Time Bank and Dynamics of its Metamodel

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Abstract: The concept of Time Banks developed over many decades. Eventually, it formed itself into an approach utilizing the dormant aspects of human activities that cannot be sold on the traditional labour market. Time Banks need to be considered as socio-economic systems, which in contrast to monetary systems are based on equality and reciprocity. Time Banks belong to the sphere of complementary economic systems which are one of the traits of postmodern society. They appeared as a reaction to various economic and societal failures, filling the empty spaces mainstream economy leaves behind. But equality and reciprocity are not the only ones on the list of properties that ought to be monitored and carefully considered when the nature of Time Banks is investigated, and ways in which they can be implemented in practice are explored. This paper exemplifies identified attributes and provides a description of their meaning, significance and outlines their mutual interrelationship. Alphabetically ordered, the list starts with Accessibility, Adaptability, or Affordability and ends with characteristics such as Tailorability or Transparency. As is well known from the systems theory, capturing the mutual relationship among attributes and the development of appropriate structure enable the so-called metasystem to be created. Mostly, metasystems are described regarding their structure. The challenge that this paper accepts is to sketch the possibility of capturing its behaviour in terms of system dynamics. For this purpose, diagrams used in this discipline are applied. The systemic features are organized into a Causal Loop Diagram which illustrates how they are connected and influenced by each other. As a result, graphs showing development of systemic features in time are presented and interpreted.

Keywords: *Time Banking, System Dynamics, Complementary Economy.*

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1. Introduction

Complementary economies have worked alongside mainstream economy for several decades (Kennedy, Lietaer, & Rogers, 2012). The main aim of these approaches is to fill empty places and correct – usually societal – problems the market economy leaves within its wake (Lietaer & Dunne, 2013). To work properly, adaptability is most important, that is, choosing or developing an appropriate approach and using it in proper context. Of these systems, the Time Bank (TB) concept can be considered one of most affordable and simple social support systems based on economic principles of equal exchange (Cahn, 2001) of skills, knowledge, and services (Valek, 2018b) and sometimes also goods (Nikitina, 2011). The TB has its own set of defining values, as we will learn later in this text, but nevertheless identifying a specific complementary economic system as a TB is not an easy task. TBs are even considered to be “chameleonic” (Collom, Lasker, & Kyriacou, 2012), because correct application of the idea requires adaptation to specific local and cultural context (Valek, 2013). This (Papaoikonomou & Valor, 2017) of TB makes it hard to identify and classify what is and what is not a TB (Blanc, 2011). Traditionally TBs are identified as systems using a time currency, which are based on five main core values and phenomena called “co-production”, as these are founding principles set by its founder E. S. Cahn more than three decades ago (Cahn, 2000, 2001; Cahn & Rowe, 1998). Nevertheless, only recently a systemic definition was added, more precisely, a definition based on evidence that the TB is a system – a soft system for that matter (Valek, 2018a). This systemic definition was created with the help of Peter Checkland’s Soft System Methodology (SSM) (Checkland, 1999). During a search for the definition of the whole context, elements and processes within TB were discovered and identified, and along with them the main features that TB as a system possesses.

As a part of non-mainstream economic systems TB is one of the phenomenon of postmodern society. With less focus on industry and profit, and more focus on community development, a TB is often mistaken for a voluntary (Cahn, 2000; Collom et al., 2012) or purely economic system (Cahn & Rowe, 1998; Valek & Bures, 2018). To a certain extent it is both and neither. By bridging fields of economy, volunteering, community development and social service, TB has become a system that came as an answer to the illnesses of postmodern society, which other more traditional means, such as financial or social intervention, cannot tackle alone. Being built on the concept of co-production, it is a tool for people to help

themselves (Valek & Bures, 2018) instead of “paying” for a change. As a tool for community development and societal problem-solving it was already widely understood by the Internal Revenue Service in USA (Cahn, 2000) and the Department for Work and Pensions (DWP) in the United Kingdom (2015). Understanding in other countries is subject to local laws and traditions and sometimes it supports the idea, sometimes it does not (Valek, 2015a).

The aim of this article is to take a closer look at the TB from the perspective of its systemic features and search how they influence each other. This is to see how these features are interconnected and how they influence each other over time, and how these influences change. Eighteen key features were uncovered during previous researches and they are accessibility, adaptability, affordability, autonomy, credibility, customizability, complexity, efficiency, emergence, equality, evolveability, interoperability, modularity, predictability, sustainability, tailorability, transparency and universality (Valek & Bures, 2018). Their mutual relationships and dynamics show how individual features influence each other; in order to show this, a Causal Loop Diagram (CLD) is used. To show what happens among them over a period of time and how they develop Stock and Flows diagrams are used. Ultimately, we will gain an overview on the basic developments in these relationships and we can also change some of the variables to create “what if” scenarios.

The article begins with the theoretical background of a TB as part of complementary economic systems, including a definition of the TB. The following section is devoted to a description of the methods used. The Results section is divided into two main parts. The first deals with the systemic features of the TB and their CLD diagram, while the second part presents a stock-and-flow diagram of the features, including graphs and their interpretation. Finally, the whole article is summarized in the Conclusion.

2. Theoretical Background

The TB is a decades-old approach to utilizing the dormant aspects of market and human activities that cannot be sold on the labour market. During that time, it has spread from the United States of America, its country of origin, to other countries around the world. Although in some sources (Miller, 2008) information can be found that suggests the world's first TB was started in Japan and was founded in the 70s by Teruko Mizushima, the idea started to spread globally approximately ten years later

when E. S. Cahn invented the Time Dollar in the US in the 80s (Cahn & Rowe, 1998).

TB is a socio-economic concept in its essence, based on the use of a time unit as a currency. However, unlike a monetary system it is based on equality and reciprocity (Clement et al., 2017). This means that instead of financial profit, other benefits are perused in the sense of the utilization of unused resources, networking – which cultivates social capital – and innovations. TB is a third-sector initiative that establishes principles of co-production and offers a model that enables users to be actively involved with other stakeholders in the delivery of services (Glynos & Speed, 2013). Understanding a TB in a particular environment, i.e. its adaptation to the current needs of a community, determines whether the social or the trade aspect is prevalent in a particular TB system.

The TB concept faces many challenges, and when it comes to various cultural environments, it is often adapted to reflect a particular regional reality (Valek, 2013). Similar to clustering initiatives in the main stream economy (Bureš et al., 2012), regional focus is one of features which define any TB, as it is focused on tackling locally and regionally based issues. Nowadays, there are many TBs around the world, with their number constantly changing, thus it is quite difficult to determine exactly how many there are (Blanc, 2011; Schroeder, Miyazaki, & Fare, 2011). Due to these adaptations and the instrumentalization of TB for various purposes, TBs have been deemed to be “chameleonic” (Collom, Lasker, & Kyriacou, 2012) and hard to identify. This is related not only to the precise number of TBs in the world, but consequently the number of people involved in them (Valor & Papaoikonomou, 2016). Nevertheless, whatever the adaptation, the focus is on locating ways to use skills, knowledge, services, etc., which people and organizations possess but are not using, as well as to provide a tool (Clement et al., 2017) by which both people and organizations can help themselves rather than expect support from authorities.

The TB is a complementary economic system, although sometimes it might be described as alternative (Clement et al., 2017; Valor & Papaoikonomou, 2016). This difference has already been explained above. In this book we consider TB to be complementary, existing in parallel to a mainstream monetary economy. And because TBs use time as a kind of currency, they can be strongly identified as a complementary currency. Nevertheless, members usually participate in a TB not for financial reasons e.g. to save money, but to gain other advantages from the system, such as learning, networking, social capital, etc. (Valor & Papaoikonomou, 2016).

Also, returning to the idea of a currency as an information system (Lietaer, 2001), the tracking of exchanges, or TB bookkeeping, among a constituency not only demonstrates a pure record of exchanges, it can actually show in detail the contributions of people and organizations toward building their community, increasing social capital, tackling possible societal and business problems, and much more. This feature gives a TB system added value, as all exchanges can be very simply monitored and evaluated (Valek, 2018b).

Previously the only way how to identify a TB was according to its core values and the fact that it worked based on the principle of co-production. Co-production was first outlined in the 80s by civil rights lawyer Edgar S. Cahn (Cahn, 2000). The simple way to explain it in one sentence is that it is the principle by which people take responsibility for solutions to their current problems (Valek & Bures, 2018). So, they co-produce the solutions. In different forms this principle can be found in other fields, such as knowledge management, as so-called “communities of practice” (Manville & Foote, 1996), open source software development (Valek, 2018b). But even in works of old classical economists, we can find, for example, the notion of “Motivation to Active Participation” in the works of John Stuart Mill (Mill, 2011).

2.1. Values

There are five core values which define a Time Bank (Boyle & Bird, 2014; Cahn, 2000; Granger, 2013; Ozzane, 2010; Valek, 2018a; Valek & Bures, 2018):

- We are all assets: Time Banking values people and recognizes that everyone has something special to offer others – knowledge, skills, resources, time, etc. Every human being has the capacity to be a builder and contributor as an individual or as a part of an organization (Granger, 2013). Thus, a service offered in a TB could be almost anything, a condition that opens up opportunities for exchange – making offers and requests – which are not “marketable”, but have value for other members of the TB (both people and organizations).

- Redefining work: redefining work means that members are rewarded for any kind of work, whether it would be considered financially profitable or not by market economy standards, as touched upon above. “Work” in this sense does not necessarily mean a “job”. In other words, this means that people mostly offer things they like to do rather than the ones which they could “sell”.

- Reciprocity: the exchange works in a two-way process. Members can both offer and request at the same time and both earn Time Credits. Requests are of the same importance as offers as they keep a TB alive.
- Social capital: the creation of social capital is very important for any community, whether it consists of individuals or an organization (Valor & Papaoikonomou, 2016). Social capital, among other things, solves problems for individuals regarding both unemployment (Carnero, Martinez, & Sanchez-Mangas, 2015) as well as learning.
- Respect: every human being matters: as a mutual understanding of what people and organizations do, this is a key element in the development of positive relationships among entities in a region. A higher level of trust leads to the possibility of further innovation by the facilitation of common projects (Lehaney, Clarke, Coakes, & Jack, 2004).

2.2. Definition

Until recently there was no systemic definition. The only definitions possible to find were actual descriptions of how the TB works, but not what it is (Valek & Bures, 2018). Only recently after extensive analysis were the following definitions outlined. The first definition defines TB as it works in reality. The second definition is stripped down to basics and shows TB purely as a system.

Time Bank is a socio-economic soft system which gathers people, both individuals and people as part of organizations, to become members of the system, in order to facilitate use of skills, knowledge, assets, resources and time, which they are actually not using, or cannot use (especially in a labour market). These skills, knowledge, assets, resources, and time are the main input into the Time Bank as a system, where they are transformed into offers and requests that can be utilized by members who require them. This transformation is a source of various outputs, the main one being utility and societal problem-solving in the sense of forming communities that actively seek problems to solve.

and

Time Bank is an open concrete continuous and stochastic soft system, which tends toward autopoiesis, and which transforms inputs from a wider system environment by leverage of knowledge, skills and resources of its subsystems into multiple outputs with positive feedbacks put back into the wider system environment.

3. Methodology

A two-stage research design is applied in this research. First, the Soft System Methodology. Then, the development of two types of diagrams from the field of system dynamics is conducted. While the purpose of the former is to identify main features or properties, the latter enables the capturing of dynamics and mutual interrelationships of features in time.

Presented for the first time by Peter Checkland, the Soft System Methodology (SSM) is a way to solve vaguely defined problems or to analyse so-called “soft systems” (Checkland, 1999). In the book *Time Bank as a Complementary Economic System: Emerging Research and Opportunities* an analysis of TB as a system was conducted. Among other results, the TB was identified as a soft system. The main difference between “hard” and “soft” systems is that “hard” systems are typified by their quite easy [straightforward?] problem analysis and generation of solutions, which can be evaluated and we can then pick the optimal one (Skyttner, 2005). Soft systems, on the other hand, are vaguely defined, depend on the human factor, and they are very hard to describe, not to mention analyse (Checkland, 1993). Finding a solution does not always mean that the one selected is the optimal one.

The causal-loop diagram (CLD) expresses the causal relationship between two variables with positive or negative polarities. The main idea of CLDs is to apply polarities to all identified relations and consequently figure out what type of feedbacks emerge in the system. Positive polarity means that as the first variable increases (decreases), the second variable changes in the same way, i.e. increases (decreases). Negative polarity expresses the opposite behaviour. Once the cycles are closed, the polarity of feedbacks (loops) can be identified and reveals the behaviour of the system. In fact, there are two types of feedbacks, namely balancing and reinforcing feedback. Details related to diagram notation can be found, for instance, in (Sterman, 2009). CLDs can be further elaborated and transform qualitative modelling into quantitative modelling. The main outcome of the transformation process is a stock-and-flow diagram, which applies a different point of view. Basically, there are six main kinds of elements that can be identified in single diagrams: stocks, flows, connectors, converters, sinks and sources. While stocks represent the accumulation of selected system variables, flows express the rate at which the value of stock is changing. Flows can either flow into a stock, which causes an increase in a stock value, or flow out of a stock, which causes a decrease in a stock value. Application of the remaining four elements is intuitive, as can be seen in the results section of this paper.

Transformation between both types of diagrams is based on a procedure described by Aronson and Angelakis (2018). Suggested steps are:

- Specification of units of all variables used in the CLD. As this paper deals with a metasystem, units of measurement on a scale of 0–100 points are used.
- Identification and development of stocks.
- Identification and development of flows. Once the stocks are identified, it should be easy to identify the flows as they are represented by variables that add to or subtract from the stocks.
- Connection of flows to stocks and stocks to flows. First, it is necessary to connect all flows to the specific stocks that they influence. Consequently, if a stock influences one or more flows, connection among the stock and the flows needs to be established through an information link. In this case, all inflows and outflows follow the logic of the CLD, i.e. any change in an associated stock leads to an increase or decrease in the next stock value by one.
- Adding and linking remaining variables. Any variables that are not identified as stocks or flows can be used as “auxiliary” variables that can be represented by either constants, or calculations.
- Definition of stocks and flows and checking of units. It is necessary to specify the equations that enable the reckoning of the value of each variable.
- Creation and linking of any additional variables. Defining the variables may result in identification of additional variables that are crucial for completion of the conversion process and making the model really quantitative.

The Stella Professional system dynamics software modelling tool is used for the development of the stock and flow diagram. Based on the links presented in the developed metasystem, each stock has a corresponding number of inflows and outflows. The simulation time is set to 24 months with $dT=1$ (i.e. the model equations are recalculated once in each month). For each dT , the increase or decrease of a stock is set to one unit.

4. Results

4.1. Features and their mutual interrelationships

A set of systemic features represents the main result of analysis of the TB as a system. It is believed that these features are possessed by any TB

to some extent. They are listed below, and the following part of this paper is focused on the search for causality among them.

In Figure 1, we can see a causal-loop diagram that demonstrates how identified systemic features influence each other. More precisely each feature is outlined and related to other features which influence it (see Table 1). That is why Adaptability and Equality are not included in the table 1 as they are not associated with any input. The connections are described in alphabetical order. Mathematical signs of (+) or (–) indicate link polarities as explained in the methodological section. Needless to say, the diagram in Figure 1 has to be considered as a simplification as it would be possible to identify a vast amount of links among variables, which would make the diagram unreadable and useless. Hence, only the most significant relationships are included.

Accessibility

TBs are open to anyone. Although they have their own specific target groups, the whole concept is highly inclusive. It is even essential to have various people with various offers, but also backgrounds, and even, limitations, to keep a TB diverse enough that offers and requests are sufficiently variable to keep it alive and running.

Adaptability

TB as defined above, based on a core values and co-production imperative, are necessarily adapted to local needs and conditions (Valek, 2013). TB is adapted in relation to local legal, cultural, language, social and other conditions.

Affordability

Although some TBs require a fee from their members, this is usually symbolic and works only when participation in a TB is desirable enough to pay for it. But when this happens, people are ready and able to pay and it does not pose much of a barrier to participation. In general, most TBs are for free so they are as affordable as they can be. TB as defined above, based on a core values and co-production imperative, are necessarily adapted to local needs and conditions (Valek, 2013). TB is adapted in relation to local legal, cultural, language, social and other conditions.

Autonomy

Although a TB usually operates on the basis of a “Base Organization” (Valek & Bures, 2018) the co-production imperative assures that the objectives of a TB will be aimed at societal problem problem-solving.

Credibility

The entire existence of any TB stands on its credibility. Exchanges are made upon mutual trust and credibility predetermines the future existence of a TB. This is also the reason why, in some contexts, when a TB concept fails several times it is very hard to start with Time Banking again (Valek, 2015a).

Customizability

Very near to “Adaptability”, customizability is a more technological term. It means that a TB as a system can be customized to fit the particular needs of a community. This would include IT solutions, Time Credit exchange platform, databases of TB members’ data etc.

Complexity

As a soft system made of purely human connections, a TB is very complex, but separate system entities can be identified helping us to find specific connections.

Efficiency

TB turns unused skills, knowledge, assets, resources and time of participants into societal benefits with only a minimum of inputted funds and effort (Valek & Bures, 2018).

Emergence

A TB is always a “melting pot” for societal innovations and spin-off projects. A TB brings together people with a similar “world view” and they often go much further and create their own projects. These emergent projects would never happen without a TB.

Equality

Equality is a basic feature of the TB. The exchange happens always 1:1 and all offers and requests are equal to each other. Equality is one of the main concepts and is inherent to the TB.

Evolveability

Since its beginnings as the TB of people (person to person) the TB has evolved into various forms. The most known other forms are Person to Organization and Organization to Organizations (Ryan-Collins, Stephens, & Coote, 2008), but there are many more.

Interoperability

Because of their same internal make up, TBs can be interconnected to networks.

Modularity

There are parts of a TB which can be added when necessary, and a TB can work with or without them. For example, a coordinator: while it is highly recommended to have one to achieve sustainability, a TB can exist without it.

Predictability

The TB works on very simple set of rules, therefore it is as predictable as a soft system can be. On the other hand, it is still dependent on human behaviour, which makes it also quite fluid.

Sustainability

If basic requirements are met, the TB is a sustainable system. These requirements are funding and external inputs of skills, knowledge, assets, resources and time (Valek & Bures, 2018).

Tailorability

The TB concept can be tailored to the various needs of organizations and situations. This is at best illustrated by the existence of the Person to Organization model of a TB where organizations use the TB to fulfil their aim or at least objectives. These are usually to make citizens more active in society through the incentivization of certain activities.

Transparency

Equal transactions, open feedback, a clear set of rules and the presence of a coordinator (not always, but usual) makes the TB a transparent system.

Universality

TB can be universally applied. This comes from the previous three features of Adaptability, Customizability and Tailorability.

Figure 1. Metasystem of TB features.

Table 1. Features and their mutual links

Feature	Link and polarity	Description
Accessibility	Interoperability (+)	The greater the number of TBs', the more access they offer to members.
	Affordability (+)	Affordable TB means that more people can join, therefore raising accessibility.
	Tailorability (+)	Tailoring the TB to specific needs of a community and/or organizations and contexts makes the TB exactly as required by stakeholders. This also raises the accessibility, as it is mostly made for specific target groups.
Affordability	Complexity (-)	The more complex a system becomes, the less affordable it would

		be. Although this is not an ultimate truth in the universe, it is in the case of the TB.
	Efficiency (+)	The more efficient a TB is, the easier it is to adopt it, and the lower the costs.
	Autonomy (+)	The more autonomous a TB becomes, the fewer the external resources it needs, thus it becomes more affordable.
Autonomy	Equality (+)	Equality is one of main features of a TB and because of it the exchanges within a TB are always 1:1. This simple rule ensures an autonomous operation.
Credibility	Transparency (+)	Credibility is in this model influenced only by transparency. The TB has to continuously demonstrate it is fair and exchanges are safe and beneficial for everyone. Total transparency is a must to keep the credibility of any TB.
Customizability	Modularity (+)	The possibility to compose, or build, a TB according to specific needs makes it customizable.
Complexity	Modularity (+)	The more parts a TB is composed from (more modules), the more complex it becomes.
	Universality (+)	The fact that the TB concept is universal gives it potential for high complexity.
	Autonomy (-)	The more autonomous a TB becomes, the less complex it becomes.
Efficiency	Universality (+)	By being universal, the TB can cover many topics and fields, which makes it more efficient in solving societal problems.
	Complexity (+)	By being more complex, a TB loses its flexibility in solving the same problems, and is thus less efficient.

	Autonomy (+)	The more autonomous a TB becomes, the fewer the resources it needs. This makes it more efficient in input-to-output ratio.
Emergence	Efficiency (+)	When a TB is efficient, it easily transforms inputs to outputs and covers the necessary tools to solve actual societal problems; this allows members to produce further “products” outside of the TB framework, but also new “modules” within.
	Sustainability (+)	Only if a TB is apparently sustainable so it has some successful history and has an apparent future is it able to produce other “spin-off products”.
Evolveability	Tailorability (+)	A TB can evolve based on being tailored to specific conditions. New approaches to TBs are evolving from needs specific to the TB system.
Interoperability	Universality (+)	By being universal, the TB concept allows interconnection and mutual operation of individual TBs.
Modularity	Emergence (+)	By taking an active role in societal problem-solving, members develop new parts – modules of an individual TB. So with increasing emergence more modules are created internally (now abstracting from emergence outside of the TB system).
Predictability	Equality (+)	A clear concept of equality increases the predictability of the TB system.
	Complexity (-)	The more complex a TB becomes, the less predictable it will be. More people in a soft system means higher entropy.
	Accessibility (-)	Similar to the point above, accessibility allows more people in. With more people involved predictability is lowered.

Sustainability	Evolveability (+)	The higher the ability of a TB to evolve and follow particular needs of stakeholders, the more sustainable it is.
	Credibility (+)	Without credibility there is no future for a TB. So a higher credibility gives more chances to sustainably exist.
	Affordability (+)	The higher the affordability, the more members will get involved and for a sustainable TB it is key to have a variable and active member base.
Tailorability	Customizability (+)	The more a TB can be customized, the more it can be tailored to specific conditions.
	Adaptability (+)	The more a TB adapts to certain conditions, the more it can be tailored to them as well.
Transparency	Equality (+)	The main concept of equality makes the TB transparent.
	Predictability (+)	The fact that it is predictable makes a TB transparent. So the more predictable it is, the more it will be perceived as transparent.
Universality	Tailorability (+)	The fact that the TB can be tailored to many conditions makes it universal.

4.2. Quantitative simulations

As stated in the methodological section, the created CLD diagram is transformed into a stock and flow diagram, which enables a shift from qualitative modelling to quantitative modelling. The output from the transformation process is depicted in Figure 2.

Figure 2. Stock-and-flow diagram for metasytem qualitative analysis.

4.2.1 Behaviour of the default settings

The simulations are firstly run with model parametrization in which all variables have the same value. This enables the behaviour of the metasytem to be identified in the initial state, which is in Figure 3.

At this configuration we can see the dependence of features of the TB. For example, when accessibility increases it is followed by heightened complexity and with that with emergence, which allows new innovations. This is as the more people can use the system, the more emergent and complex it becomes, but also the less affordable it is. With higher complexity credibility goes down, which is because transparency follows it, as we can see on lower graph. With complexity universality also increases, but this is reflected by its negative influence on predictability.

In general, the model is a dynamic reflection of the introduced causal loop diagram in real time. That gives us insight into specific relations at a specific time. In simplified words, we can also say that this graph illustrates the pros and cons of a TB system. We can compare, for example, month 13, where sustainability is at its lowest due to low transparency and high complexity, with month 20, where sustainability is at its best with high emergence, accessibility, but due to its complexity it loses transparency and with that credibility. In other words, more access means more people, more ideas, more innovation, but also less control, less transparency.

Figure 3. Initial metasytem behaviour.

4.2.2 Setting focused on Equality and Adaptability

As is apparent from both types of diagrams, there are two features in the metasytem, equality and adaptability, that can be used as triggers as they have no inputs and are associated with outputs only. Hence, the second simulation run is associated with the maximum number of points in the case of these two features, while the value of the rest equals zero. The achieved results are presented in Figure 4. The results reveal that adaptability and equality (both are positioned at the right y-axis) lead to mediocre changes and thus cannot be used as the only triggers for TB development. They support an insignificant development of accessibility, complexity and sustainability. However, these changes cannot be considered as viable.

Simulations also reveal that the continuous increase of initial values of all variables converges to the initial state with different dynamics of particular features. For instance, when all variables reach 10% of the value of adaptability and equality, universality of TB starts to dominate.

Figure 4. Using equality and adaptability as triggers for TB development.

4.2.3 Setting focused on Complexity

The third simulation run focuses on complexity as it represents a quite significant feature of all TBs. The higher the complexity, the slower the TB's development. However, as suggested in the description of Figure 1, TBs need to be complex to be able to achieve their goals and purpose. Thus, the model parametrization is based on 100 points of complexity and 10% of its value in the case of all other variables. Complexity is located at the right y-axis. Results are presented in Figure 5. It is clear from the dynamics that TBs have a natural

tendency to reduce complexity when needed. Thus, complexity and its uncontrolled rise does not represent as significant an issue as it may seem. While complexity oscillates and reaches a maximum of 113 points, other variables such as accessibility or universality are supported. Results also reveal quite intuitive findings, e.g. complexity suppresses predictability and as the complexity grows, features such as credibility or transparency oscillate in an opposite direction. This scenario might illustrate the situation of a group of people starting a TB with many features that the respective community does not have a need for. For example, taking a TB model that works elsewhere and using it without adaptations. It also shows that from a certain point of accessibility, emergence and sustainability there are opening possibilities for interoperability. That would mean the connecting of more TBs to networks.

Figure 5. Influence of complexity

4.2.4 Setting focused on Sustainability

The next simulation run pays attention to sustainability, which is a key property for the development and existence of TBs in future. Therefore, the sustainability variable is set to 10% of all other variables and is located at the right y-axis. Findings reveal that even with support of all variables, sustainability cannot be significantly increased. Although sustainability leaps from 10 points immediately after the beginning of the simulation, its maximum value is 19. Thus, its value cannot be doubled even with the support of all the other features. Thus, the other question is, what will happen if sustainability is at its maximum level and all other features reach only 10% of its value? Results presented in Figure 6 reveal that in this case sustainability is stable and other variables such as universality, accessibility, complexity or emergence rise. This suggests that sustainability is a feature that cannot be directly influenced, rather it is a compound of other features. To keep a TB sustainable we need to balance the other features.

Figure 6. Influence of sustainability.

5. Conclusion

In this study, we discovered how systemic features of the TB influence each other and how their influence is developing in time. TB has been used for more than 30 years and although it was studied from: the point of view of economics (Boyle, 2014; Cahn, 2000, 2001; Cahn & Rowe, 1998; Carnero et al., 2015; Clement et al., 2017; Collom et al., 2012; Kennedy et al., 2012; Lietaer, 2001; Ozzane, 2010; Papaoikonomou & Valor, 2017; Ryan-Collins et al., 2008; Seyfang, 1999, 2006; Seyfang & Longhurst, 2012a, 2012b); social and societal issues (Boyle, 2014; Cahn, 2001; Cahn & Rowe, 1998; Collom, 2008; Collom et al., 2012; Granger, 2013; Gregory, 2012; Marks, 2012; Molnar, 2011; Naughton-Doe, 2015; Nurse & Russell, 2015; Papaoikonomou & Valor, 2017; Ryan-Collins et al., 2008; Schermer & Simon, 2005; Shih, Bellotti, Han, & Carroll, 2015; Valor & Papaoikonomou, 2016; Whitham & Clarke, 2016); or health care (Boyle & Bird, 2014; Lasker et al., 2010; Molnar, 2011) there were only brief experiments associated with systems sciences and computer-aided simulations (Tucnik, Valek, Blecha, & Bures, 2016; Valek, 2015b) associated with application of agent-based modelling as a proper tool for modelling economic systems (Bureš & Tučník, 2014). As with any other research paper, this study has some limitations. The most significant one is related to the complexity of the developed metasystem. TB is a quite comprehensive system with many subsystems, elements and various types of relations. The presented metasystem represents simplification, which is suitable for initial analysis. Further elaboration is needed, i.e. additional features need to be identified and more links created. Although there is a limit beyond which the complexity of a model disables its meaningful analysis, the current version is definitely far from this state. Moreover, the logics of the stock-and-flow diagram can be reconsidered. Simulation of the metasystem in this paper is based on unified units of measurement. More realistic models using distinct units can be developed. However, all these limitations represent further research pathways that can follow up and elaborate on this study. This paper shows potential for practical application by presenting a structured overview that can help both theoreticians and practitioners in a better understanding of the dynamics behind the various forces driving a TB.

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