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MODELING LOCAL MONETARY FLOWS IN POOR REGIONS: A RESEARCH SETUP TO SIMULATE THE MULTIPLIER EFFECT IN LOCAL ECONOMIES

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SUMMARY

In poor regions, lack of local monetary circulation is one of the key elements causing underdevelopment. The more incoming money is passed from hand to hand, the more the local economy will be stimulated. However, in most poor areas money is spent outside the community before circulating locally, reducing the effectiveness of money inflow dramatically.

Development programs would increase their effectiveness if knowledge was available on how spending money could lead to optimized and prolonged local circulation. To gain this knowledge a simulation tool will be created, which is able to analyze financial flows, to evaluate the potency of specific actions aimed on local development, and to monitor a development scheme during the execution phase.

The basic model will be developed through a multi-agent approach, where each agent represents one (or more) family/households belonging to one of several socio-economic groups. A Social Accounting Matrix (SAM) of the local economy will be used as a basis to set up a spendings matrix for each agent, defining its spending priorities. Artificial Intelligence techniques will be used to give the agent the possibility to make decisions on how to satisfy these spending priorities. Also, social dynamics, the simulation of strategic planning behavior, learning, and exchange in limited networks will be addressed.

The simulation application will consist of a common user interface allowing the user to "play" the simulation. This user interface layer will be "pluggable" with the underlying programming layer responsible for the calculations on the simulation, so that different plug-ins may be used for different simulation techniques.

KEY WORDS

multiplier effect, simulation, multi-agent based simulation, social accounting matrix, artificial intelligence techniques

CLASSIFICATION

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INTRODUCTION

PROBLEM IDENTIFICATION

Lack of circulation

This project is based on the assumption that – next to many other reasons – one of the main causes of poverty is that poor regions are too often caught in something that can only be described as a permanent economic depression in the traditional meaning of the word, characterized by underemployment and under-use of productive capacities. Development of such regions is hindered by a whole set of economic circumstances, such as the lack of credit, weak market demand, low levels of education, weak supply chains and an overall lack of attractiveness for investors, to name only a few. A general result is that the concentration of any incoming money to be used for outside purchases and a lack of circulation of money in the local economy, with a subsequent lack of exchange, even of otherwise viable supply and demand. All other policies to improve the regional economy might fail if there is hardly any purchasing power provoking entrepreneurial qualities locally.

Commonly used strategies to improve a depression in a country (like stimulating exports, allowing more credit, and stimulating governmental debt-spending) generally focus on creating a stronger inflow of money into the domestic economy. Less studied and practiced are strategies not focusing on higher inflow, but on optimizing the local circulation of existing or new monetary resources in the local market, which is a field that can be opened once one has a sufficient overview of the expenditure and circulation patterns.

Limited multiplier effect due to fast outflow

Fishers' equation of exchange "$MV = PT$" (Fisher, [5]) can be used to explain that when the velocity of circulation of money (V) increases and the amount of money remains (M) stable, the income (PT) will increase. For a local economy this means the more inflowing money goes from hand to hand, the more it supplies the productive chain with income and liquidity and the more it leads to an overall stimulation of the local economy. This is called the multiplier effect of expenditures, a concept that receives little or no attention in the Local Economic Development debate.

Of course there is no multiplier effect if the first or second actor in the chain does not spend the money with the next but spends it outside the region. This is too often typical for what happens in poor regions: these regions are characterized by the fact that incoming money leaves the region before being properly used to perform the above mentioned tasks. Hence the (lack of) circulation of money is one of the essential aspects of the vicious circle of (under)development. This is an under-estimated aspect and it is the central focus of this research effort – which is still in a preliminary phase.

If donor or governmental project support wants to optimize the effectiveness of its financial inputs there is a need to know the actual flows of money and how these will be influenced by the potential strategies of spending. In other words: it is important to look beyond the immediate impact of these strategies, and be able to predict the multiplier effects in the longer term. Gathering knowledge about these flows and identifying the parameters which have effects on the duration and velocity of internal monetary circulation is essential in this process.

Government programs, (micro-)credit and investment programs and other local economic initiatives might increase effectiveness if activities and programs could be realized in such a way that also subsequent impacts following from the multiplier effect can be optimized

(Strohalm, [10]). To be able to do this policy makers are in need of a cheap and effective evaluation tool capable of monitoring and simulating all the flows of money in the local or regional economy – specifically where it concerns the poorer areas.

PROJECT FOCUS

This research project will focus on the realization of a computer simulation program specifically applicable for analysis of the monetary flows in poor regions and which allows simulating the multiplier effects of expenditures in the economies of poor regions. This would:

- help to increase the general understanding of all monetary flows in a particular poor local economy, and their significance for development. Even if this project would only contribute to the awareness of this issue it would present a significant achievement,
- strengthen the planning process with ex ante tests and projections of the potential effects of the policies,
- make it possible to identify and determine the parameters which have a positive effect on the duration and velocity of internal money flows,
- support innovative approaches to optimize the multiplier effects,
- in general: get more understanding about how to optimize development strategies.

LITERATURE REVIEW

SIMULATING VILLAGE ECONOMIES

To simulate the effect of a money injection that results in development efforts on a relatively small local economy, we should model the transfers between economic units in that economy. There are several ways to do that.

Literature of modeling these local economies is abundant. Taylor and Adelman [10] give an overview of different techniques for modeling these economies, described in the following sections.

Social Accounting Matrix (SAM)

In a Social Accounting Matrix (SAM) (Adelman, Taylor and Vogel [1]) the population is divided into several actors (including “Rest of the World” as an actor). A table defining all transfers between these actors is used as basis for identifying money flows in the community. The method is used to calculate how increasing or decreasing incomes work their way through the economy. Apart from defining the matrix itself, the method is relatively easy.

SAM has several shortcomings, of which the (unrealistic) assumption of fixed prices is one of the most important.

Computable General Equilibrium (CGE)

Where SAM considers the village to be a price taker for all products, Computable General Equilibrium (CGE) (Singh, Squire and Strauss [9]) acknowledges that prices for some goods are determined at village level. The method is based on maximization of the utility-function: the overall sum of the product of price and demand is assumed to be maximized for all products.

CGE is generally more complicated, and is more of an overall technique, which fails to address distributional aspects within defined groups. For this reason, we will not use it as a basic technique in the first versions of our simulation (the null version). Some CGE aspects might be used on a detailed level later on in the development of the simulation, especially where it concerns the simulation of the existence of an additional currency besides the national currency. However, as this is only in the extension of our project, it is left outside the scope of this article.

Multi-Agent Based Simulation (MABS)

Multi-agent Based Simulation (MABS) is a rather new scientific discipline, in which an environment is created where "agents" define the behavior of the system on an individual level in order to monitor the output of this behavior on a macro-level. The interactions between the individuals create effects on the macro level.

MABS is a technique which can be made as complicated as one would want to. In general, it is the best tool when one is especially interested in distributional aspects, as the tool allows for monitoring on an individual agent level, thus respecting heterogeneity in the underlying population. See http://www.econ.iastate.edu/tesfatsi/ace.htm for an overview of "agent based computational economics".

Combining techniques

Davies [4] summarizes how several of these techniques can be combined in one simulation, depending on its geographic scope and the focus and objectives of the study. A combination of techniques usually provides significantly more realistic results than using only one technique. In economic simulations it is not uncommon that different simulation techniques lead to different results.

Also, one of the basic shortcomings of customary economic simulation is the very poor concept of agent decision making that lies behind calculations in customary simulations: the basic assumption that each agent is only concerned in "optimizing" its utility function, and that this is the only driving concept behind an agent's behavior – where each economist knows this is not a realistic assumption, as social processes play a role which is at least as important. This is where the concept of Artificial Intelligence comes in.

ARTIFICIAL INTELLIGENCE

The art of creating intelligent agents

Artificial Intelligence (AI) is a branch of computer science that studies the computational requirements for tasks such as perception, reasoning, and learning, and develops systems to perform those tasks. Artificial Intelligence (AI) is the study of how computer systems can simulate intelligent processes such as learning and reasoning.

Computational Intelligence is the study of the design of intelligent agents. Computational intelligence combines elements of learning, adaptation, evolution and Fuzzy Logic (http://en.wikipedia.org/wiki/Fuzzy_logic) to create an artificial form of agent intelligence in order to simulate natural behavior as realistic as possible.

A multi-agent approach based on intelligent agents has many advantages over customary simulation techniques. First of all, not only "utility maximization" is the only driving concept behind agent behavior, but a whole set of motivations can be assigned to the "rule interpreter" which is defining an agents behavior. In this way, several complicating factors influencing economic behavior may be simulated, such as:

- social dynamics (such as copying behavior, "fashion", etc),
- strategic behavior and planning of agents – which is of course an integral part of doing investments,
- learning and experiences with certain products, producers or even networks of producers,

- the role of social conventions in exchange,
- behavioral dispositions,
- asymmetrically available information, etc.

Where classic simulation methods fail to address most or all of these issues, Computational Economics offers instruments to implement these in a simulation, resulting in more realistic results and a program that can be adapted when knowledge accumulates.

Local Networks

A special role can be given to modeling economic behavior in local networks [12]. Naturally, a large portion of economic interactions involves a very small portion of the population, as consumers seem to prefer familiar venues. This factor is typically omitted in customary simulation of markets – where agents seem to interact impersonally and efficiently with an infinite number of faceless other agents. Applying Artificial Intelligence and social network techniques can define networks where agents are assumed to occupy nodes from which they have a strong preference to interact only with agents directly linked. Applying such network structures in simulation has proven to be able to change the outcomes of the simulation drastically.

OBJECTIVES & RESEARCH QUESTIONS

PURPOSE

The **purpose** of the project is to contribute to the increase of the (understanding of) efficiency and real impact of development interventions in poor local and regional economies.

OBJECTIVE

The **objective of the research is** to develop a software for the simulation of local development policies and projects, including second-degree effects on non- direct beneficiaries, in a feasible and affordable way, including the option to test less common ways to optimize the effects.

Specific Objectives

The specific objectives of the project are:

- To develop a simulation of economies in poor regions, which can be used to evaluate and predict the effect of injections of money into the region, such as local welfare subsidies (for example the Brazilian Programa Bolsa Familia, an income-transfer policy for poor families), credit programs, infrastructural and other investments, etc.
- To create a simulation that is able to address secondary and deeper levels of impact which take place as a result of the multiplier effect.
- To add extensions to this simulation so that it is capable to simulate also the impact of actions to reinforce the multiplier effect at the local level. The following options to simulate development policies and programs will be included: specific tax policies, micro-credit programs and programs to stimulate regional trade circuits based on internal accounting structures.
- To publish results in appropriate scientific magazines and disseminate the results within several organizations, researchers and practitioners in the area of development and cooperation, with the aims of influencing policies of regional and local development, generating more dialogue and action on the issue.

- To create a gaming software extension introducing the players to the specific problems of poor regions, and the policies to tackle these problems. This will be done by making the simulation software adaptable towards a game, or by the simulation software being pluggable into specific gaming software, so that its results may be used by the gaming software. Different versions of this game might be produced that aim at different groups, like politicians, general public, community workers, etc.

UNDERLYING HYPOTHESIS

Focusing a simulation on multiplier effects suggests that increasing the local circulation of money inside a community is a possible strategy for improving local economy. This is the hypothesis underlying the research effort. The idea is that money will be more effectively organizing a region before it leaves. In the longer run all will profit if regions are more specialized and have less unused capacities.

RESEARCH QUESTIONS

The following questions will be central to the research:

- What are the general parameters that determine the flows of money in poor regions? Amongst parameters considered will be inflow of money, outflow of money, interest rates, local taxes, investment opportunities, etc.
- Which are the optimum values for the sets of these parameters resulting in optimization of economic activities, local circulation, and effective use of money?
- What is the relation between the level of local development and the patterns of flow and outflow of money in the community?
- Can temporary actions to prolong the local circulation and/or postpone outflow of money indeed benefit the long term economic development of a poor region? And is this practical as a strategy to boost local economic development?
- Is it possible to forecast the impact of various development policies and methodologies with the created simulation? If it is, what is the outcome of these forecasts?

METHODOLOGY

MODEL

Simulation techniques

As pointed out in the literature section, there are shortcomings on both SAM (with its assumption of fixed prices) and CGE (failing to address distributional effects). Our analysis has led to the conclusion that a multi-agent simulation would represent an important added-value to the research – offering optimal flexibility in general, enough possibilities to monitor distributional effects on the household level, and the opportunity to introduce intelligent decision-making on an individual level. The latter is specifically needed when applying the software for the simulation of more complex elements like the introduction of the effects of informal economy and regional exchange circuits if these would facilitate a significant part of the regional trade.

Basic model

The basic model will be a multi-agent setup. An agent represents one (or more) basic economic units being the family household, where each household belongs to one of several pre-defined socio-economic groups. Membership of a socio-economic group determines a family's main income raising activity (e.g. farmers, civil servants, merchants, pensioners, etc.).

Each socio-economic group has a set of pre-defined features, such as "household size in number of persons", "debt level", etc. This does not mean that every member of this group is exactly copying the group level features; by bringing in variation over the agents within a group, the features of members in one group fall inside a reasonable range, where the mean of all members of the group is the predefined value of the feature.

One of the features of each agent is the amount of incoming money per month – where "incoming" means coming in not from other members of the community, but from the outside world. Again this number is not exactly the same for each member of a socio-economic group, though the group membership determines the range in which this amount falls.

The basis of the model implies the application of SAM data upon a multi agent population. According to the SAM data, for each group of agents a sum of money comes in from the outside world, and we will follow all these sums of entering money on its journey through this community, passing from hand to hand by the different agents in the model, until the money is spent outside the community by any agent.

For being able to follow this money, we must know how every agent spends its monthly income: how much is given to which other agent belong to what other socio-economic group. For each agent we will have a matrix of expenditures which is a derivation of the matrix of expenditures of the group as it is defined by the SAM – again within certain bounds of variety. The matrix of expenditures of each group is determined by the global Social Accounting Matrix which serves as the basis for this model.

So, one agent is the entry point for this community of a certain amount of money; this money is spent via this agent's personal matrix of expenditures. Part of the money will be spent immediately outside; another part will be spent to another agent, which, in turn, will spend it again according to his personal matrix of expenditures, etc.

The example above sketches the starting situation of the simulation – where the general assumption is that the community is in a "steady state": as well on a global level, as on a group level, as on an individual level:

- incoming money = outgoing money,
- no growth, no shrinking,
- debts are also in steady state, neither growing, nor shrinking. (Debts will of course be paid back, but then new debts will come in place).

The goal of the simulation is not, however, to model this initial "steady state" but to gain knowledge of what would happen if an extra amount of money would be injected at certain entry points in the simulation. Therefore, it is important to realize that this "steady state" assumption only holds for the initial state as a starting point of the simulation.

When simulating the injection of money in this community, it is essential to know how households will react on this. It is not very likely that when receiving 20 % extra income a month, a household will immediately pay every recipient of its money a 20 % extra – one does not pay 20 % extra rent when having a lucky month with 20 % extra income. For each agent, a "matrix of priority in expenditures" will be set up. This is an extra dimension to the personal SAM, indicating which spending has priority at which moment. When raising income, a poor family would first want to buy more food, then more luxury, then probably think about investments – this kind of decisions are reflected in this "matrix of expenditures".

Artificial Intelligence techniques come in where it comes to an agent's decision on how to satisfy its “priority matrix of expenditures”. Within certain boundaries, an agent has the ability to weight its priorities in expenditures, depending on the availability, kind and prices of the commodities purchased. Also the agent may, within certain boundaries, actively search for “best offers” inside the community. “Best offers” can of course only be modeled when not only the consumption side of the model is flexible, but also the production side of the model allows for a dynamic approach. This will also be modeled via artificial intelligence techniques, with respect to the fact that people have a tendency to be much less flexible in changing their jobs than in changing their consumption.

SETUP

Data

Data collection is often very expensive in terms of time, efforts, and money. An associated problem is that one has to be very careful not to lose oneself in data collection, as data are never perfect, and there are always more data to be retrieved.

Also, the scope for this study is not trying to create a simulation which tries to describe as realistic as reasonable a specific real life situation. The focus is not developing a case study; the focus is developing a model to be used in various cases. Also, this model should work with most (reasonable) data.

This research effort will not spend much time on data collection in general. The first stages in the research we use data of an imaginary poor economic region. We will use existing cheap and easy available data to base our artificial population upon, and we will use various methods described by Schreinemachers [8] in order to bring diversity in our artificial population.

In various stages we will fine tune and verify the artificial data by tests with data gathered in one area, presumably the north of Uruguay.

Application setup and instruments

Axelrod [2] emphasizes the importance of replicating simulations of other researchers in order to retrieve more reliable results, and gives various suggestions for making simulations easier to be replicated. Use of the Java programming language (with the REPAST simulation library) is explicitly recommended by Axelrod. In order to improve the reliability of simulated results, the simulation application will be built as a separate user interface in Java, which can be plugged into different base-applications which handle the actual simulation, and pass the results of it to the user-interface. Various base-applications will be produced, each of them using a different (combination of) simulation methodology. With this approach, we are able to combine different simulation techniques, which may hopefully lead to more reliable results.

The Java language with its strong support for interfaces is the most appropriate tool for this approach. Java is typically supporting a setup as described above, where different, pluggable application layers communicate via strictly defined interfaces, and need no more “awareness” of each other than the interface contract. In this way, the choice for Java facilitates working on independent simulation layer plug-ins while still being able to use a single common user interface. The choice for REPAST in this application model is merely practical and based on personal experience; the choice of another Java simulation library would of course not violate this application setup.

Project setup

It is important to realize that the project is still in preliminary phase. We hope to realize the project through a joint- effort of several universities and research institutions throughout the world. At this moment there are prospects in Brazil, China, the Netherlands, Spain, and Uruguay.

Several project teams may be formed, each of which will be working on a specific model or module of the simulation. Project teams might adapt a (different) simulation methodology, and apply that to provide one of the base-applications which can be plugged into the user interface application.

The duration of the complete project is estimated for 4 years. The complete project will include several subprojects and the following corresponding phases:

1. **A null simulation** (36 months), which is able to model monetary flows inside local economies. This part of the research is of interest to any organization or project which aims to examine primary **and** secondary effects of policies or projects. This would involve:
    - 1.1. **Gathering (existing) data:** the emphasis in this first phase lies more on methodology than on validity of the data. Existing basic data will be used, completed where necessary with artificial data. See the section on data collection in the Methodology chapter.
    - 1.2. **Creating the Graphic User Interface Application:** At first, a team of programmers will create the Graphic User Interface Layer of the Application. All necessary user actions will already be programmed into the application wherever possible. The User Interface Layer will communicate via Java interfaces with the simulation layers of the application, which can be plugged in to it. These interfaces will be defined for all project groups in an early stage of the project. The first plug-in simulation layer will be a mock simulation producing mock data to feed the user interface layer, so that initial testing of the user interface can begin.
    - 1.3. The main simulation team will work out the first **simulation plug-in**. This program will be plugged in to the user interface layer. This first simulation will be based on MAS, combined with SAM for identifying the basic money flows in the community, and with CGE for determining price mechanisms related to complementary currency issues. Special attention will be given to create a population of agents which is as realistic as possible, by using various techniques to maintain variability inside the population of agents (after Schreinemachers [8]). The latter includes the implementation of local subnetworks inside the population of agents.
    - 1.4. Optionally, other teams could work on plug-ins using different simulation techniques, for example:
        - 1.4.1. a simulation where the emphasis is more on "intelligent agents" with "rule interpreters". The focus is here more on quality of decision making agents, rather than on a large quantity of relatively simple agents.
        - 1.4.2. a simulation combining CGE with micro simulation, after Robilliard, Bourguignon and Robinson [7] or Cogneau and Robilliard [3].
        - 1.4.3. a macro/microsimulation combined with SAM, after Lattarulo, Paniccia and Seielone [6].
    - 1.5. A first game based on the simulation will be produced.
2. **The "actions" simulation (24 months, partly overlapping)**, focusing on **modeling supportive actions.** Software is developed that allows testing different ways of reinforcing the economic impact of monetary injections. What if these expenditures are done in a specific context? For example: Does it help to spend under limiting conditions

like binding the purchasing power inside a regional trade circuit? What difference would it make to induce it as a credit? What kind of credit has what kind of effects, etc?

The software not only allows introduction of purchasing power in different points of the economy, but specifically models several actions which are performed in order to stimulate the effectiveness of this injection.

RESULTS

Measurements of results

The results of the simulation are defined in the following ways for the case of different kinds of projects and methodologies of development interventions:

- Evolution/impact on gross product for the complete population, and for each of the defined groups of families.
- Development of multiplier effects: how long (in time and in the amount of transaction steps) does it take before the value of 1 national currency unit leaves the community?
- Evaluation of efforts that target on reinforcing the multiplier effect.
- Evolution of distribution of income in the local society, in particular the reduction of number of poor families.

Validation of the simulation

In the final stage of the project, the simulation must be validated. This will be done in several ways:

- Feeding existing studies of other economic models into the simulation and compare our results with the results of those studies. This will be done with several studies based on various different simulation techniques.
- Feeding data of a real world situation in the simulation, and verify if the simulation reasonably describes the development of that specific region. In order to validate the results, there should be data available for two different points in time (which define a reasonable time span, preferably 3 to 5 years). If applicable data are available from literature, these will be used.

RELEVANCE OF THE FORTHCOMING STUDY

VALUE OF THE PROJECT

Modeling of local economies has been done numerous times before. We believe this project to represent an added value to previous research because of the following features:

- Focus on the practical application of a software tool that facilitates measuring and predicting the effectiveness of development projects.
- Approaching the subject from a monetary point of view, by taking the multiplier effect as a basis of the simulation. Through this approach, also secondary and longer term effects of money injections can be included.
- Applying state of the art technology in favor of the poorest.
- Use of multi-agent simulation as the basic simulation technique, combined with "artificial intelligence" techniques to make decisions of agents as realistic as possible. Each agent is representing (a group of) economic units, and gets a "rule interpreter" allowing him to take reasonably intelligent decisions.

- Additional to multi-agent simulation as the base technique, several combinations of other simulation techniques will be applied and compared.
- The end application will be able to compare large sets of several simulation runs under varying circumstances, and to apply sound statistical analysis to them.
- Ability to present the outcomes of the research as a playable "game".

Application of the tool

Basically, the overall application of the tool will be focused on evaluation and improvement of development projects and strategies. The tool will be used as:

- **A policy tool**, contributing to refinement and higher effectiveness of development tools and policies.
- **A research tool** that will provide the model and instrument to:
    - Represent and understand more completely the monetary dynamics at the level of local economy.
    - To make comparative studies of the (*ex ante*) simulation of the potential effects of (combinations of) different development approaches.
- **A monitoring and evaluation tool** usable during the execution of development programs, allowing to evaluate, in a more accurate manner, their progress and impact.
- **A training tool** for existing and new employees working on projects with a monetary development approach: as the subject of these projects is very complex, a training tool that simulates the operation and impact of the activities would be very helpful to train employees and staff in how to set up a program and even offer the opportunity to learn by "trial and error".
- **A tool to create awareness** and interest of third parties, policymakers, local actors and the public in general, especially when the program is applied as a "game". From this point of view, people must be able to use and handle the application without intensive training and should be able to apply growing complexity of the simulation in a step-by-step process.

Relevance of monetary focus

Though at present several simulations are available for testing the effectiveness of development projects, generally there is very few attention to monetary aspects. For example: too often, evaluations on micro credit programs only focus on the direct receivers of credits, but fail to determine how the money flows through a community after this first step – thus ignoring indirect effects. In that case evaluations could create wrong impressions. For example a credit to finance a bakery may be considered as successful, while it might not especially contribute to the economic development of the region. This could be the case if five other bakeries nearby go into bankruptcy and no additional exports towards outside the region are realized, only a swift within the internal market. Therefore, we believe economic simulations and evaluations should also include secondary effects and monetary flows, and should also be able to visualize effects on a detailed level.

Relevance of implementing Artificial Intelligence techniques

The fact that Computational Economics is a relatively new technique which offers various extremely interesting features to cover many shortcomings of classical simulation techniques has unfortunately not yet been realized enough in the world of econometrists and modelers of economies. In practice, Computational Economics techniques are not often being used in economic simulations. Computational Economics provides the opportunity to closer simulate the reality. This is of special importance for our simulation, as it is not merely meant to simulate a static reality, but is also meant to test whether investments in different places or different ways might create better results.

Especially the objective to simulate the multiplier effects of innovative policies towards financial injections is in need of advanced simulation techniques which are able to simulate planning behavior and strategy building by agents. As this part of the simulation is specifically aimed at actions which are focusing on, or at least resulting in (stimulation of) increased investments, there is a definite need for simulation techniques able to handle planning and strategy building behavior at an agent level.

Also the options offered by Computational Economics to simulate the existence of subpopulations and networks of agents is a very important addition, as in reality most trade in a community is taking place inside informal networks of people knowing each other, and only a small part of money is spent outside the small circle of “people we know”. This feature is also of major importance when it comes to simulating the effect of networks such as existing in micro credit programs or semi open circuits of local businesses.

With the application of Artificial Intelligence techniques, the simulation program we hope to produce will be a learning program which is capable to integrate the understanding of its users and grow step by step in usability to implement investment policies in poor regions.

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MODELIRANE LOKALNOG TOKA NOVCA U SIROMAŠNIM PODRUČJIMA: ISTRAŽIVAČKI POSTAV ZA SIMULACIJU UMNAŽAJUĆEG UČINKA U LOKALNIM EKONOMIJAMA

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SAŽETAK

U siromašnim područjima, smanjeni opticaj novca jedan je od ključnih uzroka nerazvijenosti. Što se više novca uključi u opticaj, više će lokalna ekonomija biti stimulirana. Međutim, u većini siromašnih područja novac se troši izvan zajednice prije lokalnog opticaja čime se dramatično smanjuje učinkovitost uključivanja novca.

Razvojni programi bi povećali svoju učinkovitost kad bi bilo poznato kako trošenje novca može dovesti do optimiranog i produženog lokalnog opticaja. Za saznavanje navedenog bit će razvijen simulacijski alat kojim se može analizirati financijske tokove, radi izvrijednjavanja utjecaja specifičnih akcija na lokalni razvoj i radi praćenja sheme razvoja tijekom faze izvršavanja.

Osnovni model bit će razvijen u multiagentskom pristupu pri čemu svaki agent predstavlja jedno (ili više) kućanstava iz nekoliko socio-ekonomskih grupa. Na temelju matrice socijalnog računanja za lokalnu ekonomiju bit će postavljene matrice potrošnje za svakog agenta, definirajući njihove prioritete. Pomoću tehnika umjetne inteligencije agentima će biti dane mogućnosti odlučivanja kako zadovoljavati prioritete potrošnje. Također će biti razmotrene socijalna dinamika, simulacija strateškog planiranja, učenje i izmjena u omeđenim mrežama.

Primjena simulacije sastojat će se od sučelja pomoću kojeg će korisnici postavljati parametre za simulaciju. Korisničko sučelje će biti nadogradivo dodatnim programskim modulom odgovornim za proračune, tako da će biti moguće upotrijebljavati različite module za različite simulacijske tehnike.

KLJUČNE RIJEČI

učinak umnažanja, simulacija, višeagentna simulacija, matrica socijalnog računanja, tehnike umjetne inteligencije