USE OF TIMEBANKING AS A NON-MONETARY COMPONENT IN AGENT-BASED COMPUTATIONAL ECONOMICS MODELS

PETR TUČNÍK
Faculty of Informatics and Management
University of Hradec Králové
Rokitanského 62, 500 03 Hradec Králové
Czech Republic
petr.tucnik@uhk.cz

LUKÁŠ VÁLEK
Faculty of Informatics and Management
University of Hradec Králové
Rokitanského 62, 500 03 Hradec Králové
Czech Republic
lukas.valek@uhk.cz

PETR BLECHA
Faculty of Informatics and Management
University of Hradec Králové
Rokitanského 62, 500 03 Hradec Králové
Czech Republic
petr.blecha@uhk.cz

VLADIMÍR BUREŠ
Faculty of Informatics and Management
University of Hradec Králové
Rokitanského 62, 500 03 Hradec Králové
Czech Republic
vladimir.bures@uhk.cz

Abstract: The current mainstream in economic research is intensively supplemented by new modelling paradigms that have been established only recently. Application of agent-based modelling in the realm of economic systems labelled as Agent-based Computational Economics (ACE) represents one rapidly evolving approaches. On the other hand, there is a lack of research focused on timebanks (TBs) as an economic concept. TBs are grounded in collaborative creation of value through (typically voluntary) exchange of timebanking credits, which represent worked hours for the benefit of TB community members. As a non-monetary concept of economic exchange of value, TB represent interesting complement to standard monetary systems. Effective utilization of TB concepts have potential to improve both social and economic standing of its community members, since TB membership allows access to services that would not be otherwise available. The idea of expanding agent-based economic models with timebanking component allows research and study of economic principles from the less traditional, and more novel perspective. Thus, timebanks represent the main research construct of this paper. This manuscript focuses on TBs definition and categorization and it develops TB in a form of general architecture utilizable in agent-based economic computational models.

Key-Words: Timebanking, agent-based computational economics, economic models, complementary currency.

1 Introduction

In the economics domain the agent-based computational economics (ACE) [16] represents relatively new field of study. It is primary based on using of computational power for research and scientific purposes. At the current stage of technological development, it is possible to undertake computationally demanding experiments required to model the interactions of a large number of heterogeneous agents with bounded rationality in an economy characterised by non-equilibrium dynamics and information asymmetries. Latest research directions aim at simulating and synthesizing emergent phenomena and collective behaviour in order to understand economic and social systems. Particular topics addressed in scientific journals include artificial markets with heterogeneous agents, multi-agents in economics, experimental economics [21], financial markets with heterogeneous agents [12], non-linear economic dynamics [11], interacting particle systems in economics, markets as complex adaptive systems [20], or theory and simulation of agent-based models to name a few. The main purpose of ACE existence is the necessity to replace the reductionist approach [3] at the heart of mainstream a dynamic-stochastic-general-equilibrium model with an approach rooted on the science of complexity and agent-based modelling [4].

Although the main part of the ACE research is aimed at the functioning of economic subjects such as companies providing services or products - and their mutual interactions (see [5], [21] for more details) - there is an interesting sub-area related to utilization and/or management of idle workforce – timebanks (TBs). TBs can provide inclusive working opportunities, allowing all members of the community, even socially excluded, unemployed or otherwise disadvantaged groups of people, to participate and gain benefit. The engagement of community members in working opportunities provided by membership in a TB may improve their economic situation or provide useful working experience, which can be beneficial for the economy as a whole. Effective functioning of TB can have impact in areas such as labour economics, regional economics, and can contribute to establishment of sustainable urban neighbourhoods. Hence, TBs represent the main research construct of this paper, while the main objective is to develop and present conceptual model enabling inclusion of TBs into ACE models.

The paper is structured as follows. After the brief introduction, definition and depiction of the current state of timebanking is provide. The third section focuses on TBs characteristics that might be used in the developed model. While the fourth section develops and present the conceptual model, the last section concludes the paper.

2 State of the Art

Timebanking as an approach originated in the United States of America as an idea of a civil rights lawyer and economist Edgar Cahn. The concept is thoroughly explained by Boyle and Bird [2] and other authors [7, 9, 10]. The principle can be simply described as utilization of time as a currency to recognize contributions that people make to the greater common good or to hold together circles of informal volunteering.

Timebanking is a socio-economic concept which uses time unit as a currency. “Time Dollar” is the first time currency ever introduced [7]. It is based on equality and reciprocity, and unlike mainstream monetary system, it is meant to maintain community and create social capital instead of monetary capital. It might resemble other forms of economy known from the past, e.g. barter. It also resembles a volunteering, but timebanking is more formalized and more concentrated on co-production [6].

The concept of time banking is not homogenous and it differs in various contexts and environments. Particular participants claim that social and trade part of a TB system is very significant. For some of actors trade and saving of money might be paramount. Others may feel useful, being part of a community, getting reward and appreciation for work they love.

TBs are part of broader concept of complementary economies, which are sometimes incorrectly titled as “alternative”. Whereas alternative would mean that an economic system is aimed to replace the mainstream one, The complement only fills the places where the mainstream economic system fails [13]. Timebanking is one of these complementary economic systems and, in general, it is aimed more at solution of social issues than exchange itself. Nevertheless, there are many approaches and differences among timebanking concepts around the world.

Timebanking very often differs in its execution, but the main core values define what is and what is

not TB. These values show that timebanking is more than just a trade system; they define its direction towards the social aim and its complementarity to the mainstream economic system. The core values were defined by Cahn [6] and later updated and expanded to the five main values which are [15]:

- We are all assets – every human being has something to contribute.
- Redefining work – rewarding the real work in our society by creating a currency which pays people for helping each other and creating better places to live.
- Reciprocity – giving and receiving are basic human needs which help to build relationships and trust with others.
- Social Networks – building people's social capital is very important, belonging to a social network gives our lives more meaning.
- Respect - encouraging people to respect others in their community.

The values predetermine the profile of participants/members of a timebanking and their motivation to participate. Unlike in monetary based economies, the utility is based on more than only obtaining either a product, or a service. It does not mean that their motives are always altruistic; they are often motivated by a personal incentive and try to satisfy their own needs, but the values mentioned above guarantee also social benefits. Aside of the "selfish" stimuli, there are also other ones, e.g. a need to be part of a community, sharing knowledge and skills, avoiding loneliness, helping the local community etc. The role of a TB is to connect right people allowing them exchange in transparent and safe environment, creating a shared social economy "market" on the way.

At this moment there are TBs all around the world with USA and the United Kingdom being the most developed in this area. There are many risks and challenges in every country, which need to be overcome, such as cultural environment, funding, or management issues [23]. The variability of timebanking approaches poses a challenge also for the Agent-based computational models and they have to be narrowed down and categorized. There were attempts in the past to make classifications of complementary currency systems (including TBs). For instance, one classification is based on various generations of complementary currency systems depending on their specific monetary organization and specific relationships with the socio-economic world and with governments [1]. Further classification is grounded in the membership base where there are differed TBs such as: Person-Person, Person-Agency, Agency-Agency [19]. Next, broader classification of TBs depending on their main aim - the main social issue – they are solving, can be used: youth, prison, elderly, cost saving, community etc. Our aim is to take these classifications into consideration when developing original and general TB instance, which would be suitable for Agent-based models. Usage of classifications should ensure that created architecture will be general, complex and realistic enough to be applied latter in practice.

3 Characteristics of TBs

TBs share some common characteristics (such as nonmonetary payments for work) but there are also differences derived mainly from the variedness of their own participants. Architecture of a TB must reflect needs of the community that establishes it, and these can be explicitly expressed as shared ideas about how TB should be functioning in order to be acceptable for majority of TB members. On this basis, it is possible to outline TB`s internal processes. This is a result of voluntariness of participation. People, who consider participation in a TB, anticipate fulfilment of their expectations (at least to some reasonable degree). Since creation of TB is not centrally controlled or normalized, various forms of TBs may occur. On the other hand, the TB communities (globally) feel the need to somehow standardize the functioning and establish framework for foundation of new TBs which reflex lessons learnt and best practices. This should subsequently allow achievement of better compatibility between various regional or even national TBs. There seems to be a global trend to make TBs.

This makes the whole TB concept more difficult to capture through the modelling tools since there is not just a single "apply-to-all" TB framework, but rather a variety of them with many additional features which altogether forms up different types of TBs. Because it is difficult to model or control what is not understood clearly, key characteristics related to functioning and construction of TBs will be presented and discussed in this part of the manuscript.

3.1 Homogeneity and Heterogeneity

In a typical case, the TB members mutually provide services according to their specialization. Specialization is defined as the service that TB

members decided to provide (rather than specialization gained by education according to the first core value of timebanking stating that all members are considered to be assets). Heterogeneity of such TB provides more complex variety of services, allowing member looking for a service to get complementary access to services otherwise potentially difficult or impossible to obtain. In this case, the TB members motivation to participate is based upon the fact that specialist is more skilled and efficient in his/her area of expertise and is able to provide services in a quality service seeker is unable to create by himself/herself. In principle, there may occur a disproportion between market value of service provided by an expert (such as IT, medical or law expertise, for example) and non-experts participating in the TB. This may lower the motivation of highly skilled (and on the labour market highly valued) experts to participle, but TBs are working under assumption of voluntariness often even with altruistic motives to help the community. This is the social dimension of the TB and many individuals joins the timebanks among other reasons also to fulfil their need to socialize. This means that people who participate in TB (or those who would like to join) have not only aim to gain monetary or physical utility, but also need to be part of the social network and build their social capital. This fact, among others, makes TB specific and different from classical monetary economy and have also impact in case a computer simulation of a TB system is attempted.

The second extreme is represented by the homogenous TBs, where all or significant majority of members provide services of the same type/specialization. Implementation in project "Man Shed" may be mentioned as an example of such concept. Man Shed is a community project designed for men to spend free time productively working on common projects (most often craftsmanship). TB might be set up by a group of manually skilled craftsmen who are working on the various projects in a workshop (which provides tools and suitable working space), such as repairs, furniture construction, etc. In this case, the specializations of TB`s members are similar or even the same for all and through participation, larger projects may be handled efficiently.

3.2 Timecredits Employment

Timecredits are traditionally used for consumption of services provided by other TB`s members. In the standard case, saved timecredits can be exchanged for services in the ratio 1:1 (measured in hours of work). Underlying idea is to provide the motivation for involvement of all community members in TB activities (even with not specialized or less profitable working skills). This maximizes the social benefit for all TB members since they feel e.g. connected, useful or needed. There are also known cases when TB rewarded new members with small amount of "free" timecredits to give them motivation to participate and invest some of their time into study of TB`s internal processes. However, this practice can be easily exploited by unethical behaviour. Therefore, the joining process in these cases is usually based on peer recommendations system in order to prevent it. This practice is common only in more professional TBs. Anyway, potential fraud is very unlikely, because the TB system does not pose any monetary profit and mutual feedback, and presence of a TB coordinator gives to a fraud little chances before being revealed.

Less common case, used rather occasionally, is exchange of timecredits for commercial products or services. In this case, the companies accept timecredits e.g. in the less frequent business hours, such as so-called "happy hours". Their goal is to attract more customers, and cooperation with TBs may address whole TB communities with minimum cost. In a sense, this can be perceived as a special type of marketing strategy because company in this case provides goods for better price (with discount) or even for free. Like for example project of organization called Spice [16].

3.3 Timecredits Transfers

How timecredit is transferred differs depending on many factors, but main are a type of software application applied and existence of a TB coordinator. To the date there are about 30 web platforms in use for timebanking [2], but there are also TBs without any platform implemented. Some TBs work solely on virtual basis and there is no coordinator/broker in order to lower expenses. Nevertheless, TB has very often a person who coordinates exchanges, mostly because of security, but also to provide the human element, which is very necessary with community network as a TB. Timecredits are transferred usually based on a record of both sides that an assignment was fulfilled. Again it is based on trust, that the particular amount of timecredits was earned/worked, and again, any potential frauds are usually discovered quickly, at least in the case a coordinator is present.

3.4 Scope of TB types

This section briefly describes various types of TBs. The source of the information is mostly the network Timebanks UK, which integrates more than 300 TBs and has strong experience in the field:

- Local community development: TBs aimed on developing local community. Main aim is to connect people with similar interests and create a community in places where citizens are indifferent to their living environment.
- Youth, Elderly or Student time banks: Are based on mentioned interest groups aimed to fulfil their needs.
- Justice or Prison time banks: Giving imprisoned people a chance to do additional service for community and getting something back as well.
- Social Exclusion: TBs aimed on socially excluded groups of population.
- Cost Savings: Usually people with lower income are members. The aim is to save real currency by using economic feature of timebanking.
- Unemployed: Giving unemployed people stay in touch with a profession they like and get something in return.

Aside of that, there are two more suggested models based on previous research [22]:

- Composite TB based on groups of interest: a TB starting on building small self-organized cells of interest groups (as above: students, elderly, unemployed etc.) later connecting these cells for mutual benefit.
- Company clusters: Using timebanking concept as a trade concept in clusters of companies.

4 Timebanking Model

In this part of the paper, the "general timebank" architecture is be introduced. This is the basic component in our timebanking model framework. Principles of its functioning reflect - as much as possible - common characteristics of various types of TBs (which are mentioned above) regardless of their specific purpose. It is expected that this concept will be further modified for more detailed experiments in future, but its general applicability is useful at this stage of the research. It may be also taken into consideration that up to date research mostly lacks formal description and frameworks for development of such models and there is no established methodology in this regard.

4.1 Working Stages of TB`s Participants

From the perspective of agent-oriented modelling, there is a number of organizational paradigms that may be used in order to create reliable and valid timebanking model. Overview of such organizational paradigms presents Horling and Lesser [8] in their survey, with the list of many additional resources on the subject. From the range of possible options, an incorporation of facilitator agents can be perceived to be most realistic and with accordance to the real timebanking functioning. In a similar way to real-world timebank (RWTB), the facilitator agent serves here as a mediation service between two participating parties: service provider and service seeker. The functioning of the TB can be divided into several stages, as it is shown at the Fig. 1.

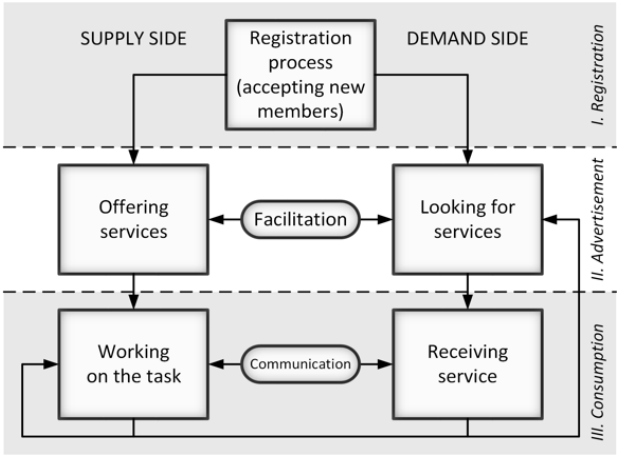

Fig. 1 Stages of TB`s work

Two agent-based concepts for handling facilitation suitable for application here are (a) matchmaker and (b) broker facilitator agents. Both types of facilitators use similar approach; they collect information about agents providing services and agents who are offering tasks use facilitator agents to obtain contact information in order to establish communication (see [8]) for more detailed explanation). This can be done directly in case of matchmaker agent (which "introduces" both parties according to contract specifics) or indirectly if broker is used. The broker agent also accept responsibility for fulfilment of contract. Although the facilitation in the model is actually combination of both approaches (provider of the services enters into direct communication with service purchaser at some point of contract processing, and TB representative is guaranteeing contract fulfilment at the same time), the term "broker" will be used to

label the facilitation agent in the model in the following text.

The first stage is called “Registration” and covers initial steps of TB development, i.e. gaining new members. Although there may be various slight differences in this stage, the idea is always similar. New members are required to provide certain personal information (at least a contact info) and a description of what they are able to provide and/or what they need.

To obtain the membership, one may be required to provide peer recommendation, but since this is not generally required, agent-based model does not contain this feature.

The second stage is an advertisement, i.e. public and present information about work capacity one is able to provide (supply side) or what is required to be done (demand side). In this stage, the TB coordinator facilitates communication and finds matching combinations of supply/demand offers. This step actually may be automated. Usual way of handling requests is web application with suitable user interface for communication. Should be noticed that service provider does not have to make all of the personal information public. The only person with full access to personal data is usually TB coordinator, to protect members` privacy. The job offer can be formalized in the standardized contract, which is actual mechanism utilized in the proposed model to ease machine processing or job offers/orders.

The last stage is the actual fulfilment of the contract. After the work is done, service purchaser confirms the completion of a contract and timecredit is deducted and added to the respective involved parties.

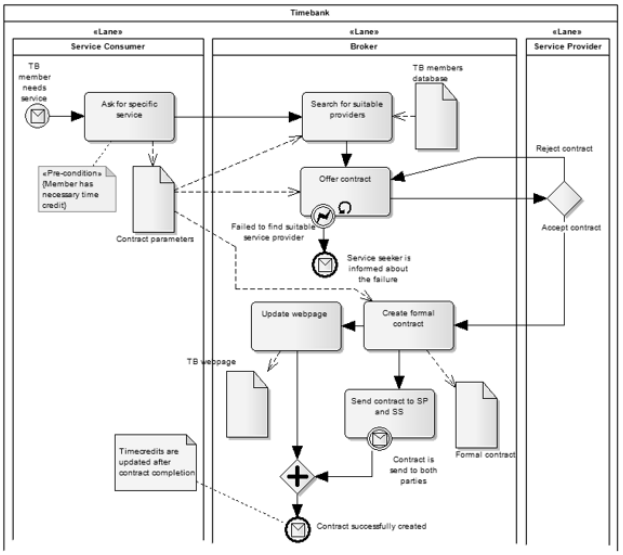

Fig. 2 Process of arranging the TB contract

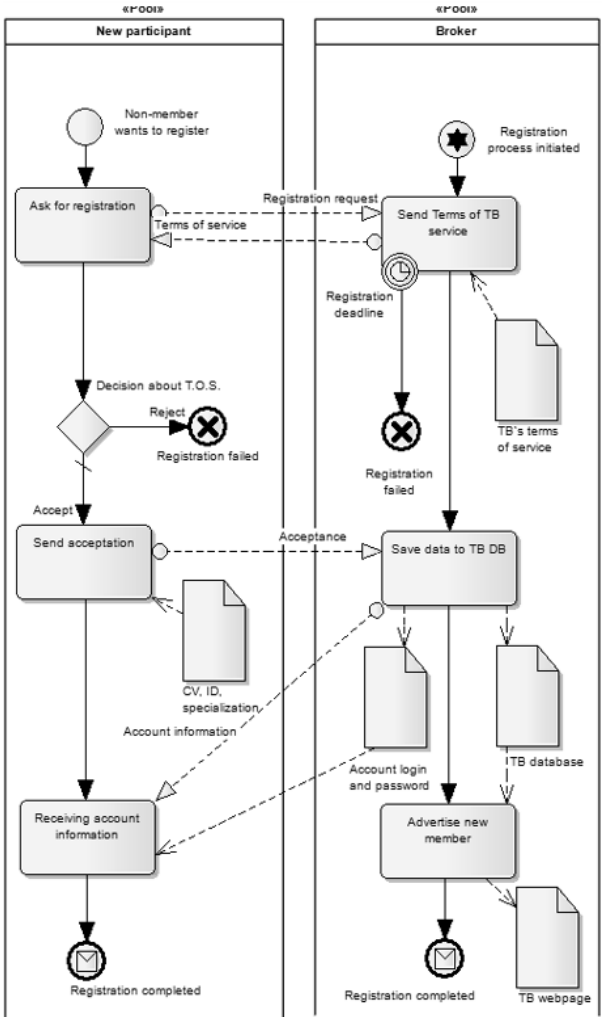

Fig. 3 Process of a new member registration

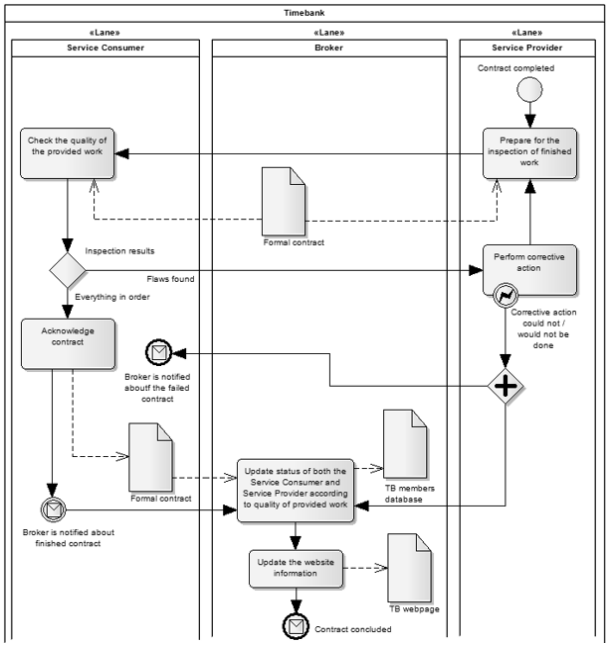

Fig. 4 Process of the contract fulfillment

4.2 TB`s Internal Processes

The internal processes of the TB are shown at the Fig. 2-4. The initial registration phase (Fig. 3) involves both the TB coordinator in RWTB (called ”Broker” in the agent model) and the “New participant”. In this phase, it is expected from both parties to achieve agreement upon terms of service (or another document with similar legal semantics) to provide the TB membership with more formal, enforceable shape (obligatory compliance with certain rules is pre-requisite of long term effective functioning of the TB).

Fig. 2 and 4 captures initial phase of contract creation (Fig. 2) and its completion phase (Fig. 4). As can be seen at the Figures, there are certain control (verification) mechanisms implemented in internal processes in order to avoid abuse or sub-optimal performance of involved parties, especially of service provider.

4.3 Agent-based Model

Based upon internal processes showed at the Fig. 2-4, an agent-based model was implemented. Mechanisms of its internal functioning are shown at Fig. 5-6.

The final Fig. 7 shows the user interface of the model application. The network of TB members (agents) is spread over GIS data layer and user is able to monitor their position and state during model runtime.

When matching contracts with service providers, broker agent takes into consideration preferentially specialization, but other factors may be important as well, such as accessibility of the place where the job takes place or distance. These factors are not always strictly considered in RWTB cases, but it is useful to study their impact in order to optimize TB`s performance and internal processes.

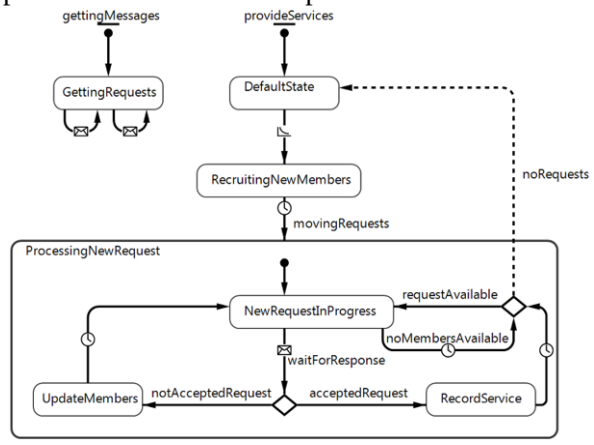

Fig. 5 Process of registering a new TB member

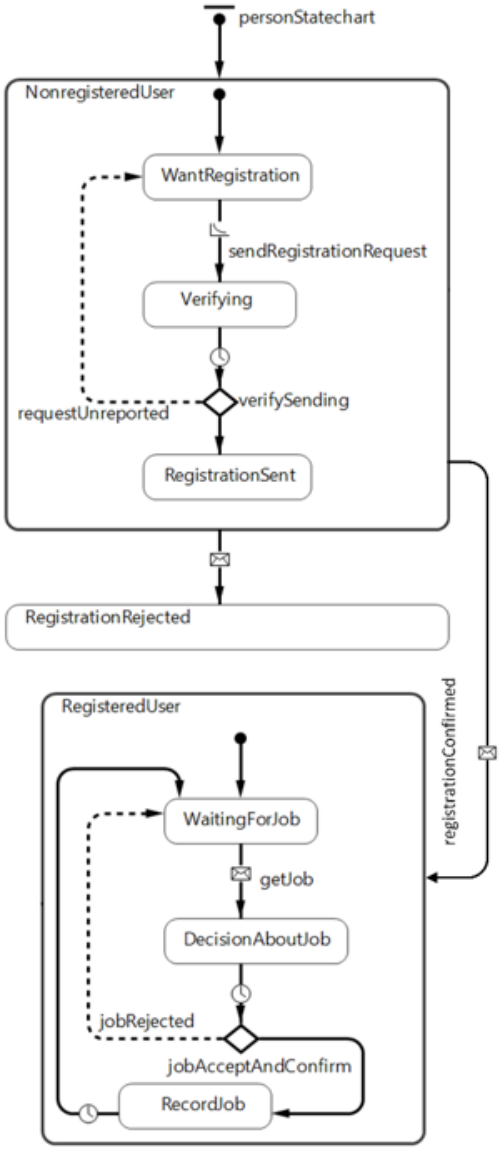

Fig. 6 Finishing the process of registering a new TB member and the job processing

Fig. 7 User model interface example (person icons represent TB members)

5 Conclusion

The introduction of the TB concepts into agent-based economic models provides platform for research and study of complementary economics. This paper provided overview of many important key characteristics of TBs which have to be understood. The potential contribution of TBs applications regarding especially societal benefits, community-related services, quality of life of participating people, sustainable development to urban neighbourhoods, or healthcare services [14], is making research in this area interesting and meaningful, although it now lies outside of the mainstream of economic research effort. Certainly, there are limitations associated with this paper. First, model application requires construction of dynamically complete economic models. It means that a modeller has to start from initial conditions and the model must permit and fully support the playing out of agent interactions over time without further intervention from the modeller. This completeness requires detailed initial specifications for agent data and methods determining structural attributes, institutional arrangements, and behavioural dispositions. Although complex models are already available (e.g. [4]), further development is needed. Second, in general, there is the difficulty with validating ACE model outcomes against empirical data. ACE experiments provide outcome distributions for theoretical economic systems with explicitly articulated micro-foundations. Mostly these outcome distributions have a multi-peaked form suggesting multiple equilibria rather than a central-tendency form permitting simple point predictions [18]. This issue is connected with the presented conceptual model as well. However, these limitations represent new challenging research pathways.

6 Acknowledgement

This work is supported by the Czech Science Foundation project “DEPIES - Decision Processes in Intelligent Environments” n. GA15-11724S. The collaboration and support of the research from Timebanking UK (http://www.timebanking.org/) is gratefully acknowledged.

References:

[1] J. Blanc, Classifying “CCs”: Community, complementary and local currencies’ types and generations, *International Journal of Community Currency Research*, Vol. 15, 2011, pp. 4-10.

[2] D. Boyle, and S. Bird, *Give and Take: How timebanking is transforming healthcare*, Stroud, Gloucester: Timebanking UK, 2014.

[3] V. Bureš, Systems thinking as a basis for ambient intelligence, *Proceedings of the 11th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education*, 2006, pp. 318

[4] V. Bureš, and P. Tučník, Complex Agent-based Models: Application of a constructivism in the Economic Research, *E+M Ekonomie a Management*, Vol. 17, No. 3, 2014, pp. 152-168.

[5] V. Bureš, P. Blecha, and P. Tučník, Agent-Based Modelling and Simulations as an Integral Functionality of the Business Intelligence Framework, *Information and Software Technologies*, Vol. 538, 2015, pp. 236-245.

[6] E. S. Cahn, *No more throw-away people: the co-production imperative*, Washington, D.C.: Essential, 2000.

[7] E. S. Cahn, *Time dollars: the new currency that enables Americans to turn their hidden resource--time--into personal security & community renewal*, Chicago, MI: Family Resource Coalition of America, 1998.

[8] B. Horling, and V. Lesser, A survey of multi-agent organizational paradigms, *The Knowledge Engineering Review*, Vol. 19, No. 4, 2004, pp. 281-316.

[9] M. Kennedy, B. Lietaer, and J. Rogers, *People money: The promise of regional currencies*, Axminster, UK: Triarchy Press, 2012.

[10] J. Lasker, and al., e., Time Banking and Health: The Role of a Community Currency Organization in Enhancing Well-Being, *Health Promotion Practice*, Vol. 12, No. 1, 2011, pp. 102-115.

[11] B. Lebaron, and L. Tesfatsion, Modeling Macroeconomies as Open-Ended Dynamic Systems of Interacting Agents, *American Economic Review*, Vol. 98, No. 2, 2008, pp. 246-250.

[12] B. Lebaron, Agent-Based Computational Finance, *Handbook of Computational Economics*, Vol. 2, No. 1, 2006, pp. 1187-1233.

[13] B. A. Lietaer, and J. Dunne, *Rethinking money: how new currencies turn scarcity into prosperity*, San Francisco, CA: Berrett-Koehler, 2013.

[14] P. Marešová, H. Mohelská, and K. Kuča, Social and family load of Alzheimer's disease, *Applied Economics*, Vol. 48, No. 21, 2016, pp. 1936-1948
[15] L. K. Ozzane, Learning to exchange time: Benefits and obstacles to time banking, *International Journal of Community Currency Research*, Vol. 14, 2010, pp. A1 - 16.
[16] Spice, 2015. Just Add Spice, Available at: http://www.justaddspice.org/
[17] L. Tesfatsion, Agent-based computational economics: modeling economies as complex adaptive systems, *Information Sciences*, Vol. 149, No. 4, 2003, pp. 262-268.
[18] L. Tesfatsion, Agent-Based Computational Economics: A Constructive Approach to Economic Theory, *Handbook of Computational Economics*, Vol. 2, 2006, pp. 831-880.
[19] TimebanksUK, 2015. Timebanking types, Available at: http://www.timebanking.org.
[20] P. Tučník, and V. Bureš, Inclusion of complexity: Modelling enterprise business environment by means of agent-based simulation, *International Review on Modelling and Simulations*, Vol. 6, No. 5, 2013, pp. 1709-1717.
[21] P. Tučník, P. Čech, and V. Bureš, Self-organizational Aspects and Adaptation of Agent Based Simulation Based on Economic Principles, *Advances in Systems Science*, Vol. 240, 2014, pp. 463-472.
[22] L. Válek, Development of a complementary currency system: the Czech position in the international context, *Proceedings of the 18th International Business Information Management Association conference*, 2012, pp. 251-259.
[23] L. Válek, Risk Factors and Issues Which Might Arise While Implementing and Running a Time Bank: Learning from Success and Failure, *Proceedings of the 22nd International Business Information Management Association conference*, 2013, pp. 200-204.