolf et al., 2011 b). The second section provides an overview that includes the model's rationale, the operating agents, the boundaries the model faces, and the type of relationships and activities developed by the agents. The third section concerns the design concepts and, in particular, the following model aspects: time and activity patterns, interaction protocols, forecasting and behavioural assumptions, and decision making. The fourth section describes and analyses the functional specification of the model. And, finally, the fifth section draws the main conclusions of the paper and incorporates some ideas for discussion and policy suggestions.

Figure 1. **General Structure and data bases of the MOSIPS Model**



Data bases of the MOSIPS Model



Source: own elaboration, IAES-UAH team, Mosips Project

2. Overview

This section provides an overview of the MOSIPS ENTREPRENEURSHIP module focusing on the agents involved in entrepreneurship and firms' dynamics.

2.1 Rationale

Following an ABM methodology, this module presents the model of behaviours, decisions, and interactions dynamics that individuals in an economy adopt from the perspective of entrepreneurship and business activity. Therefore, two basic types of agents are considered. On the one hand, individuals who, as such, are born, live, and age in a society made up of households. These are individuals who, throughout their lives, based on optimising their utility (Fishburm, 1970) and on expectations (Edwards, 1954), make decisions about behaviours and variables of a personal nature (e.g., starting a new family and having children) or about other aspects more in connection with the economic sphere (e.g., consumption, education, work, or the willingness to become an entrepreneur). On the other hand, the other agents include entrepreneurs and (non-financial) firms which, as agents, also have their own dynamics in terms of their emergence and entry into the market, growth and consolidation, and closure or exit from the market. Therefore, these adopt individual decisions as far as their mode of economic

and business performance is concerned including when and where are they to be established, how much will they invest, what and how much will they produce, what kind of workers and technicians will they hire, where will they sell and draw their benefits from, and how will they grow or disappear.

Building on the main trends and theories of entrepreneurship and business activity, this model investigates and tries to forecast, first, how the entrepreneurial spirit is shaped, which are the determinants that reinforce it, and what is the propensity to become an entrepreneur or to give up (Blanchlower and Oswald, 1990). And secondly, although in connection with the above, the model examines how the business activity can be broken down by looking at the choice of the characteristics of a firm, its development into one or more establishments, its growth strategy (through available or internally raised funding, through externally raised funding—of its own or of others—, through acquisitions of—or mergers with—other companies), the adopted optimisation decisions in terms of location (Casson, 1982), as well as the eventual closure of firms and establishments.

2.2 Agents

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.

The model 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) (i.e., 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.

The aggregation of the characteristics of individuals obtained from the simulations defines, in turn, the characteristics of the population. Thus, through the simulation of individuals, the entrepreneurial capital of society, its size and attributes can be endogenously obtained.

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.

2.3 Other entities

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

Being a distinctly local analysis, the Entrepreneurship and Firms' Mobility module—as with the rest of the MOSIPS project—must incorporate the aspects lying outside its domain yet having a determining influence on it. Consequently, during its execution, the model requires exogenous information inputs (such as interest rate or GDP growth), which usually come from statistical and prospective centres and institutions.

2.5 Relations

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).

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 which 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.

Section 2.2 below provides more comprehensive information on interaction protocols among agents and their spatial pattern of operation (local environments).

2.6 Activities

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.

3. Design concepts

This section presents some of the highlights of the general approach of the model. An outline of this model appears in the section called ‘Functional Specification’ below.

3.1 Time, activity patterns, and activation schemes

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

Pairing 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 pairing 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

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

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 2.2.

Generally speaking, agents do not take their decisions in terms of utility maximisation but by using rules of thumb. This approach is more efficient for agents since they operate in an imperfect and costly information environment.

3.5 Learning

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 fitness (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.

3.6 Population demography

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 businesspeople.

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

3.7 Levels of randomness

There are two main sources of randomness: that which derives from the matching processes (pairing relationships, hiring relationships between the firm and the

employee, and customer-supplier relationships), and that stemming from genetic evolution. The latter is associated to processes of learning through imitation and mutations. This leads to stochastic dynamics for a large number of variables (household characteristics, prices, amounts, innovation, location, etc.).

3.8 Miscellaneous

The MOSIPS model is inspired by the circular flow 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. Functional specification

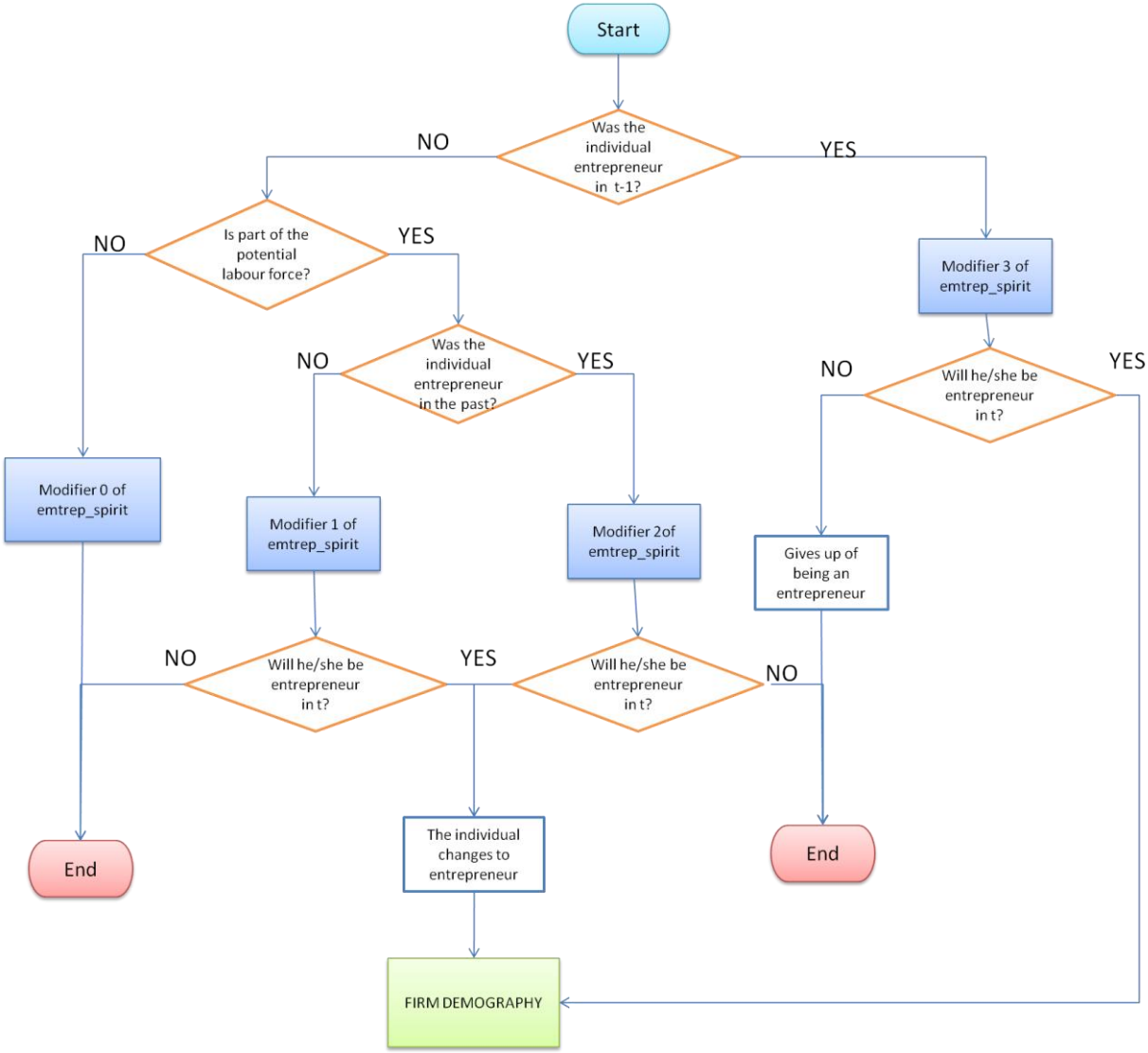
This section provides a detailed description of the agents, other entities, their actions and interactions, the initialisation procedure, and runtime-input requirements. The details provided in the specifications as to variables and parameters, along with their description and update, seek to give a good understanding of the process followed in the modelling and the subsequent simulation work. Variables are named using pseudocodes.

4.1 Description of agents and other entities, action and interaction

Figure 2 shows the 'Entrepreneurship' sub-module, which is the first of the four sub-modules that make up the 'Entrepreneurship and Firms' Mobility' model. This is intertwined by means of the 'Labour Market' module with the 'Households' (individuals-families) module, since only individuals can be or become entrepreneurs.

In each period, the previous situation is evaluated to determine whether an individual will be an entrepreneur or not in the next period. The procedure starts in period t, in order to find out whether the individual concerned was or was not an entrepreneur in t-1. If s/he was not and was not included in the workforce, s/he cannot be an entrepreneur. By contrast, if s/he is included in the workforce, s/he may have already been an entrepreneur before; if s/he was not, s/he may decide to become an entrepreneur in t or stay on the labour market; but if s/he was a businessperson in the past, s/he may change in t his/her prior decision to be an entrepreneur and stop being one or maintain the decision to remain so. Such changes in the decisions of individuals (or businesspeople) are influenced by the so-called 'modifiers' of the entrepreneurial spirit. At the same time, and also based on the 'modifier' of entrepreneurial spirit, if an individual was already an entrepreneur in t-1, s/he may continue being an entrepreneur in t or give up and stop being so.

Figure 2. **Entrepreneurship (individuals)**



Source: own elaboration, IAES-UAH team, Mosips Project

A 'modifier' can be defined as the set of rules that establish and govern the behaviour of variables. These rules can be based on a simple function, in which case the rule is very simple, or on various more complex or chained functions.

The variables chosen fit some of the most widely used variables in the literature on the analysis of entrepreneurship and entrepreneurs. These variables also derive from the work on entrepreneurship carried out between 2003 and 2012 at the University Institute of Social and Economic Analysis (*IAES* in Spanish).[2]

[2] In this line of research of the *IAES* on Spanish entrepreneurship, developed with the financial support of the Rafael del Pino Foundation, three books and numerous publications in national and international journals have been produced. The book titles include: *Emprendedores y espíritu empresarial en España en los albores del siglo XXI* [Entrepreneurs and Entrepreneurial Spirit in Spain at the Dawn of the 21st Century]; *La actividad emprendedora. Empresas y empresarios en España, 1997-2006* [Entrepreneurship. Firms and Businesspeople in Spain, 1997-2006]; and *Empresas y empresarios en España en la primera década del siglo XXI. La mujer en la actividad emprendedora* [Firms and

Specifically, the variables comprising this sub-module include:

ENTREPR is a dichotomous variable that determines whether the individual is an entrepreneur or not by taking the values 1 or 0 respectively.

ENTREPR_SPIRIT takes values between 0 and 1 and determines the propensity to become an entrepreneur. From 0.75, it is considered that the individual becomes an entrepreneur.

At the time of birth, individuals are 'non-entrepreneurs', but at that very moment in time their initial ENTREPR_SPIRIT level is randomly generated using a normal distribution. The initial value of this variable changes in each period based on the following variables:

- Gender: GEND. The probability of becoming an entrepreneur is higher for a man than for a woman.
- Entrepreneurial family: ENTREPR_FAM:
    - If age is greater than 18, ENTREPR_FAM (t) = ENTREPR_FAM (t-1);
    - If age is less than or equal to 18:
        - if t-1 = 0, ENTREPR_FAM takes the value 0 if neither parent is a businessperson and 1 if at least one is.
        - if t-1 = 1, ENTREPR_FAM = 1.
- Family situation (income-necessity): INCOM_NECES. If this variable has a value of 50% below the average income of the region under analysis, the probability of becoming an entrepreneur, and, thus, the ENTREPR-SPIRIT level, increase.
- Business experience: EXP_BUS denotes the number of years as a businessperson since the start of the first business. This is computed using:

$$\sum_{i=1}^{Exp\_Bus} t(1+r)^t$$

- Business success: SUCC_BUS defines the outcome of the entrepreneurial trajectory. This is computed as the ratio between the number of successful years divided by the years of experience. The closest experience is more relevant than the oldest.

The logistic function that includes this set of variables has the following specification:

$$ENTREPR\_SPIRIT = \frac{1}{1 + e^{-(\alpha+\beta_1 GEND+\beta_2 ENTREPR\_FAM+\beta_3 INCOM\_NECES+\beta_4 EXP_{BUS}+\beta_5 SUCC\_BUS)}} \quad (1)$$

In each period, the ENTREPR_SPIRIT level is or can be modified (as higher or lower). Modifiers 0 1, 2, and 3 are used, respectively, for those who, because of their age (labour force), cannot be entrepreneurs in t, to those who were not businesspeople in the past but could become entrepreneurs in t, to those who were businesspeople in the past and could be again entrepreneurs in t, and to those who are already entrepreneurs in t-1.

Businesspeople in Spain in the first decade of the 21st Century. Women in entrepreneurship]. All three books have been edited by Marcial Pons, Ed. in 2004, 2008, and 2012, respectively.

This specification is based on the fact that the determinants for being an entrepreneur are not the same according to the age and the circumstances for being an entrepreneur or not:

The ENTREPR_SPIRIT determinants (modifier 0—non-entrepreneur due to age—) are:

- Gender: GEND. Computed as indicated above.
- Entrepreneurial family: ENTREPR_FAM. As above.
- Family situation (income-necessity): INCOM_NECES. As above.

In the same vein as above, the logistic function that includes this set of variables has the following specification:

$$\text{ENTREPR\_SPIRIT}_0 = \frac{1}{1+e^{-(\alpha+\beta_1 \text{GEND}+\beta_2 \text{ENTREPR\_FAM}+\beta_3 \text{INCOM\_NECES})}} \quad (2)$$

The ENTREPR_SPIRIT determinants (modifier 1—for individuals who were not businesspeople in the past and can now be entrepreneurs) considered are:

- Gender: GEND. As above.
- Entrepreneurial family: ENTREPR_FAM. As above.
- Dependents (children/ascendants under their care): DEPEND. If this variable has a value of 50% above the average dependents in the region under analysis, the probability of becoming entrepreneur and, therefore, the level of ENTREPR_SPIRIT increases.
- Inheritance of a business (an operating firm): BUS_INHERIT. The probability of becoming an entrepreneur increases, so if a business is inherited, ENTREPR_SPIRIT reaches a value of 0.75. According to a follow-up empirical work on Spanish entrepreneurship (García-Tabuenca et al., 2012), it is estimated that 15% of firms owned by men have been passed down as inheritance as compared to 7% in the case of businesswomen.
- Education: EDUCA. It is considered that the probability of becoming an entrepreneur increases according to the level of training achieved. This is computed in terms of the number of years of study completed along the various stages of formal education.
- Unemployment: UNEMPL. Being unemployed for longer than one year increases the probability of becoming an entrepreneur.
- Personal and family situation (income-necessity): INCOM_NECES. As above.
- Job satisfaction: DISSATISFACT. Job dissatisfaction, identified by means of the desire to change jobs and have a higher income, increases the probability of becoming an entrepreneur. It is computed according to the variables of Surveys on the Labour Market (Noorderhaven et al. 2004).
- Opportunity cost of wage labour: WAGE_OPPORT. If the average wage of an individual is 50% lower than the average for the region, the probability of becoming an entrepreneur increases.
- Location: LOCAT. An individual is more likely to become an entrepreneur if s/he lives in a local environment characterised by

economies of agglomeration, clusters, or industrial districts. An economic or industrial agglomeration is measured in terms of its land area, the number of incumbent firms, the industries in which it operates, and the technological investments in R&D performed by firms.

- Entrepreneurial dynamism: ENTREPR_DYNAM. The probability of becoming an entrepreneur increases when the rate of business creation is high. This is computed in terms of the variation of the entrepreneurship rate (number of firms existing at the end of each year in the workforce) in the last three years: if growth surpasses 3%, probability increases.

The specification of the logistic function is similar to equations (1) or (2), now according to the variables specified for this modifier.

The ENTREPR_SPRIT determinants (modifier 2—individuals who were businesspeople in the past and can now again become entrepreneurs—) are:

- Gender: GEND. As above.
- Entrepreneurial family: ENTREPR_FAM. As above.
- Unemployment: UNEMPL. As above.
- Opportunity cost of wage labour: WAGE_OPPORT. As above.
- Business dynamism (high rate of business creation): ENTREPR_DYNAM. As above.
- Failure of business project in the past: FAILURE. Having had a previous experience of failure in a firm of the owner increases the probability of becoming an entrepreneur again (Stam et al., 2008; Metzger, 2008).

The ENTREPR_SPIRIT determinants (modifier 3—individuals who are already entrepreneurs in t-1) are as follows:

- Gender: GEND. As above.
- Dependents (care of children/ascendants): DEPEND. As above.
- Family situation (income-necessity): INCOM_NECES. As above.
- Opportunity cost of wage labour: WAGE_OPPORT. As above.
- Failure of business project in the past: FAILURE. As above.
- Age (closeness to retirement): AGE. From age 60, the probability of stopping being an entrepreneur increases by 25%, and by 50% from age 65.

Again, the specification of the logistic function is similar to equations (1) or (2), according now to the variables specified for this modifier.

It is to be noted during the simulation process that:

- If ENTREP_SPRIT1and2 is equal or greater than the threshold of 0.75, a ‘non-entrepreneur’ becomes an ‘entrepreneur’; the ENTREPR variable takes the value 1.

- If ENTREP_SPRIT3 falls by 20% or more of the threshold of 0.75, an 'entrepreneur' becomes a 'non-entrepreneur'; the ENTREPR variable takes the value 0.
- ENTREP_SPRIT1and2 is greater than ENTREP_SPRIT3 because, once an individual is an entrepreneur; a significant drop in the EMP_SPRIT is needed to give up (20%).
- ENTREP_SPRIT control: results must generate a stock of entrepreneurs well above 8%, which represents approximately the existing businesspeople as compared with the total population (net, once the entrepreneurs who give up in the process have been removed).

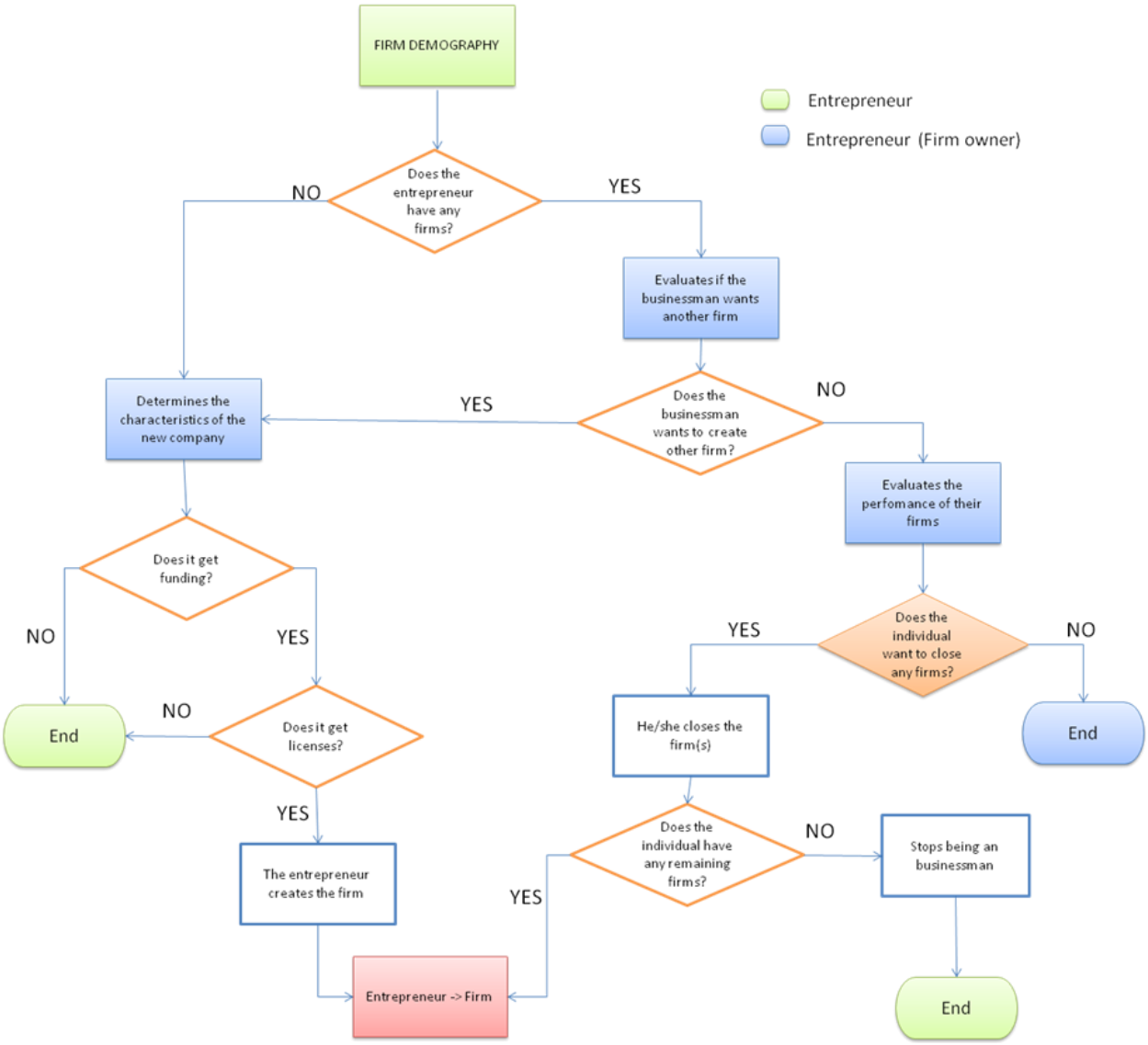
Table 1 summarises the state of variables related to entrepreneurial spirit, which account for the reasons why an individual assumes the role of an entrepreneur. The table features a description of such variables as well as the updating period and the initialisation mode during the simulation stage.

Table 1. Entrepreneurship/Entrepreneur: Variables and Parameters

Name	*Type*	*Description*	*Updating*	*Initialisation*
Entrepreneur (individuals)				
ENTREPR	dichotomous: 0, 1	Determines whether the individual is an entrepreneur or not	quarterly	0
ENTREPR_SPIRIT	value: 0 to 1	Determines the propensity to become an entrepreneur	quarterly	computed
GEND	0,1	The influence of gender on entrepreneurship	invariant	computed
ENTREPR_FAM	0,1	Influence of entrepreneurial family (father...) on becoming an entrepreneur	quarterly	computed
INCOM_NECES	0,1	Influence of family income	quarterly	computed
DISSATISFACT	0,1	Dissatisfaction with the wage earned	quarterly	computed
DEPEND	no. of children and ascendants	Influence of dependents on being an entrepreneur	periodic	computed
INHERIT	0,1	Influence of getting a business as inheritance on being an entrepreneur	punctual	computed
EDUCA	N	(Formal) studies completed	quarterly	computed
UNEMPL	0,1	Being employed or unemployed	quarterly	computed
WAGE_OPPORT	0,1	Opportunity cost of wage labour	quarterly	computed
LOCAT	R+	Existence of economies of agglomeration, etc.		computed
ENTREPR_DYNAM	0,1	Rate of business creation		computed
FAILURE	0,1	Influence of previous business failure in being an entrepreneur	quarterly	computed
AGE	N+	Influence of age on being an entrepreneur (start, retirement)	quarterly	computed

Figure 3 shows the "Entrepreneurship (individuals)" sub-module, which is the second of the four sub-modules that make up the "Entrepreneurship and Firms' Mobility" model.

Figure 3. **Entrepreneurship and firm demography**



Source: own elaboration, IAES-UAH team, Mosips Project

It is assumed that in each period only one firm can be created (with a single establishment). A firm exists from the moment that it has been legally incorporated even if it lacks physical space for production. An establishment is needed for production. For those firms that do not have any physical space for production (street vendors, professionals without a registered office, etc.), the owner's fiscal address is allocated as the physical space.

BUSINESS_PERS is a dichotomous variable that determines whether the entrepreneur in t already holds one or more firms, or does not hold any and is just an entrepreneur for the time being. This takes the values 1 or 0 respectively.

The businessperson who does not have a firm (value 0) assesses whether s/he wants to establish one by considering three aspects: the productive activity to be developed, the

provision of necessary resources, and the granting of the administrative licence authorising a firm. Three variables are related to this decision making:

- The SECTOR_RESTRICT variable determines the chosen productive activity. According to the above cited work on Spanish entrepreneurship (García-Tabuenca et al., 2012), it is assumed that when entrepreneurs create a firm, they do not choose the sector in 70% of cases, as this is imposed on them, most importantly, because of their professional experience, due to family reasons or to getting a business as inheritance, or on account of having a chance to create or acquire a business with low added value. In 30% of cases, entrepreneurs encounter no restrictions when choosing the sector of activity, i.e., they choose it depending on the strategic business opportunity, proactively-randomly.
- Having decided on the productive activity of the potential business, the FINANCE variable determines if adequate funding is available. This variable, in turn, depends on others:
    - Personal income, PERS_INCOME.
    - Household income, HOUSH_INCOME.
    - Access to external funding, CREDIT.
    - Access to public funding, PUBLIC_GRANTS.
- If adequate funding is procured, public approval is sought for the production of such activity. The LICEN_BUSINESS variable determines whether or not such authorisation is granted. If the licence is granted, the new firm is born.

If the businessperson already has one or more firms (variable value: 1):

- If s/he wishes to create a new one, s/he has to follow the above process and determine the characteristics of the new firm: SECTOR_RESTRICT, etc.
- If s/he does not wish to create a new firm, the businessperson evaluates the firm or firms that s/he already holds:

    - The EVAL_LOCK-OUT variable determines whether the business of one or more firms is in a bad economic situation that involves the suspension of operations and their closure. This is dependent, in turn, on the following variables:

        - COMPET_SECTOR. Strong competition and sector crisis.
        - INEXPER. Inexperience, youth, lack of decisions.

      There are other reasons referred to in the literature that affect business failure and closure, such as problems relating to inter-generational succession or disagreements between partners. In this version of the model, these reasons are not dealt with, but they can be included in later versions.

      In this case, the businessperson shall stop being one except if s/he has one or more firms that remain open.

The logistic functions include the aforementioned variables according to a specification which is similar to (1) and (2).

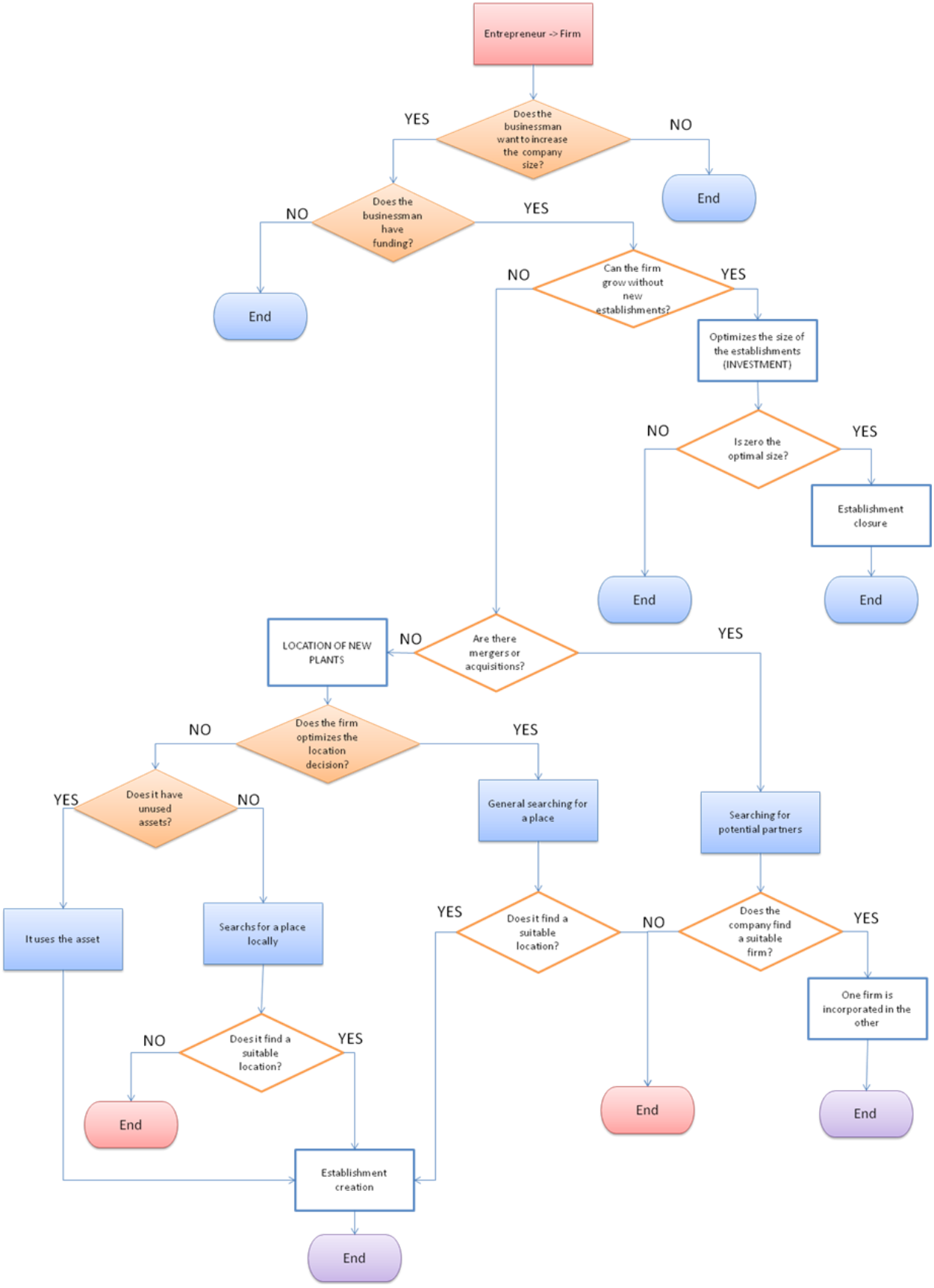
Table 2 summarises the state of variables relating to the behaviour of firms and firm dynamics. It contains a description of such variables as well as the updating period and the initialisation mode during the simulation stage.

Table 2. **Entrepreneurship: Firm Demography**

Name	*Type*	*Description*	*Updating*	*Initialisation*
Entrepreneur / Businessman-woman				
BUSINESS_PERS	Value: 0,1	Determines whether or not an entrepreneur is a businessperson	quarterly	computed
SECTOR_RESTRICT	value: 0,1	Measures whether the entrepreneur has any restrictions when choosing an activity	quarterly	computed
FINANCE	0, 1	Determines if adequate funding is available	quarterly	computed
PERS_INCOME		Personal income of the entrepreneur	quarterly	computed
HOUSEH_INCOME		Family income of the entrepreneur	quarterly	computed
CREDIT		Access to external bank funding or otherwise	quarterly	computed
PUBLIC_GRANTS		Access to grants or public funding	quarterly	computed
LICEN_BUSINESS	0,1	Approval of licence to open a business	punctual	computed
FAILURE	0,1	Failure of business	quarterly	computed
COMPET_SECTOR	0 to 1	Influence of competition or sector crisis at closure	quarterly	computed
INEXPER	0,1	Influence of inexperience at business closure	quarterly	computed

Figure 4 shows the "Entrepreneurship: Firm Growth" and "Firm Location" sub-modules, which are the third and fourth sub-modules that make up the entrepreneurship model.

Figure 4. **Firm growth and firm location**



Source: own elaboration, IAES-UAH team, Mosips Project

These sub-modules have the following variables:

GROWTH_SIZE is a dichotomous variable that determines whether the businessperson wishes to increase the size of his/her firm, so it can take the values 1 or 0, depending on whether the decision is positive or negative, respectively. The interactive process ends both if the value is 0, in case of lack of adequate funding, and if it is 1.

FINANCE is the variable that measures the access to own funds or to external funds enabling the growth of the firm. This variable depends, in turn, on the following variables:

- FINAN_PROFITAB, which measures the ratio of the firm's financial profitability, or net earnings on own funds used.
- EBITDA, closest indicator to the cash flow generated by the firm, measured by earnings before interest, taxes, depreciation, and amortisation on turnover.

  Both variables define the chances of firms to increase their growth. To qualify for this growth in period t, in t-1 both indicators must have achieved a positive performance. It is assumed here that the businessperson who takes the decision to increase the size of his/her firms has internal or external resources to meet the costs of the new investment.

This growth can be accomplished by means of two alternative routes, represented by two variables:

- OPTIM_SIZE, through optimising the size of the firm's plant or plants (and, thus, increasing the production capacity). This optimisation is linked to new investments and hiring of workers. If the optimum plant size is 0, the firm closes. Otherwise, the firm must resort to the labour market, and this module on 'entrepreneurship' is thus linked with the module on the 'labour market (labour demand)' in the model.
- ESTABLISHM, by creating or adding new production establishments to the firm. If growth is chosen to be implemented in this way, there exist two alternatives:
- growth using internal resources, INTERN_GROWTH
- or external growth, MERGER_ACQUISIT

The INTERN_GROWTH variable is associated with the location of the new establishment or establishments. This location can be optimised through a general and adequate search on the market to find the right place for the new establishment. Alternatively, it may not be optimised. In the latter case, the businessperson may have unused assets in t-1, which s/he now uses in t. Or s/he may not have such assets and searches in his/her local environment for a place available so as to create the new establishment.

The MERGER_ACQUISIT variable determines whether the businessperson finds or fails to find on the market a suitable firm, which s/he acquires and with which it merges, thus leading to the disappearance of a firm.

The logistic functions include the aforementioned variables according to a specification which is similar to (1) and (2).

Table 3 summarises the state of the variables related to growth and the location of firms and establishments. As in the other two tables, it contains the description of the variables as well as the updating period and the initialisation mode during the simulation stage.

Table 3. Entrepreneurship: Firm Growth and Firm Location

Name	*Type*	*Description*	*Updating*	*Initialisation*
Entrepreneur/Businessman-woman				
GROWTH_SIZE	dichotomous: 0, 1	Determines if the businessperson wishes to increase the size of the firm	quarterly	
FINANCE	value:	Measures access to own funds or external funds for growth	quarterly	Computed
FINAN_PROFITAB	value:	Ratio: net income earned on own funds used		
EBITDA	value:	Ratio: earnings before interest, taxes, depreciation, and amortisation on turnover		
OPTIM_SIZE		optimisation of the size of the plant		
ESTABLISHM		Creation of new productive establishments		
INTERN_GROWTH				
MERGER_ACQUISIT		Determines if the businessperson acquires/merges with another firm		

4.2 Initialisation (and run-time input)

To start the simulation of the model, values and ranges need to be set for each instrument of the policies considered. It is possible that no changes be made, in which case the forecasts obtained would correspond to the current state of the policies.

The databases contain adequate information on the agents provided, so there is no need to input additional information on the number of agents or their characteristics and decisions.

Regarding the macroeconomic environment, complete information is available up to the present moment and forecasts are available for the following periods. Yet, as the simulation proceeds, the aggregate values obtained from such simulation are calculated, enabling to recalculate the forecasts recursively.

5. Conclusion and outlook

At the risk of being repetitive, it should be reminded that this work, which follows the Dahlem Conference formal guidelines, puts forward and presents an agent-based model designed to analyse entrepreneurship and firm dynamics. This work develops one of the parts that make up a wider project called MOSIPS, which consists of six modules and is aimed at the modelling, simulation, and evaluation of policies for small and medium enterprises in a local or regional environment.

By contrast to traditional models, which give a partial view of the economic reality, and to the DSGE models, which, even though they offer a global sphere of analysis, hardly provide for the heterogeneity of agents, the ABM model approach adopted by this study focuses on the actions and interactions of these agents in their local environment. The paper also seeks to establish an integrated framework in which both entrepreneurship

capital and entrepreneurship are complementary and irreplaceable parties in a market economy.

The model includes two basic types of agents: individuals (and their families)—which may become entrepreneurs under certain circumstances—, and firms. In each period referred to, there are entries and exits of both agents. Along with these agents, other complementary entities emerge, such as the public sector, the financial system, and the local environment. These do not take any direct decisions in the process but influence the expectations and decisions of individuals and firms. Moreover, the model also requires information exogenous to the local environment in which agents operate to be input.

Relations among agents vary depending on the diverse activities that they perform. The market sets a 'virtual' kind of network relations among firms in their pursuit of needs and opportunities, based on rivalry and competition, but sometimes on cooperation. There are also contractual relationships on the labour market between firms and individuals. It is assumed that the pairing interactions and business activities are bilateral, of a gravitational kind, and occur in their close environment; their intensity depends on the 'visibility' or relevance expected by the two partners, so that when they achieve the best combination, a match occurs.

The main activities of individuals (pursue an education, consume...) are developed within the context of their households. They also choose to be employed or self-employed, becoming in this case entrepreneurs/businesspeople. Firms, in turn, produce and sell their products on the market but they can also grow and innovate if they have adequate human and financial resources. Both agents make forecasts based on their past experience in a context of bounded rationality and imperfect information. Both households and firms evolve by learning through imitation or mutation processes.

Time in the model is entered discretely and a "central clock" is provided to determine each period and in which activities are carried out instantly. The period of reference is a quarter, as it considered ideal in the decision making of agents, but other time intervals may also be considered. The simulation system starts in 2007 and forecasts of the modelling are developed from 2012. The flexibility of ABM simulations enables the trajectories of the agents in the short-term model to be converted, through period-by-period updating, into a complex long-term model.

Regarding its methodological development, this model on entrepreneurship has a modular structure with four sub-modules: entrepreneurship, firm demography, firm growth, and firm location. This provides the model with great flexibility. Each part, which has its own structure and specification, is malleable but not contradictory; it is developed independently without altering the overall structure. Thus, the model has an additive capacity, so that shortcomings can be corrected without having to change its basic structure.

The result is similar to a survey, which integrates and systematises the main ideas also derived from the literature on entrepreneurs and firm dynamics. At this stage, we present the theoretical work, without any simulation results, but we offer some novel ideas pertaining the modelling of a system of firm dynamics and the methodology of agent-based models, which could inspire future work.

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