THE "STOCK AND FLOW" APPROACH TO THE GOVERNANCE OF SELF-SUSTAINABLE RURAL SYSTEMS

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Abstract

The aim of this study is to present the "stock and flow" model - based on the Georgescu-Roegen bio economic paradigm and on the *ecological economics* principles - in a regional key and to discuss the implications of such an approach on the local system governance in order to guarantee a long term economic, social and environmental self-sustainability. These theories give a dynamic characteristic to this approach, by interconnecting the production process (supply) with the responsibilities of the welfare generation (demand). Starting from this theoretical model, it is possible to look at the integrating modes of production and consumption processes at a local scale that consent to guide a rural system towards conditions of sustainability. This perspective of rural system governance imposes the relocation of the control of resources (stock) to a local level and, therefore, a deep change in the idea of the politic procedures.

Key words: ecological economics, stock and flow, ecological footprint

Introduction

The aim of this study is to present the "stock and flow" model in a regional key and to discuss the implications of this approach on the local system governance in order to guarantee a long term economic, social and environmental self-sustainability.

The "stock and flow" model, which will be briefly described in the second paragraph, is based on the Georgescu-Roegen bio economic paradigm (Georgescu-Roegen, 1971; Georgescu-Roegen, 1975) and on the *ecological economics* principles (Mayumi, 2001; Daly e Farley, 2003). These theories give a dynamic characteristic to this approach, by interconnecting the production process (supply) with the responsibilities of the welfare generation (demand) (Bonaiuti, 2003). Starting from this theoretical model, it is possible to look at the integrating modes of production and consumption processes at a local scale that consent to maintain a rural system in conditions of sustainability or, in the case that these are already exceeded, to guide it towards the recovery.

The conditions of environmental sustainability of a territory are closely tied to its rural connotation; indeed, as it will be discussed in the third paragraph, the presence of strong rural characteristics, determines not only an increase in resource availability for the local population, but it also determines the tendency to reduce the environmental impact of the residents' lifestyles. Therefore, while in the metropolitan areas, the impact of human activities is largely greater than the loading capacity of the territory and, thus, it is impossible to reach self-sustainability conditions (Rees and Wackernagel, 1996; Rees 1997, Martinez-Alier, 2004), in rural territories, it is possible to aim at a model where all the energy needed to sustain the consumption and to absorb the waste of the local community is available on the place.

For this reason, in rural systems, it is possible to look for a kind of governance that, through a participative and conscious management of the local stocks, has the objective of maintaining/recovering balance conditions between consumption and production processes (Midmore and Whittaker, 2000). This balance, as highlighted in the last section of the paper, must be centred around the agricultural sector, which is able to satisfy the local demand of primary goods through the utilization of the technical and natural capital stocks and represents an essential element for the relational good nets that, thanks to their ability to maintain and develop "not material" stocks of knowledge, represent the base for the models of local self sustainability (Laville, 1994; Gui, 1996).

An overview of theoretical framework

According to the "stock and flow" model, the structure of the local economic system can be described starting from the production side (Georgescu-Roegen, 1971; Georgescu-Roegen, 1984; Daly, 1996) and then transposing the theoretical framework to the consumption process.

The production process involves four stock typologies (fig. 1): the natural capital (K_N), taken as organized matter energy system (Costanza and Daly, 1992); the capital (K), taken in its traditional sense, that is to say the combination of tools and machinery used in the production; the social structure involved in the production process, represented by the labour stock (S); the culture, that is to say, the system of know-how and values (no sphere - N) that have a decisive influence on the productive capacities of a society (Berkes and Folke, 1992). Concerning the flows, the production process foresees an input in a flow of natural resources from the biosphere (x_n) which joins a flow of know-how and information from outside the productive system (n_i). Finished products (q_i) and waste (w_i) constitute the two types of outgoing flows. It has to be considered that a certain amount of the flows should be used so that the different stocks are able to maintain their own functional and organisational structure.

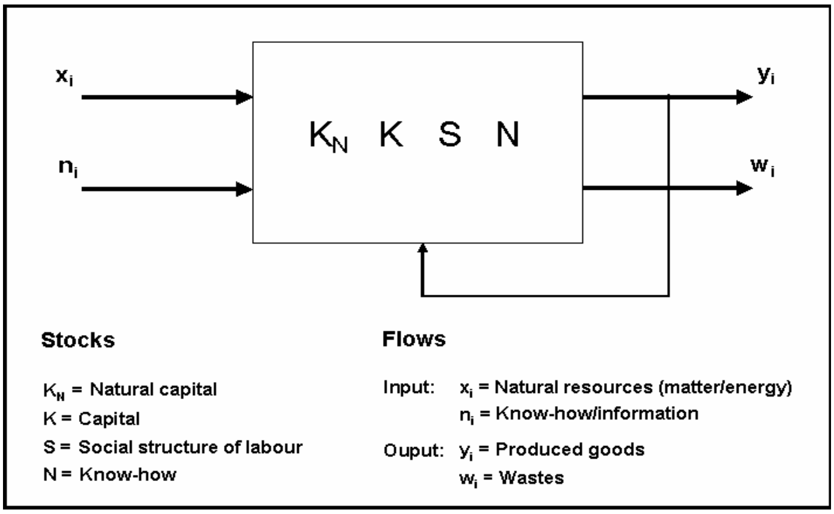

Figure 1 - The system of production: Stocks and Flows

To move towards a systemic analysis of the economic process, the flow and stock approach is extended to the theory of the consumer (figure 2). Therefore, the consumption system is described by a stock and flow model (Bonaiuti, 2008). The stocks involved in the creation of well-being are the same that characterize the production process: the ecosystems (K_N), the capital (or wealth) owned by "consumers" in the form of lasting goods (K), the system of social relationships (S) and the system of know-how and values (N).

Although the role of natural capital is more obvious in the process of production, both in providing resources and as an agent of transformation, local ecosystems play a significant role even in the demand side. Indeed, an important part of the well-being people can attain depends on the *stock* K_N that *already exists* and requires no effort to be produced (either in the sense of "labour" or in the use of capital), apart from that connected to its preservation. The second type of stock is made up of the wealth (capital) owned by "consumers" (K_C) in the form of lasting goods. The wealth accumulated in the form of lasting goods is a "direct" source of well-being/happiness not connected to the flow of market goods. In order to enjoy such lasting goods, only a modest flow of matter/energy (x_n) is required to maintain them in the same conditions in which they entered the process. That the enjoyment of life is a function of *wealth*, and hence of stocks even more than income (flow), is an important distinction compared to standard theory. Stock S is made up of the social and relational structures contributing to the basic fulfilment of needs. The stock of know-how and values (N), if considered from an individual point of view, reflects the consumer's "preference structure"; actually, it is the resultant of the complex interaction with other subjective values and preferences, social organization and production sphere.

The input flows of the consumption process are the quantities of goods and services (z_i), generally coming from the market, and natural resources (x_i). The output flow is represented by enjoyment of life (L) to which a flow of waste (w_i) produced by the entropic degradation of consumption goods has to be added.

The systemic approach to consumer theory emphasizes how *the flows of goods and services are not able on their own to produce any well-being.* It is the interaction between stocks and flows to originate the enjoyment of individual life and the community's well-being.

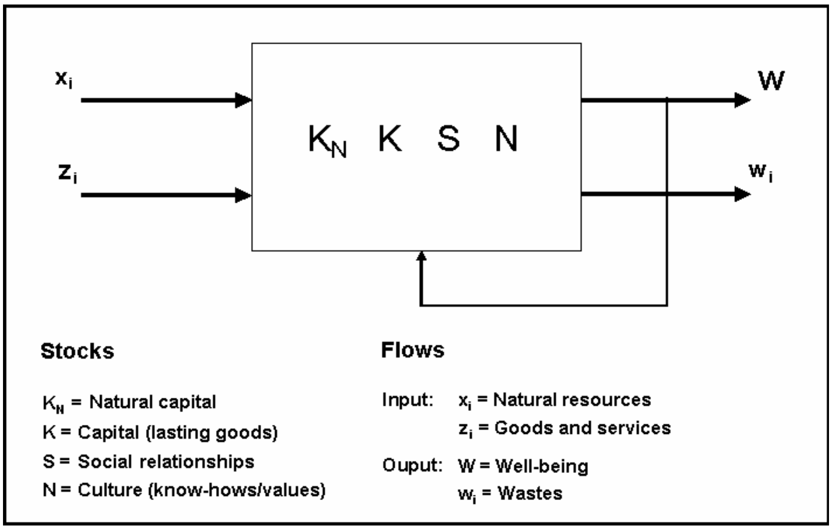

Figure 2 - The system of consumption: Stocks and flows

Check of the conditions of local system sustainability

The integration at a local level of the production and consumption models described through the stock and flow approach consents, on one hand, a global view of the local system in economics and social terms and, on the other hand, offers the chance to verify the environmental sustainability in empirical terms.

In order to achieve this second target, it is fundamental to compare the entering (matter/energy) and the outing (waste) flows of the production and consumption processes that take place in the local system with the ability of the stocks present in the territory (mainly the natural capital) to supply the first and absorb the second ones. To carry out this comparison, it is necessary to have two synthetic indicators: the first one should be capable of quantifying the whole demand of resources coming from the resident population of a territory; the second one should express the availability of the total resources present in the same territory. The two indicators that have these characteristics and that are considered suitable for this purpose at an international level are the Ecological Footprint (EF) and the Bio capacity (BC).

The Ecological Footprint (Rees, 1992; Wackernagel and Rees, 1996) measures humanity's demand on the Earth's ecosystems. It represents the amount of biologically productive land and sea area needed to regenerate the resources a human population consumes and to absorb the corresponding waste. The EF tracks human consumption and waste generation (given prevailing technical and economic processes) in terms of the area needed to provide ecological resources and services – food, fibre, and timber, land on which to build, and land to absorb carbon dioxide (CO2) released by burning fossil fuels (Hails, 2008).

The EF has gained popularity for its pedagogical strength as it expresses the results of its analysis in spatial units, called "global hectares" (gha) that can easily be communicated. In addition, by allowing to compare human impact (measured by EF) to the planet's limited bio productive area (measured by bio capacity), this method tests a basic ecological condition for sustainability (Holmberg et al, 1999).

Indeed, *BC is the amount of biologically productive area – cropland, pasture, forest, and fisheries – that is available to meet humanity's needs.* The BC does not only depend on natural conditions, but on agricultural and forestry techniques too. This indicator is also measured in global hectares, calculated taking into account the average bio productivity of the different land categories, which are constantly adjusted through equivalence and production factors.

By subtracting to the supply of biologically productive area (BC) the relative demand of the local population (EF), an environmental balance is obtained: a negative (positive) value shows an ecological deficit (surplus), that is a situation of un-sustainability (sustainability) in which the consumption of natural resources are greater (lower) than the regeneration levels of the local ecosystems (*Hails, 2008*). The amount of the ecological deficit or surplus represents an estimation of the level of sustainability/un-sustainability of the local population lifestyle compared to the resources of the territory as a spatial dimension (Bagliani et al., 2008).

Relation between sustainability and rurality of the local systems

Once identified the theoretical framework and the empirical tools for the evaluation of the environmental sustainability of the local systems, the relation between environmental sustainability and level of rurality has also been studied. Indeed, besides checking the un-sustainability of the urban areas, it is important, when defining governance models, to express the conditions of ecological surplus/deficit in relation to the rurality level of the local system.

For this part of the study, 12 Italian provinces, for which the values of EF and BC are available in literature, have been considered (Arpa, 2003; Bagliani et al., 2008; Provincia di Bologna, 2007; Provincia di Milano, 2008; Provincia di Torino, 2005). The Ecological Balance reported in the first three columns of table 1 has been calculated referring to these provinces. The result is a general un-sustainability that in some cases appears of low entity, while in other reaches extremely high levels. This outcome should not be surprising, if we consider that Italy has an EF=4.8 gha and a BC=1.8 gha, with an ecological deficit equal to 3.0 gha (Hails, 2008).

As it regards the evaluation of rurality in the local systems, two aspects must be considered. The first one is represented by the adoption of a clear and pragmatic definition of rurality, from which its identifying characteristics emerge without doubt. The second aspect is measurement that is the quantification of the level of presence of the characteristics that define rurality in the single studied territorial units.

Without entering in the multifaceted debate about the definition of rurality (Blanc, 1997), in this study the definition proposed by OCDE for the classification of rural areas in the member States has been adopted: "*the rurality of a territory is expressed by the quota of residents in municipalities with low population density*" (OCDE, 1994). The provincial (NUTS III) rurality has been calculated considering this definition and adopting a methodology that measures the rural population resident in the single municipalities (NUTS IV) by using a *fuzzy set theory* approach (Franco e Senni, 2001). The rurality level calculated in this way is determined by the density and the population distribution between urban and small inhabited centres. This is a way to look at rurality in a local system that, since it takes into consideration the residential division and, indirectly, the localization of the economic activities, can be effectively put in relation with the resources, available and utilized, of the territory.

The last column of table 1 reports the rurality level, measured in a 0-1 scale and calculated adopting the methodology of the 12 considered provinces.

Table 1 – EF, BC, Ecological deficit and Rurality level in 12 Italian provinces

Province	EF (gha)	BC (gha)	Ecological deficit (gha)	Rurality level
Ancona	6.11	2.07	4.04	0.178
Ascoli Piceno	6.54	2.42	4.12	0.197
Bologna	4.34	1.70	2.64	0.200
Cagliari	5.43	4.03	1.40	0.277
Forlì Cesena	7.43	2.56	4.87	0.175
Milano	4.17	0.14	4.03	0.003
Pesaro Urbino	6.32	3.43	2.89	0.333
Rimini	7.78	0.83	6.95	0.048
Siena	5.80	5.74	0.06	0.502
Torino	3.38	0.43	2.95	0.092
Venezia	5.71	2.33	3.38	0.098
Viterbo	3.31	3.03	0.28	0.632

The correlation analysis between ecological deficit and rurality level shows a value of $r=-0,801$, which is statistically very significant ($p<0,01$). Thus, it is possible to conclude that, at least in Italy, the greater is the rurality of a territory, the higher is the level of sustainability (or the lower is the level of un-sustainability) of the human activities that take place there.

This result could be easily predicted by considering the narrow link between rurality and BC, both reversely linked to the density of population; the test shows a very high correlation coefficient ($r=0,763$; $p<0,01$). This is a confirmation of the higher availability of the stock of natural capital in local systems with an elevated rural connotation.

The relation between EF and rurality is less obvious, but even if not particularly high ($r=-0,231$), it shows an interesting tendency, which is that the lifestyle of the populations resident in rural contests appears less expensive in terms of dimension of entering and outgoing flows.

Governance for rural system self-sustainability

The local systems with a high rural connotation are more sustainable from an environmental point of view because, considering their low inhibitive density and population dispersion; they are characterized by a greater individual endowment of natural capital stock. Furthermore, the analysis results highlighted how lifestyles in the rural areas are more sober in the profile of the flows of the consumption system.

This situation is partially explainable due to the fact that rural communities can face their needs by limiting the utilization of out coming inputs by using efficiently the available stocks. The natural capital, represented by agricultural and forestry resources, permits to face the food and energetic needs through a lower utilization of fossil fuels and a larger area for the CO_2 absorption. The stock of relational structures represented by a spread and consolidated net of solidarity economy which still characterizes the social structure of rural communities, allows the supply of services to the local population through non-monetary exchanges (Laville, 1994).

Starting from these considerations, rural system governance that has the aim of maintaining the local community welfare in the long period should focus on the valorisation of the available stocks reaching, at the same time, a flow level compatible with the system self-sustainability conditions. In other terms, it is about making choices that aim for an "efficient" balance between production and consumption processes and within a scale of the production-consumption system compatible with the loading capacity of the local ecosystem, verified through a constant comparison between ecological footprint and bio capacity. Obviously, it should be a dynamic scale that will lead to the development of the system conditioned by the availability of technologies able to reduce the unitary resource utilization and improving the capacity of recycling waste. Therefore, in the case that a territorial system is in conditions of un-sustainability, that is to say with production and consumption processes above its loading capacity, the stock and flow approach imposes the adoption of policies of decrease in input flows in the consumption system, in particular of material goods, and the valorisation of the stocks present in the territory, mainly relational goods (Latouche, 2006).

This prospective of rural system governance imposes the transfer at a local level of the resource control and, thus, a deep change in the idea of the political procedures. On the other hand, only through forms of participative democracy, it is possible to reach an agreement on the welfare production process and thus find the will and the information needed to conserve and increase the value of the peculiar characteristics of a place as wealth (*stock*) to be protected and increased, and not as resources (*flows*) to be exploited for profit (Bonaiuti, 2008).

From this point of view, it becomes necessary to clearly specify the scale of the local system: this must represent the spatial dimension on which directly analyze the relation existing between human activities and natural resource availability and, at the same time, the place of policy decisions that, through a participative and shared process, must get into proportion the production and consumption processes in order to reach the difficult balance between ecological sustainability and community welfare.

Literature

1. Arpa (2003), Impronta Ecologica a Rimini, quanto è lungo il cammino per la

sostenibilità, Arpa Rivista, n.2.
2. Bagliani M., Galli A., Niccolucci V., Marchettini N., (2008), Ecological Footprint analysis applied to a sub-national area. The case of the province of Siena (Italy), Journal of Environmental management 86, 354-364.
3. Berkes F., Folke C., (1992), A system perspective on the interrelations between natural, human-made and cultural capital, Ecologica Economics, 5, 1-8.
4. Blanc M. (1997), Rurality: concepts and approches, Paper presented at 48th Seminar "Rural restructuring within developed economies" of EAAE, Dijon, 20-21 March.
5. Bonaiuti M., (2003). Introduzione in Georgescu-Roegen N., Bioeconomia, Bollati Boringhieri Torino.
6. Bonaiuti M., (2008), Economia e territorio. Un approccio sistemico, Sviluppo locale, Vol.11, n.27, 32-56.
7. Chambers N., Simmons C., Wackernagel M. (2000), Sharing Nature's Interest: Ecological Footprints as an Indicator of Sustainability. Earthscan, London.
8. Costanza R., Daly H.E., (1992), Natural capital and sustainable development, Conservation Biology, 6, 37-46.
9. Daly H.E. (1996), Beyond Growth. The Economics of Sustainable Development, Beacon Press, Boston.
10. Daly H.E., Farley J. (2003), Ecological Economics: Principles And Applications, Island Press, Washington DC.
11. Franco S., Senni S., (2001), The regional modulation of rural development policies: a methodological proposal, paper presented at 73rd Seminar "Policy experiences with rural development in a diversified Europe" of EAAE, Ancona, 28-30 June.
12. Georgescu-Roegen N., (1971), The entropy law and the economic process, Harvard University Press, Cambridge (USA).
13. Georgescu-Roegen N., (1975), Energy and economic myths, Southern Economic Journal, Vol. 41, n.3 , 347-381.
14. Georgescu-Roegen N., (1984), Feasible Recipes Versus Viable Technologies, Atlantic Economic Journal, XII, March, 21-31.
15. Gui B., (1996), On 'relational goods': strategic implications of investment in relationships, International Journal of Economics, vol. 23, n. 10/11, 1996.
16. Hails C. (Ed.), (2008), Living Planet Report 2008, WWF International, Gland, Switzerland.
17. Holmberg J., Lundqvist U., Robert K.H., Wackernagel M., (1999), The ecological footprint from a systems perspective of sustainability, International Journal of Sustainable Development and World Ecology 6(1):17–33.
18. Laville J.L., (2004), L'economie solidaire, une perspective internationale, Desclée de Brouwer, Paris.
19. Latouche S. (2006), Le pari de la décroissance, Fayard, Paris.
20. Martinez-Alier J. (2002), The Environmentalism Of The Poor, Edward Elgar, Cheltenham (UK).

21. Mayumi K. (2001), The Origins of Ecological Economcs: The Bioeconomics of Georgescu-Roegen, Routledge, London.
22. Midmore P., Whittaker J. (2000), Economics for sustainable rural systems, Ecological Economics, Vol. 35, 173-189.
23. OECD, (1994), Creating rural indicators for shaping territorial policy, OECD Publications, Paris.
24. Provincia di Bologna, (2007), Impronta ecologica della Provincia di Bologna, (www.provincia.bologna.it).
25. Provincia di Milano, (2008), Impronta Ecologica della Provincia di Milano, (www.provincia.milano.it).
26. Provincia di Torino, (2005), Impronta ecologica della Provincia di Torino, (www.provincia.torino.it).
27. Rees W.E., (1992), Ecological footprints and appropriated carrying capacity: What urban economics leaves out, Environ. Urban., 4, 121-130.
28. Rees W.E., Wackernagel M., (1996), Urban ecological footprints: why cities cannot be sustainable and why they are a key to sustainability, Environmental Impact Assessment Review, Vol. 16, Issue 4-6, 223-248.
29. Wackernagel M., Rees W.E., (1996), Our Ecological Footprint: Reducing Human Impact on the Earth, New Society Publishers, Gabriola Island, BC.