8th International Scientific Conference
"Business and Management 2014"
May 15–16, 2014, Vilnius, LITHUANIA
Section: Social and Economic Business Enviroment
http://www.bm.vgtu.lt

ISSN print 2029-4441/ ISSN online 2029-929X
ISBN print 978-609-457-652-2/ ISBN online 978-609-457-651-5
Article number: bm.2014.063
http://dx.doi.org/10.3846/bm.2014.063

THE AGENT-BASED STRUCTURAL APPROACH IN INFRASTRUCTURE FOR ECONOMIC GROWTH

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Abstract. The recent development of the EU exhibits the challenge of large infrastructure investments intended to eliminate disparities among the EU Member states. The Structural Funds and the Cohesion Funds form together one of the largest parts of the European Union's budget. This paper is aimed to carry out the applicable theoretical methods for the infrastructure development policy, which provide the conventional methods describing the random behavior of the heterogeneous economic agents, the changing structure of entire markets and the institutions, considering the influence the heteroscedasticity of the global processes beyond and within the EU and provide the mechanism to link intertwined cross-border components with high degree of freedom into a system. The agents are continuously adjusting their behavior in the dynamically changing environments through generation of new patterns of behavior and raised complexity of the interactions. The argued method based on agent-based macroeconomic model, which differs from the common dynamic stochastic general equilibrium approaches.

Keywords: agent-based models, logistics, policy, EU, non-EU countries.

JEL classification: E60, F18.

1. Introduction

The recent development of the European Union exhibits the challenge of a large infrastructure investment needed for restoration of infrastructure capital stock in the member states, which joined European Union lately. The Structural Funds and the Cohesion Funds resources were involved into the implementation process of the European Union regional policy having in focus to reduce regional disparities in terms of income, wealth and opportunities. The new European Union member states receive the most of funds pervaded for the entire European Union however.

The Structural Funds and the Cohesion Funds form together one of the largest items of the European Union's budget. The worldwide trends demonstrate clearly that due to a number of global processes such for instance climate change, intensifying of international trade through the World Trade Organization's enlargement and population growth, the infrastructure network is getting fatigued under the rapidly changing circumstances. The basic setting for this work paper implies the definition of the infrastructure predominantly in economic terms at the first stage; however the framework might become more sophisticated by introducing new agents into environmental settings with other patterns and behavior.

The authors make difference clearly the economic from social infrastructure. The last includes the facilities and equipment needed for satisfying society's essentials in terms of education, health and community services. The entire infrastructure belongs to capital assets, which considered being public infrastructure if governments own them predominantly, or where private funds raised for the investments. From the historical perspective, governments had the leading role in developing and managing infrastructure facilities.

In the literature, the macroeconomic aspect of infrastructure related issues appears through different channels. Therefore, we need to discuss the possible role of infrastructure in the economic growth in a broader sense.

The infrastructure separately was reviewed by the theory of growth in the literature by K. J. Arrow and M. Kurzs (1970), where the application of Pontryagin maximum principle applied to an infinite horizon neoclassical growth model with a single output which can be consumed or used as government or private investment. The optimal path is to be achievable under perfect capital markets conditions and the private utility maximization of a single representative consumer by a government policy of lump-sum taxation and government expenditures. M. Weitzman (1970) followed the optimal Ramsey's economic growth and presented the overhead capital sector exhibits returns to scale. The study considered an entire economy on the most general level with introducing β which consist of all social overhead capital including public service facilities in extended sense, agricultural overhead and hard public utilities including but not limited to transportation and communication. However, R. Barro (1990) in his study of endogenous growth gave a real push for further deeper researches in the area of infrastructure. Barro's model has extended growth model introduced the tax-financed government services that affect production or utility. Growth and savings rates fall with an increase in utility-type spending. With an income tax, the decentralized choices of growth and saving are getting lower, but in case of Cobb-Douglas production function, the optimizing government still satisfies a natural condition for productive efficiency.

Infrastructure becomes an important issue of growth as shown in the researches carried out by D. Aschauer (1989, 1990).These works concentrated on the estimation of the production elasticity of government expenditure, using aggregated data for countries. There are also cross-country studies that emphasize the role of infrastructure for a country's growth.

2. Out-of-equilibrium models: theoretical framework

The economics have been developing science adjusting methods and theories for the constantly mutable environment settings. The fact of the matter is that the dome has been opened for discussion, which theoretical and conceptual approach can embrace the processes itself and explain underneath causes a better way. From the literature body it is obvious to see that equilibrium approaches in different forms have been enormously successful along with the economic science. The main principles of equilibrium have been incorporated into the neoclassical structure widely known nowadays and common accepted to explain macroeconomic processes in every possible detail. Latest Dynamic stochastic general equilibrium (DSGE) models are popular nowadays in macroeconomics, which development of DSGE models that deliver acceptable forecasts as followed by N. Marco (2003), F. Schorfheide (2011), M. Negro and F. Schorfheide (2006) etc.

However, the discussion of emerging models in economy has been intensifying and debated in the literature body over the last decade. A. Brian (2005) pointed conceptually out that traditional studying equilibrium patterns of consistency required no further behavioral adjustments. With time passing by economists begins to study the emergence of equilibrium and the general unfolding of patterns in the economy, which motivated to study the economy out of concept of equilibrium. The way of doing economics calls for an algorithmic approach by involving a deeper approach to agents' reactions to change. Algorithmic approach recognizes that agents are naturally heterogeneous, what rose complexity of economic process demanded more sophisticated methods, which should explain individual behaviors collectively create an aggregate outcome and their reaction to this outcome. Such individual and group behavior creates pattern and pattern in turn influences behavior. This differs from the equilibrium approach tends itself to expression in equation form whereas by definition a pattern that doesn't change. Such simplicity that makes analytical examination possible has a shortcoming. To ensure tractability such models assume in general homogeneous agents or at most two or three classes of agents. The agent behavior assumed that is intelligent but has no incentive to change. Hence it should be assume that agents and their peers deduce their way into exhausting all information they might find useful, so they have no incentive to change. Out-of-equilibrium systems may converge to or display patterns that are consistent, where standard equilibrium behavior becomes a special case.

Back to the modern macroeconomics formalized by equilibrium equations as illustrated by M. Grabner (2002), who argues the representative agent models abound, where instead of modeling the behavior of millions of different consumers and thousands of firms, one usually studies instead the decision problem of the representative economic unit and applies the results to aggregate quantities. Representative agent models allow the researcher to avoid the Lucas critique[1], they are of help in the construction of Walrasian models, and they may be used to establish microfoundations for macroeconomic analysis. However, C. Bruun (1999) claims that in the general equilibrium and Keynes theories heavily used the principle of representative agent is rather difficult to formalize heterogeneity by introducing one or few right agents in order to establish a link between the micro and macro world. The view of the economy developed by A. Kirman (2004) represents heterogeneous interacting agents who collectively organize themselves to generate aggregate phenomena which cannot be regarded as the behavior of some

[1]Named for Robert Lucas' work on macroeconomic.

average or representative individual. There is an essential difference between the aggregate and the individual and such phenomena as bubbles and crashes, herd behavior, the transmission of information and the organization of trade are better modeled in the sort of framework suggested here than in more standard economic models.

Another aspect of processes formalization is related to a bounded rationality. The definition of bounded rationality given by B. Jones (1999) asserts that decision makers are in general rational, so they are goal oriented and adaptive, but because of human cognitive and emotional architecture, they sometimes fail, occasionally in important decisions. In politics science this conception has an important implication. In structured situations, at least, we may conceive of any decision as having two components: environmental demands and bounds on adaptability in the given decision-making situation. Standard statistical techniques give the tools to distinguish systematic from random factors, so in principle it should be possible to distinguish the rational, adaptive portion of a decision from bounds on rationality. H. A Simon *et al.* (2008) looks deeper into phenomena of bounded rationality for economics interpreting the role of individuals' decision making and debating details of information awareness. The aspect of bounded rationality is not reflected in traditional equilibrium-based modeling but it can be seen from the game theory point of new to a certain degree. Per H. Matsushima (1997) the game theory for economy is not dealing with bounded rationality so directly and the incorporation of the principles based on bounded rationality for agents have been seen by Matsushima as important issue to analyze the agents' behavior.

Another discussion raised by P. Howitt *et al.* (2008) exhibit a strong undercurrent of opposition to modern macroeconomic models which have coalesced around DSGE models. Howitt's study also supports the main ideas of A. Brian (2005) and A. Kirman (2004) of enormous ad hoc assumption in the standard equilibrium models based on introspection, not on any mass of coherent empirical evidence or even on any intuitive plausibility criteria. So any meaningful model of the macro economy should analyze not only the characteristics of the individuals but also the structure of their interactions. The advantage of the agent-based modeling and simulation[2] (ABMS) approach for macroeconomics in particular is that it removes the tractability limitations that so limit analytic macroeconomics. ABMS modeling allows researchers to choose a form of microeconomics appropriate for the issues at hand, including breadth of agent types, number of agents of each type, and nested hierarchical arrangements of agents. It also allows researchers to consider the interactions among agents simultaneously with agent decisions, and to study the dynamic macro interplay among agents.

L. Tesfatsion (2003) gives insights into the meaning and the definition of a complex adaptive system representing the entire economy which phenomena associated with decentralized market economies, such as inductive learning, imperfect competition, trade network formation, and the open-ended co-evolution of individual behaviors and economic institutions. A challenging issue motivating ABMS research in the area of economic network formation is the manner in which economic interaction networks are determined through deliberative choice of partners as well as by chance. A key concern has been the emergence of trade networks among collections of buyers and sellers who determine their trade partners adaptively, on the basis of past experiences with these partners.

C. Bruun (1999) supports that the economic system should be perceived as a complex adaptive system, and that within economics, complexity arises from at least three different sources:

1. from the fact that the economy is a large composite system;
2. from the fact that economic agents adapt their behavior to the system;
3. from the fact that economics is characterized by a lot of relations that must hold in the aggregate, but need not hold for the individual agent.

C. Bruun's (1999) study highlights further characteristic of complex adaptive systems is that they have a capacity to self-organize and adapt to changing environments, where despite the lack of a global controller, complex adaptive systems appear to perform quite well.

The study of C. Chan and K. Steiglitz (2008) with a sample model explains further the principles of ABMS, which integrates this notion of emergent behavior with the study of the economy. Normative insight into economic behavior is derived from the bottom-up through the simulation of computational agents. Further, they provide three broad categories of ABMS:

1. the first category includes the simulation models that merge traditional economic theory with machine learning and other computational techniques;

[2]Agent-based approach has a few definitions in the literature body, which have the same meaning. In this paper the author uses abbreviation ABMS for all such common methods.

2. a second category of agent-based macroeconomic study consists of massive simulations of real economies;
3. the final category consists of agent-based simulations of relatively basic economies that do not directly model a real economy.

There is a number of prerequisite arisen from its nature of the infrastructure development as a complex system. The analytical framework should provide the conventional methods describing the random behavior of the heterogeneous economic agents, the changing structure of entire markets and the institutions, considering the influence the heteroscedasticity of the global processes beyond and within the European Union and provide the mechanism to link intertwined components into a framework. From the global perspective the infrastructure denotes the complex systems represented as a network, which diverges from an initial state even by local events can spawn large-scale patterns and the global shocks.

The whole infrastructure system can be spitted into subsystems organized hierarchically. The fundamental problem of the infrastructure development analysis is that the complex system of infrastructure evolve through time emerged from responses on external factors, interactions among agents characterized often by bounded rationality, but not equilibrium enacted by policies exogenously.

The infrastructure itself does not subsist separately from the environment. The agents are continuously adjusting their behavior in the dynamically changing environments through generation of new patterns of behavior and raised complexity of the interactions. All these criteria impose limitations on the theoretical framework, which might be applied. From this point of view the ABMS represents a simulation modeling technique that might help develop the estimation framework considering the natural patterns agents and sufficient level of flexibility. One of the advantages of considering the ABMS allows incorporating the asynchronous approach implying events influence decisions are happening at different time-frames and different order, what might be an appropriate assumption for the framework.

Based on M. Rieser (2010) transportation simulations are an important part of today's decision making process for transport infrastructure and management. A transit system, or public transportation system, contains several transit lines, run by different operators. Traditional traffic assignment models are getting more and more complex, to a point where a mathematical formulation of the problem is often no longer feasible.

C. Macal and M. North (2010) gives first notions of agents in the ABMS approach, where the complex systems composed of interacting following elements:

1. a set of agents, their attributes and behaviors;
2. a set of agent relationships and methods of interactions;
3. the environment, where agents interact with their environment to other agents.

N. Gilbert (2008) points out the possibility of modeling agent-to-agent interactions is the main way in which ABMS differs from other types of computational models. Agents have behaviors, often described by simple rules, and interactions with other agents, which in turn influence their behaviors. By modeling agents individually, the full effects of the diversity that exists among agents in their attributes and behaviors can be observed as it gives rise to the behavior of the system as a whole.

Based on an evidences from the literature body it is possible to establish a strong link between micro-processes, taking place on the firms or consumers level and macro-processes, represent governmental institution and some global player, who might have direct impact on the economy output.

3. Cross-border overview of infrastructure settings

An important part of ABMS modeling is a clear understanding of environment, where agents interacting. According to K. Kabasov and N. Kabasov (2007) countries and regions can be grouped or clustered together based on similarities, measured on the basis of several macroeconomic variables, which can be analyzed with the use of evolving clustering methods. U. Blien *et al.* (2008) develops regional welfare improvements are viewed as a natural outcome of cluster building efforts. Regional-level specialization, which is clearly seen in a large number of industries, raises the related issue of clustering. The term regional cluster refers to the geographically bounded concentration of independent organizations. The regional clusterization encouraged specialization at the regional level, despite the increased range of options for firms to relocate production away from higher cost locations (OECD, 2007). R. Salais (2005) shows that countries with close interindustrial production and value chains could be interested in cluster policy.

From a broader perspective, the European Union is facing profound challenges because of the eastward expansion of the Union and the need for reform, enhancing the efficiency of management and public support. One of the key subjects in this area is the European Cohesion Policy, aiming at diminishing the regional economic disparities. Infrastructure plays a central role in such investments. The reason is that new EU members, who joined the EU after 2000, generally have a less developed transportation sector. G. Peterson and P. Annez (2007) examine the pattern for spending cohesion funds followed the examples of Spain, Portugal and Ireland in the 1980s. The regulating document of the Council Regulation is focused on covering major transportation and environmental protection infrastructures, according to the EU Council Regulation No 1164/94. In order to describe Russia's case, it needs to be elaborated on larger scope. Firstly, according to D. Wilson and R. Purushothaman (2003), over the coming decade, Russia and China could become a much greater force in the world economy. Secondly, however, according to the historical data of the World Bank, the share of gross capital formation of the Russian GDP is extremely low, considering the current level of development. Russia should have invested more intensively to achieve a better and more stable growth, such as that of Estonia, where the share of investments is much higher. China's investments have been about 3540 percent of the GDP over the last quarter of the century, which guaranteed a significant economic growth.

The infrastructure clusters across European borders are divided not only geographically, but also by common interests, for example in the transshipment sectors, with five main modes of transportation, which are rail, road, pipeline, water and air (Gourdin, 2000). Each of them requires a certain degree of developed infrastructure in order to render services. A good example of cluster configuration by trans-shipment mode might be the stimulation of shorter delivery times for goods from China to the EU via Russia, using railroads network. Such long transshipment corridors require a new approach in the railroad freight concept, involving all interested parties, who are able to manage a modal shift of cargo from road to rail, creating an effective and scalable freight corridor.

Note that the Russian and EU policy is to collaborate. The EU has launched a number of projects, which aim to facilitate the economic growth through infrastructure development among various regions. It pays to mention the First Rail Infrastructure Package EC/13/14/16/EC by the EU Member Countries and the ongoing work on the adoption of the Interoperability Legislation EC/16/2001, which enabled rail operators to have access to the trans-European network on a non-discriminatory basis.

4. Environmental setup

According to C. Chan and K. Steiglitz (2008) the agent-based model of the minimal economy is evaluated in terms of its ability to enable though the emergence of stability in production, prices, employment and other factors. In the basic AMBS model setup for two regions it can be represented by a number of types of agents, such as households, firms, municipal authorities and a central government, which however can be clustered together.

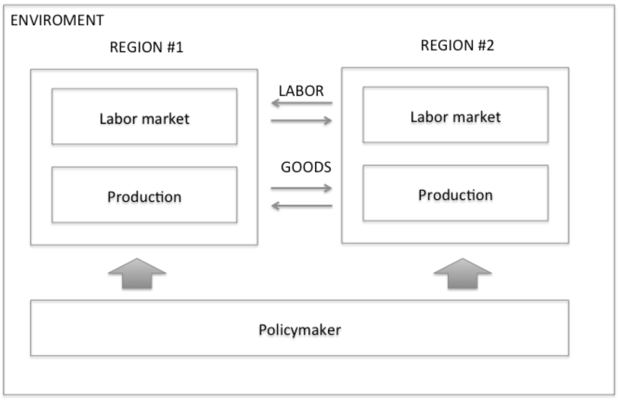

Fig. 1. Basic ABMS setup

Important features of the regional economy are that there are not restrictions in the respective region, but the policymaker can endogenously impose some restrictions. Besides, explicit spatial representation of different linkages is presented such as connections depending on the specific topology.

Environment represents in the model the constant values, which cannot be modified by any policy such as climate change or global crisis. Further, the urban sectors can be linked together by circular economy flows. The spatial economic modeling structure might include interconnections among all the regions or clusters.

Scenario of production firms is assumed to deal with imperfect competitive markets. The total demand for products in a region is equal to the individual household demand functions of the product. The wages in each region is determined in the beginning of the period and change accordingly to the policymaker assumed to be competitive. Each household gives one labor units. The total demand for labor in each region is the sum of the labor demand of each firm in the region.

5. Agents' problems representation

In order to represent a number of agents the clustering methods can be employed in form of partition methods or hierarchical methods. The difference between two methods is that by applying partition method one specific agent belongs to one specific cluster. The hierarchical method allows attributing agents to the parent group.

The agents are represented by datasets include population entities, which are characterized by individual agents. The observations are performed at the aggregated population level, however population properties are taken from the agents' individual dataset. Populations subsampling is a part of cluster analysis based on the agents' data observed at clustering level. Often the cluster characteristics are not the mean of individual agents data implying the data heteroscedasticity.

For the purpose of this paper the term cluster describes to a subgroup features homogeneous characteristics within a population. In clustering there are no classifications referring to the class, so that the agents can be grouped together based on their mutual homogeneity. The clustering method implies the distance between the clusters. Depending to the specific distance, the agents belonging to own cluster are close to each another from the same cluster and logically distanced from those in other clusters.

A. Gelman (2004) shows that the distance in the matrix can be represented in Euclidean metrics, Manhattan distance or Mahalanobis distance. Taken into account the dataset D characterized the *y* observations by means of n-dimensional vectors of attributes can be presented as a matrix X with m rows and n columns:

$$D = [d_{ik}] = \begin{bmatrix} 0 & d_{12} & \dots & d_{1,m-1} & d_{1m} \\ & 0 & \dots & d_{2,m-1} & d_{2m} \\ & & \dots & \vdots & \vdots \\ & & & 0 & d_{m-1,m} \\ & & & & 0 \end{bmatrix}. \quad (1)$$

In the given symmetric matrix distances between pairs of observations between X_k and X_i:

$$d_{ik} = dist(x_i, x_k) = dist(x_k, x_i), \quad i,k \in M. \quad (2)$$

By R. Decker (2007) per definition the Mahalanobis distance can be applied when the datasets are correlated, with different variances and a different range. The definition of the Mahalanobis distance is the following:

$$dist(x_i, x_k) = \sqrt{(x_i - x_k)V_{ik}^{-1}(x_i - x_k)'}, \quad (3)$$

where V_{ik}^{-1} is the inverse of the covariance matrix of the pair of observations x_i and x_k. For simplicity the covariance matrix reduces to the identity matrix assuming observations are independent, so the Mahalanobis distance corresponds with the Euclidean distance.

For the visualization purposes the dendrogram represents graphically the process of subsequent mergers indicating on X the value of the minimum distance corresponding to each merger and the observations on Y.

However, the economic science implies the given degree of uncertainties. The simulated outcomes need to be compared with the statistical methods to distinguish true responses. From one point of view, the simulation result can provide explanation of the events taken place in the past from the past times series but is not able to compare future data inputs at the current point in time. For the analysis there is important to bear in mind that the theories in statistics represent the probability of events driven by the hypotheses. Therefore it is needed to find the broader framework for validation of simulated results in agent-based simulations because artificial results are very sensitive to the agents' architecture and to the parameters setup in the model:

Prior x Data > Analysis model > Posterior: (4)

Bayes' theorem in its general form incorporates components of knowledge and past experience, what can be represented as Prior knowledge (prior probability) and new data combined in an analysis model to posterior knowledge (posterior probability). As soon as the simulation results are uncertain in advance, there is normal distribution is assumed. The posterior probability is derived from the prior probability by input new data. An uninformative prior for the simulation might cause a very wide normal distribution, which might have dominant weight to the posterior. The observations y normally distributed parameterized by a mean θ and a variance σ2. The prior probability p(θ) comes as follows:

$$p(\theta) = \frac{1}{\sqrt{2\pi\tau_0^2}} \exp\left(-\frac{(\theta - \mu_0)^2}{2\tau_0^2} \right). \quad (5)$$

Whereas there is $\theta < N(\mu_0, \tau_0^2)$, hyper-parameters μ_0 and τ_0^2. It means the mean of prior probability μ_0 and the variance of prior probability τ_0^2.

$$p(\theta \mid y) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(y - \theta)^2}{2\sigma^2} \right). \quad (6)$$

The observations y from a normal distribution parameterized by a mean θ and a variance σ^2. The conditional probability $p(y|\theta)$ represented as follows.

The posterior probability using Bayesian analysis and the normally distributed observation $y = (y_1, ..., y_n)$. The posterior probability p(y|θ) represented as follows.

$$p(\theta \mid y) \propto p(\theta)p(y \mid \theta) = \\ p(\theta)\prod_{i=1}^{n} p(yi \mid \theta) \propto \exp\left(-\frac{1}{2}\left[\frac{1}{\tau_0^2}(\theta-\mu_0)^2 + \frac{1}{\sigma^2}\sum_{i=1}^{n}(y_i-\theta)^2\right]\right). \quad (7)$$

The multiple normally distributed observation $y = (y_1\ldots, y_n)$ parameterized by the mean μ_n and the posterior probability variance τ_n^2:

$$p(\theta \mid y_1 \ldots, y_n) = p(\theta \mid \bar{y}) = N(\theta \mid \mu_n, \tau_n^2),$$

$$\mu_n = \frac{\frac{1}{\tau_0^2}\mu_0 + \frac{n}{\sigma^2}\bar{y}}{\frac{1}{\tau_0^2} + \frac{n}{\sigma^2}}, \quad (8)$$

$$\frac{1}{\tau_n^2} = \frac{1}{\tau_0^2} + \frac{1}{\sigma^2}.$$

Such level of formalization allows approaching the issue of multiple agents clustered generally, which are distanced from each other.

6. Empirical evaluation run of the simulation

Thanks to substantial public research the software selection for the simulation of various models has a large number of options. These include Repast, Swarm, NetLogo and MASON among many others. Proprietary toolkits are also available shaped for transportation sector such as AnyLogic.

The authors decided to go for R language for Bayesian analysis and clustering. The simulation NetLogo gives a power of a programming language for modeling and simulating environment of complex phenomena and complex systems evolving over time through independent agents all operating concurrently.

The initial state of the system is in equilibrium. The agents recognize the situation in own region as stable, which does not imply to interfere into other regions. The important precondition is that the labor supply is positive in terms that there is no excess in production or unemployment.

The rule patterns for households, producers and policymaker are represented as bellow:

```
Policymaker:
          int trCost #setup the tran-
sition costs
          int Wage #setup of wages
          int totGoods=totGoods+1 #one
goods unit taken as tax
          int HHgrowth #growth rate of
households

     Households scheme:
          If  laborNeed(int totGood -
     int numHH) > 0
          #their labor needed in the
region

          If laborNeed == 0 #if not
          If wage < trCosts  #check
transition costs and wage
          If nrTries>a #check nr of
tries to access region2
               then stopInteraction
          #if too much then stop
          elseif
          migrate() #household migra-
tion function

Producers scheme:
If  (totHH<totGoods) #check situa-
tion in ALL regions
     Then
     Produce() #production func-
     tion
     Elseif
     CheckTrCosts () #compare
     transition costs function
     If nrTries>b
          Then DeleteProducer()
```

The purpose of this experiment is to investigate the robustness by giving model's parameters and variables in terms of influence of probability in action taking by producers, which has opportunity to employ both markets for own utility maximization purposes.

This model sets compliance mechanism and reduction of agents as the difference parameter to analyze the interactions among different clusters. In order to inspect the probability of cause using the model's parameters applying Bayes' theorems from simulations, at the initial stage all agents and regions in the test experiments have the model's parameters of the same utility maximization targets given that producers tries to maximize own profit and households avoid the transaction costs, which lower their wages.

The parameters are investigated under the compliance mechanisms using the parameters as bellow:

Table 1. Parameters selection

Parameter	Initial value	Value change
Wage	10	+5%
Transition costs	14	N/A
totGoods for both regions	1000	Rand(+/-8%)
Household / Producers	Rand(400..800)	N/A
Discount rate γ	0.9	N/A
Learning rate α	0.1	N/A

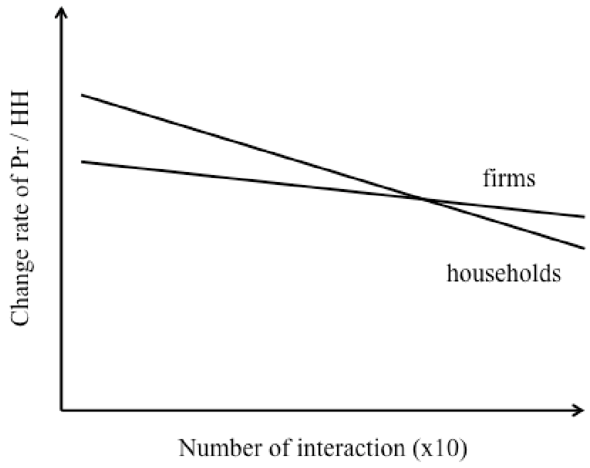

Fig. 2. Change rate in producers and households at constant policymaker's variables

The test experiment with basic economic setup shows some controversial results and need to have a mechanism of tuning the parameters by raising number of interactions dynamically. However, the most interesting feature of the model is that the decision rules derived from the interaction data but not utility maximization only to sustain its decision making process for agents behavior.

At some level of interaction the learning mechanism plays undeniable role, which can be captured as maximization of reward defined by the successful degree of a single interaction. The households have less demand on learning rate. They have only regional knowledge at the most about own environment and therefore they have less interaction within the model.

In the proposed simulated model the knowledge obtained results fewer calls for Stop or Delete functions because the agents learn more efficient way and their transition costs have a positive effect.

Estimating the influence of infrastructure is not an ordinary task. Considering in general utilization of infrastructure as the function of interaction among agents and the environment, so the model can explain learning process among the agents in the traditional Bayesian network terms.

The Bayesian updating takes place when one agent receives new signals from the outside environment or related agents. A Bayesian networks can add the ability to deal with fractional agents knowledge about the others and to offer a learning mechanism that allows the development of knowledge based on the observations of the environmental settings and the other agents.

Therefore the infrastructure development should be captured not solely in economic terms, but should be shaped for knowledge exchange among agents. Adding a factor of uncertainty into analysis opens a specific question of incorporating social processes aspects into study.

7. Concluding remarks

Depending on a number of factors, it is crucial to elaborate a theoretical framework, which can embrace as many factors dynamically. Therefore, any research on infrastructure should have a broader scope and should not be limited on country-specific parameters but include configurations in clusters over the borders.

This work paper is a conceptual model, where proposed applications are described with its general features of complexity or simplicity of further analysis. The next development of the paper will be simulation experiments, where applications will be tested in a simulation environment. As P. Davidson *et al*. (2009) proposes for data sources in the simulated experiment either it can be real data taken from existing systems in the real world, or data that is not real generated data to see how the model will work. As the final step we see is the field experiment and evaluation of results, which might find practical implementation in the real world.

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