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The Closed Loop Model by Regional Economics or How Big is the Ants' Footprint?

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ABSTRACT.
The economy is communication between Man and Nature. It is an interaction-network between our outside and inside Nature, that is, the external Nature surrounding us and the internal nature expressing our human essence. Money is an institution of the society, an infrastructure that ensures division of labour, enables the flow of information and material between the participants.
The concept of regional material and financial circular flow will be more important with the oncoming peak-oil and post-carbon era. We should describe in time the outlines of closed or semi-closed loops economy. The fundamentals of Input-Output will flourish once again; it could help us formulate the link between the efficiency and resiliency of a regional complex system.

Keywords: closed loop economy, sustainability, input-output model

1. Introduction: THE NEED FOR CHANGE

1.1. What time says?

Third blast at Fukushima nuclear power plant, fire at reactor No. 4, workers leave plant, crises worsens.... These are banner headlines about the latest situation in Japan. After a devastating 8.9-magnitude earthquake off the coast of Japan, a few nuclear power plants suffered damage and were having trouble with their cooling systems. This nature caused disaster is not over yet, it is still going on. Japan is a nation of 127 million people on a territory, where earthquakes are very frequent. We should analyse how a community, an economy (including the man built environment, networks, etc.) should be prepared to such traumas.

Although this isn't the time to draw any conclusions in case of Japan's biggest devastation since World War II but we could already state the following: in Japan there is a big difference between the resilience of the human behaviour and the manmade system. Close to the epicentre of the earthquake and tsunami, workers at a warehouse offer coffee and soda to the passengers for free. Four days after the earthquake and tsunami, there isn't any sign of panic that so often bursts in other countries.

The manmade system (in this case the Fukushima nuclear reactor) wasn't that resilient to the shock: the disaster, namely the tsunami, which was consequences of the earthquake, knocked out its cooling systems. Experts warn that nuclear crisis is approaching a point of no return.

1.2. Is the manmade bad or mad?

The economy is an interaction-network between our outside and inside nature. Our outside Nature (the natural and the built environment) surrounds us and our internal nature expresses our human essence. The task of this paper is to analyse this interaction-network, as communication, to find answers to the question: how could the failures in communication be decreased?

The human activities are changing the environment, in the last centuries they are rather harmful. If somebody doubts the validity of this statement, he should imagine something he finds beautiful in Nature. Is there any sign of human activity? The Nature without human interference is beautiful, with it rarely. The cooperation of Nature's stakeholder, namely the environmentalists and the executors of industrial, technological processes is antagonistic. The struggle among them is based on a typical paradigm: the industry, the whole human activity serves the consumption of the man and for this task it uses the resources of the Nature and transforms them. This connection is one-sided: the natural resources are the input for the industry, the Nature gets into worse and worse condition, while from the industrial output it gets the worst part: it becomes a waste container. The idea of recycling the materials and the filtering of harmful contaminations, any way of protection may only reduce the danger, but never eliminate it. It could be only delayed the catastrophe.

„The trouble of the world is not, we do something in the wrong way. The trouble is that we do wrong things. If finally we would do good things, even if in the wrong way, the result would be good, maybe less good. But if we intend to do the wrong things in a good way, the result is even worse." This citation is from Agócs (1991)[1], who formulated the system of the vortex type loop economy, where every loop mutually supports other loops, like the biosphere as well.

The conflict of the Man and Biosphere is economically determined. Because the human activities eliminated the woods, decreased the nutrients in the soil, irreversibly changed the diversity of life on Earth – this is true for species, for features of landscapes. The biosphere is a self-supporting system, where four sustainable flows could be described, which presumes and determines each other. These are: water-, carbon-, nourishment cycles and soil maturation. Every kind of consumption is limited in a finite system, not only the growing consumption, as we used to think about it. If the consumption is one sided, and uses the supply of the resources from that finite system and does not countervail it. In any finite system the permanent existence requires that the nourishment never ends, the outputs of material circles never accumulate. Any output should be an input. The one way flows, i.e. from mines to carbide container, from the hill to the bottom of the sea, cannot be sustainable in long term.

[1] Agócs, J. (1991): Örvénytudomány in: Harmadik Part, 1991. 9. szám

1.3. The biosphere imitator

The management of human activity should shift to another paradigm: until now we are producing only for the needs of Man, this behaviour used up the resources, caused wastes and indigestible materials for the Biosphere. It's time to introduce a new communication and behaviour system between the Man and the surrounding environment, based on the closed loop model. This model has three characteristic:

1. The human activity should also supply the needs of Biosphere
2. The linear flows should be transformed to cyclic flows, the waste formation should be diminished
3. The extent of the human activity should depend only on flow-type energy instead of stock-type.

The last one may sound a bit strange. Before the industrial revolution our civilisation used mainly flow-type resources, like solar energy, energy from wind, water, and only some from coal and wood. These formed natural limits to the growth of the population and the production as well. But the civilisation two hundreds year ago has found a very huge stock-type resource: it was the fossil energy, a concentrated form of the last 200 thousand years' flow-type solar energy. The success of industrial revolution was based on the fossil leverage, the civilization got another 200 years to follow its system of communication and behaviour with the Biosphere, while polluted it and used up its resources[2]. After the industrial revolution the man used much more the above mentioned four sustainable flows of the biosphere (water-, carbon-, nourishment cycles and soil maturation). It is time for a new, or better to say: an industrial counter-revolution.

The human activity and the biosphere should form from now on an integrated closed loop nutrition circle, where the human activity satisfies the needs of biosphere and vice versa. Instead of tailoring the nature, namely the Biosphere, the human activity should copy and imitate the natural processes. The flowing of materials, the logistic system should be similar to a nourishment cycle, as resilient metabolism.

The Walter R. Stahel created phrase "cradle to cradle", which was spread by McDonough - Braungart (2002)[3] expresses this requirement in a picturesque way.

2. THE FRAMEWORK OF THE CLOSED - LOOP MODEL

The closed loop approach has already some other related usage, like: regenerative economy, bio-mimetic approach, circular economy, cradle to cradle model. We will use mainly the above mentioned phrase to emphasize how the system works, and we will use the regenerative approach when the new human behaviour is analysed.

Starting with the latter one, in our framework we will adopt the work of McDonough - Braungart (2002). In the linear economy the process is the following: take the resources, make the product and at the end dispose the waste for ever, polluting the Nature. But in the

[2] At that time Maltus was right, as Krugman, P (2008) stated.
[3] McDonough, W – Braungart, M (2002): Cradle to Cradle. Remaking the Way We Make Things, NPPress, 2002.

regenerative model the technical and biological nutrients should circle in an integrated system, each circle supports the other, and there isn't any waste.

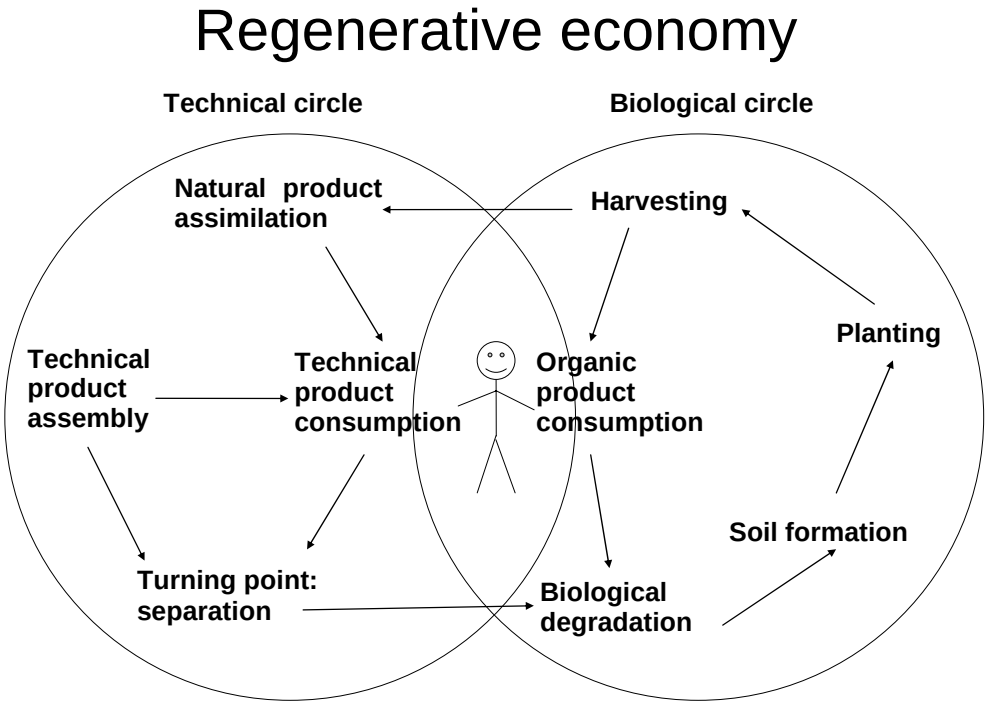

Figure 1. The concept of regenerative economy

This scheme shows the functioning of a regenerative society. If we would have such production techniques, which are not just effective but basically waste free, the endpoints of the linear line of economy would disappear and we would have negative footprint, just like the ants.

A supply chain that fully recycles all materials (through reusing and composting) creates a closed loop supply chain.

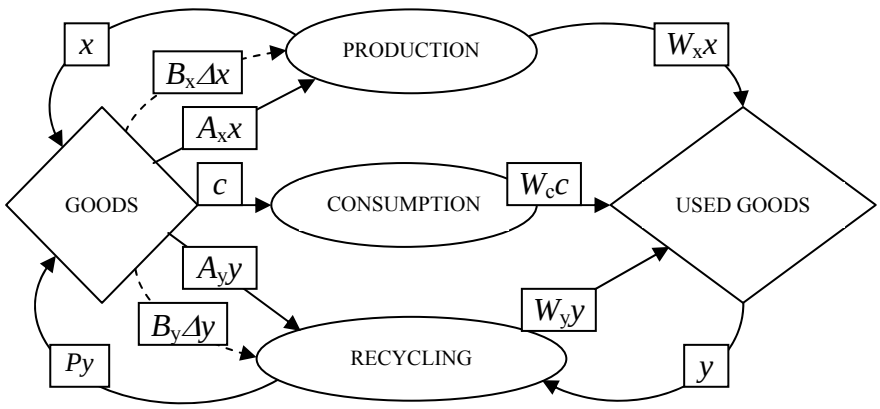

Figure 2. The material flow in the extended input-output model (Dobos – Floriska (2008))

3. THE CLOSED LOOP SUPPLY CHAIN MODEL

The closed-loop model, or sometimes closed-loop supply chain is the name of a regional economy with/without any excess material from abroad. It means that the quantity of the newly manufactured product is reduced to a minimum and the demand for new items is satisfied from recycled and remanufactured products. Modeling this situation we can apply the well-known Leontief input-output model in regional context. The material flow of the model is shown on figure 2.

The model uses the following constants and variables. The input-output balance of the regional economy can be described by the balance relation of economic goods and balance relation of remanufacturable goods.

Suppose that there are n traditional activities each activity producing a single commodity and m categories of used, remanufacturable products. We formulate a mathematical model supposing that both the balance of economic goods and of remanufacturable goods is nonnegative. In economic context this means that we could not use up more products than as much as issue from the correspondent economic activity.

The balance relation of economic goods:

$$x + Py \geq A_x x + A_y y + c\,.$$

- x is the nonnegative n-dimensional vector of gross industrial outputs of the region,
- y is the nonnegative m-dimensional input vector of the used, remanufacturable products,
- c is the nonnegative n-dimensional vector of final consumption demands for commodities,
- A_x is the nonnegative $n \times n$ matrix of conventional input coefficients of production, showing the input of goods of all axctivities that are required to produce a unit of product, the matrix has a nonnegative Leontief inverse,
- A_y is the nonnegative $n \times m$ matrix of input coefficients of remanufacturing, showing the input of goods of all industries that are required to remanufacture a unit of used product,
- P is the nonnegative $n \times m$ matrix of output coefficients of remanufacturing, showing the output of remanufactured products produced by the remanufacturing sectors.

The total output of goods of production and of the output of remanufactured goods must cover the total input of goods of all activities of the economy and the consumption.

The balance relation of remanufacturable (recyclable) goods:

$$y \le W_x x + W_y y + W_c c .$$

- W_x is the nonnegative $m \times n$ matrix of used-output coefficients of production, showing the output of used, remanufacturable products issue from production,
- W_y is the nonnegative $m \times m$ matrix of used-output coefficients of remanufacturing, showing the output of used, remanufacturable products issue from remanufacturing, the matrix has a nonnegative Leontief inverse,
- W_c is the nonnegative $m \times n$ matrix of used-output coefficients of final consumption, showing the output of used, remanufacturable products issue from consumption.

This relation shows that we could not remanufacture more used goods than it was issued from the activity of the production sectors, remanufacturing and consumption.

Since there exist such sectors of the economy like the energy sector or mining, which could not produce remanufacturable products, we could not establish a one-to-one correspondence between the output configuration of the used, remanufacturable products and the actually remanufactured ones. Thus y could not mean the output vector of remanufacturing, it characterizes only the operation level of the remanufacturing, and now coincides with the input of remanufacturing. The total output of the remanufacturing corresponding to this level of operation is exactly Py.

Throughout this paper we assume that the consumption vector is zero $c = 0$, i.e. we examine a closed dynamic augmented Leontief model. In a closed version of this dynamic model the input coefficients of matrices A_x and A_y represent not only the technological input relations of a production and a remanufacturing process but also the consumption input of goods generated by that process. Therefore the constancy of input coefficients of matrices A_x and A_y implies the constancy of both the consumption coefficients and the technological input coefficients.

In what follows we consider the operating level of production and remanufacturing as the state vector of the model. Relating to this state vector the model described above can be reformulated as a system of difference inequalities in the next form:

$$\begin{bmatrix} I_n - A_x & P - A_y \\ W_x & W_y - I_m \end{bmatrix} \cdot \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} -I_n \\ W_c \end{bmatrix} \cdot c \ge \begin{bmatrix} 0 \\ 0 \end{bmatrix}.$$

The goal of the problem is to calculate the production and remanufacturing/recycling levels of the region. The best the solution is the lower the production level x. The production level is zero in an ecological optimal solution of the above model, i.e. all used products are recylable and they are remanufactured without newly manufactured items. For this case the ecological-economic system is fully closed without any use of non-renewable resources.

4. THE SUSTAINABILITY AND THE REGENERATIVE ECONOMY

As it is clear from the above, the model of regenerative economy is the closed loop model. This way sustainability could be realized, which is necessarily a local, community question. In a closed loop model everything very close to each other, it avoids the long distance

transportation, it keeps the variety in two different aspect: in the diversity of agents and in the interconnectivity of the point of views. The regenerative economy wants not only to be efficient, but also to be effective. The latter means to what extent the new type of economy could follow the rule of nature to ensure the resilience of the society.

SUMMARY

This paper studied the question, how could we, i.e. our civilization do good things just before the oncoming peak-oil and post-carbon era?
The authors are aware to find how could we, i.e. our civilization do good things is much more important, than going on a good way but into a bad direction, with other words: doing bad things on a good way.
The human activity with its technical circle should maintain with the Biosphere (the biological circle) a closed loop, where not only the biological circle nourishes, gives resources to the technical circle, but also the technical circle does the same to the biological circle.
We have tried to investigate a regional environmental system from the viewpoint of closed-loop supply chain. We have shown that such kind of model can be modeled with the classical input-output model.

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