Micro- and Macroeconomic Models and Optimization Procedures

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SUMMARY

The conventional economics lies on the fundamental assumption of neoclassical welfare economics according to which the primarily aim of economics is to achieve Pareto optimal conditions. Pareto optimum has two meanings: if Pareto optimum means Pareto norms, it reflects relevant conditions for economic policy. If Pareto optimum is linked with marginal analysis when a determined fictitious economic optimum is sought for in a perfect competition situation, it an instrument used for formal analytical analysis. According to this allocation of resources or the volume of production is optimal if there is a situation in which it is possible to make any individual better off without making someone else worse off.
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MICRO- AND MACROECONOMIC MODELS

It is obvious that during economic education we often come across economic models. In microeconomics this is consumer and producer behaviour. In macroeconomics, models are used for description of macroeconomic equilibrium and economic growth. The majority of these models are static, but some are dynamic, explaining factors and processes over periods of time. Thus, conventional economics is considered static and does not contain variables related to time or various time periods. (In an equilibrium model the demand is related to a particular time period of supply and price). There are economic models that use variables related to different time or time periods, but their factors are not 'properly' linked. It is obvious that real economic processes undergo different changes with time; therefore dynamic models are more efficient and realistic than static ones.

Modelling in Conventional Micro and Macroeconomics

Conventional economic theories use over simplified models which fail to reflect complex reality for several reasons (Bartmann, 1996:30):

- In real life preferences, applied techniques and technologies as well as behavioural norms are subject to continuous variation. Consequently, permanent preferences and production functions cannot be used in the models.
- Reality cannot be characterised by conditions for perfect competition or circumstances for permanent competition. Monopolies, oligopolies and other competition barriers cause major stabilisation and allocation problems.
- In most areas of economics decisions are not made on the basis of perfect information and involve a number of uncertainties. Rational expectations and perfect information ensure grounds of existence for static equilibrium theories, which are not applicable for description and explanation of decisions made in sustainable non-equilibrium and uncertain conditions.
- The illustrated equilibrium models leave out of consideration social relationships existing in the reality. Conflicts of interests and continuous clashes are experienced in distribution of incomes and wealth, of work and production factors, and in issues related to quality of natural environment, competition environment and public welfare.
- Effects of externalities are neglected in the models and are considered to be temporal problems which make economic subjects behave properly by environmental policy tools, assuming that this will resolve problems.
- The conventional theory considers Pareto optimal point to be a socially optimal condition. Even if the production and the distribution are believed to be socially acceptable and in line with Pareto optimum, not every allocation can be supposed socially acceptable since social legitimacy of such allocations can be queried.

- Evolution of society is naturally dynamic and is considerably affected by social scales of values which shape institutions, human behaviour and world views. Since the equilibrium theory takes value judgment as its starting point, it fails to give an acceptable interpretation of a complex reality.
- The conventional economic theory takes into account only factors relying on quantitative indicators and seems an exact science, which narrows the validity area of the theory. It excludes social, ecological and psychological dimensions of management in the field of raising and shooting problems.
- Conventional economists take simple rationality problems as a starting point of complex human behaviour. A human being is an idealist and is able to perform cooperative activities

Societies which base their existence only on rational behaviour do not prove viable.

Absolutization of Consumer Autonomy

Conventional economic theory deals with sovereign consumers who make their choices from possible alternatives on their own. Models often make a supposition that the behaviour of an economic player does not have an impact on the extent of a particular economic factor. Environmental economics thinks that if only one member of the group under investigation behaves non-environmentally friendly, this does not have an impact on the total profit. The feasibility study conducted of a player considers positive alternatives (the environment friendly behaviour in the model mentioned above) irrational. (See the supposition in the free rider game theory).

The conventional environmental economics neglects the idea that the impact of the laid burden on the environment will be experienced only in the future, but the profit gained from the consumption can be enjoyed at present, so the effect of consuming natural resources is often uncertain and non-transparent for economic actors. For instance, overexploitation of natural resources can lead to irreversible processes the consequences of which even the promoter is not able to predict.

The conventional presupposition saying that consumers can correctly define the product value is wrong since the information flow need improving and both social and psychological factors have an impact on the value judgment.

Limits of Applied Economic Models

Reliable data about incomes and expenditures trends cannot be provided. Resolving this issue by an ordinary discounting does not seem a good idea since due to the nature of the method discounting undervalues the present importance of long-term impacts. The climate change to be experienced in one hundred years does not require any measures to be taken at present due to a high discount rate. Thus, discounting, as an evaluation mechanism, cannot be considered relevant. On the other hand, conventional economics does not have another mechanism showing how to appraise environmental damages and incurred costs. If there is no discounting done, the incurred expenses completely affect the decisions made at present.

Conventional economics attempts to solve the market deficiencies of the distribution of natural resources by internalisation of external costs. The problems stemming from this are as follows:

- Cost internalisation requires perfect information about the extent of the damage and the expenditures to be made averting it, but this is only theoretically possible.
- If the externalities are irreversible or result in accumulating processes, the static internalisation strategies fail to work

From the difficulties listed above we cannot draw the conclusion that internalisation is a completely unnecessary mechanism. We are attempting to point out that it should not be done in a simple formalised ways or simply by computing the costs of environmental damage since the internalisation problems listed above cannot or can hardly be taken into account.

Relationship Between Economy and Ecology

One main false assumption of conventional economics apart from the already mentioned above is the pessimistic one according to which all environmental problems arise from cost issues. Actually, economic exchange processes can be non-economic (ethical, legal, political, etc.) consequences. Irreversible processes (extinction of species) or even diseases or deaths caused by environmental pollution can hardly be compared with produced material goods. The economy is only one of the sub-systems of social and ecological systems consisting of human beings having different needs. Certain basic services of the nature cannot be substituted by services and goods produced artificially. There are three functions and services which cannot be substituted:

- Life supporting functions of the nature: appropriate climate, protection against harmful rays, clear air, soil, water and other natural resources are of the utmost importance for humanity and cannot be replaced artificially.
- Complex functions of ecological systems: for instance, not only does a forest provide leisure facilities for people (which perhaps can be substituted), but have an impact on climate, store water resources, prevent soil erosion and promote sustainability of biological diversity.
- Resource and energy generating ability of the nature: laws of thermodynamics show that economy fails to operate without its natural resources in the long-run since the generated waste and the used energy cannot be regained by 100%.

Consequently, both economy and ecology are disciplines subordinated to more general and more comprehensive laws. On the other hand, proper tools to be applied for overcoming contradictions between basic approaches of the two fields do not exist yet. Humanity is not able to exist without nature, but nature can get by with humans, so the false concept related to priority of economy should be rejected. It is the economy that should be adapted to limits created by natural environment.

From the considerations above, it follows that conventional economics attempts to provide an explanation to complex social, human and organizational behaviour forms experienced in the field of economics by applying simple models. The descriptions it offers are appropriate only for understanding some aspects of particular fundamental economic processes. They are of didactic (teaching and instructing rather than explaining) character and bear features of positivism. Positivist norms hold that science should restrict itself to describing and systematising phenomena and should not explain them, since human senses are not able to comprehend internal correlations and regularities. This approach identifies objects and links them with perceptions created about them. It rejects making a distinction between the internal and external world, subjects and objects, but sets norms. The applied models face principled barriers, which conventional economics has failed to overcome despite making continuous improvements to the theory.

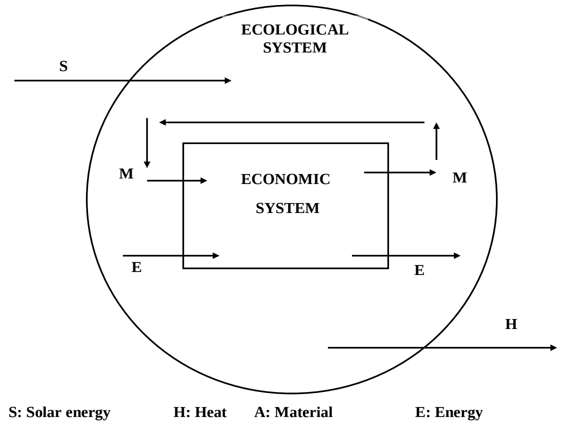
ALTERNATIVE ECONOMICS OPINIONS AND MODELLING

Several trends looking for new solutions have evolved in economics. There are two major trends in which theorists attempt to overcome the assumed shortcomings of problem solving methods by reconsidering conventional suppositions and axioms and applying methodological pluralism.

Ecological Economics

Ecological economics evolved in the 1980s and attempted to give a broader interpretation to economics incorporating ecological ideas. Pearce (1998) gives a general description of so-called ecological economics. This trend considers economics to be a subsystem of a complex ecological system. It does not completely reject conventional economics and its followers rely on the achievements of conventionalists. The pioneers of ecological economics (Kapp and Odum, among others) further developed neoclassical economic models, supplementing them with ecological factors.

The distinguishing feature of ecological economics is that instead of focusing on the relationship among nature, society and economics in monetary terms, it describes changes in natural units of measurement. Seeber (2001) holds that since theorems of ecological economics do not make up a single theoretical system, the primary task should be to create such a system.



Seeber (2001:27)

Figure 1. Ecological economics:
the economy as the subsystem of the ecological system

Ecological economics can be introduced on the basis of two trends, which are perfect examples of an interdisciplinary approach and broad perspectives. One of them urges the application of thermodynamic main theorems in the description of economic processes, while the other attempts to define the total economic value.

Criticizing conventional economic approaches, Georgescu-Roegen (1971) did not agree with the general picture developed of economic circulation, emphasizing rather that management is also involved in physical issues. The major idea behind the analysis that Georgescu-Roegen urged was energy, more precisely, energy flow and energy transformation related to economic processes since they had both been unconsidered the scope of analysis until then. According to him, economics has to take into account the major laws of thermodynamics. The Second Law of Thermodynamics holds (Georgescu-Roegen, 1974) that in a thermodynamically single system like the Earth the amount of energy remains constant, but with its exploitation the utility factor of a given energy unit continuously deceases. The amount of energy which cannot be exploited further can be characterised by the term entropy. The processes going on in thermodynamics can be either reversible or irreversible. In case of reversible processes entropy remains constant. In an irreversible process entropy increases. When the natural process reaches a state of equilibrium, it reaches its maximum. An entropy change quantifies the extent of irreversibility of a physical process. Economic processes exploit low-entropy materials and energies from nature and transform them into higher-entropy wastes and pollution in production processes (Faber et al, 1998). For instance, incineration transforms highly ordered low-entropy fossil matter and when it is burnt the stored energy is released and dispersed into the environment. The generated gases and particles can be utilized at a great cost.

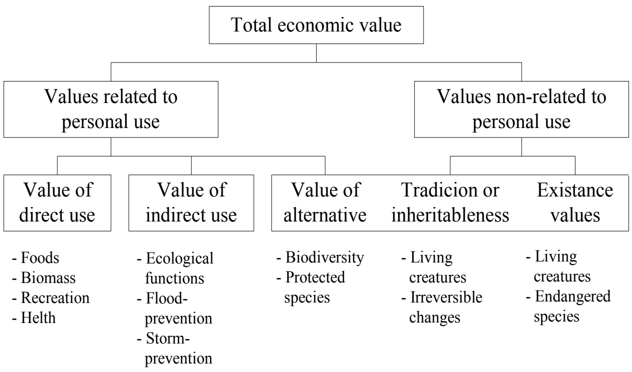
Georgescu-Roegen (1974) holds that the most serious shortcoming of conventional economics is that it neglects the existing physical boundaries and creates the illusion that the energy to be utilised is infinite.

The subject of the second trend of economics is total economic value, and a precise definition of it plays an essential role in the relevant decision making processes.

There are several factors which determine the total value of a natural matter (see Bromley, 1995; Pearce, Turner, 1990; among others). Factors determining the total economic value can be classified into two major groups: direct-use and indirect-use values. Direct-use values arise from active personal exploitation of the environment. An angler, a hunter, a hiker and an ornithologist use the natural environment and gain benefits from this. If a person finds pleasure in looking at the beauties nature either on the spot or in a photograph, he uses nature and generates benefit from this. Economic terminology defines this value as an economic value (Kerekes, 1995). The total value of private goods equals the profit generated from the exploitation.

In case of natural goods their existence value is one of the non-use values and stems from their simple existence. In this case, the individual acknowledges the right for something to exist; for instance, nature, and is willing to make sacrifices in order to conserve it.

Option value is another non-use value which includes the value of ensuring future use of the goods by an individual or by a future generation and the value of ensuring others' use of services provided by nature. The components of total economic value are presented in Figure 2.



(Kerekes 1995:26)

Figure 2. The value components of the natural resources

Neglecting differences in estimates of our achievements and natural goods results in making invalid conclusions when investment decisions are made.

If a particular investment involves the transformation of nature, nature loses some part of its total economic value. Thus, while estimating the extent of losses, not only the value loss originating from exploitation, but the value decrease (existence value, bequest value) resulting from this has to be taken into account.

There is a distinct contradiction within this idea since ecologic economics measures ecosystem services from a monetary aspect while questioning their quantification in money. (Marjainé Szerényi, 1999).

Evolutionary Economics

Evolutionary economics deals with ecological problems indirectly. It is an economics theoretical trend, which - unlike the static approach of mainstream economics - deals with evolution and dynamics of economic systems and actors (Dosi and Nelson, 1994). The representatives of evolutionary economics hold different views on the actual content of the economic evolution concept (among the biological processes there are some that can be matched with economic processes and there are some that cannot), but basically they all agree that behavioural forms of economic systems and actors undergo constant changes.

The subject of our analysis is the explanation of changes of an endogenous character emerging in systems: the idea that in economics a constant change is generated from the inside is a fundamental premise in evolutionary economics which is accepted by all trends (Witt, 1992).

Several followers of evolutionary economics experience similarities between evolutionary and selection processes of economic and ecological evolution. They hold that economic phenomena show more similarities with biological organisms and processes than with the mechanical world preferred by neo-classicists. They focus on historical determinism and post dependence of evolution. They believe that future is unpredictable. Future is not simply unknown, but at the moment when a decision is made, it does not even exit.

There are three trends in the methodology of evolutionary economics that are as follows (Witt, 1992):

- ➢ The verbal trend is based on traditions of Austrian economics schools. Its representatives deal with growth, economic boom/bust cycles and institutional changes. Its followers go back to their predecessors' main ideas and attempt to apply them to the current troubleshooting.
- ➢ Another trend is based on mathematical models and computer simulations. This trend examines the spread of new technologies, innovations and economic growth. Its most popular model, developed in 1982, considers innovation to be an evolutionary process.
- ➢ The third trend models complex systems from the perspective of structures and operations. The created models attempt to analyse time and space interdependencies between economic agents who are able to learn and are limitedly rational.

From the considerations above, it follows that the conventional economics and environmental methodologies used for describing complex and dynamic economic processes are not applicable and have shortcomings. On the basis of the above-mentioned features of economics trends, we hold that shortcomings experienced in neoclassical environmental economics can be overcome by broadening the interdisciplinary approach to theoretical aspects of evaluation.

OPTIMIZATION PROCEDURES

The technical literature distinguishes three main types of global optimization methodology. The first is gradient-based; the second is direct search based and the third is random search based global optimization methodology. In the units to follow we are going to give a short overview of methodologies, laying special emphasis on the advantages and shortcomings of the major ones.

Conventional Methodology

The elaboration and the study of the gradient–based method of optimization started several decades ago. There are two types of this method: direct and indirect.

While using the indirect method, the extreme value can be found by defining the zero positions of a derived function, which generally means resolving a whole equation system. In the case of functions with several dimensions, the extreme values are the points where the curve rise of the tangential plane is equal to zero in all directions. When direct methods are applied, the extreme values are shifted towards the local gradient. This is usually called hill climbing, meaning that, in order to reach the extreme point (depending on the type), the steepest slope (gradient) is either 'climbed' or 'descended'. The shortcoming of both methods (they have been modified, changed and revised several times) is that they are not robust enough to be applied in a wide range of problems to be solved in practice. Indirect methods stipulate that the derived function of the problem to be resolved has to be known. Unfortunately, since this assumption is not true in a huge proportion of problems experienced in real life, the practical implementation of the indirect method is extremely limited.

Although direct methods soft conditions for problems, in practice they can only be used for determining the local extreme values.

Methods Based on Random Search

The second major type is the method based on direct search. The main principle of this method is that an algorithm finds the global optimum by examining each point of the space in a given probability space. The probability space points can often be described with a tree structure. When the whole space is walked around, intersection points are approached. Different strategies are applied for tree walking: for example, in-depth walking and width walking. The probability space of problems is so extended that it is impossible to walk along the paths in a reasonable amount of time. In some cases branching and restriction principles can be applied. They are used when conditions and/or stipulations allow us to examine given vertices on the basis of which we can decide whether the optimum is in a sub tree that does not start from the given vertices. In this case the sub tree can be neglected and the extension of the search space gets smaller. However, the complexity of the probability space of real problems puts restrains on the efficiency of the method, since it is impossible to tour along the whole or even a part of the problem paths efficiently or/and economically in a reasonable amount of time.

It is becoming more and more typical of practical problems that their probability space is large and/or multidimensional there is little information about the evaluation function estimating the 'goodness' and it is generally burdened with noise. Thus, the application of the deterministic methods mentioned above is limited in our case.

Stochastic or random search based methods belonging to the third type of global optimization algorithms attempt to fill in this gap. Randomness is beneficial in choosing the points to be examined in the search space. One of the most fundamental and simplest method is stochastic hill climbing. In this method we start from a randomly chosen actual point of the search space. Then using the stochastic method we chose one point from 'neighbourhood points'. The point with a higher value than the value of the point originally chosen will be the following actual point. The advantage of this method is that it does not use any information about the estimated space structure of the problem. Its shortcoming is that with great probability it falls into the local optimal trap. The most promising and the most intensively researched area of stochastic methods using random search is a group of optimisation methods based on different metaheuristics. Metaheuristics, compared to problem specific heuristic, provide solution probabilities to a wider level of problems. The basic idea of their methodology most often lies in processes observed in the nature. Although they do not ensure a global optimum, they give a suboptimal solution that is very close to the optimum, in a reasonable amount of time.

A short overview of the most essential metaheuristic methods and their features follows.

Simulated Cooling

Simulated cooling copies the development of an energetically 'optimal' grid system of solid materials during heat treatment. The material particles of the solid heated up to a high temperature move between energy levels relatively freely. Then the gradual decrease in the temperature allows particles to perform only small movements between energy levels and to become stabilized in a crystal structure having a very low internal energy. The algorithm implementation steps are very similar to stochastic hill climbing steps.

During the implementation of the algorithm, from a randomly chosen 'neighbourhood' the value lower than that of the actual agent is also accepted with a changing probability that depends on the temperature during algorithm. The temperature is gradually decreased while the algorithm is running meaning that cooling is applied, which decreases the probability of accepting worse agents. The algorithm developed in this way may allow us to finding the global optimum, but it is very energy consuming and extremely sensitive to the proper selection of its parameters. At present there is no rule which could help implement proper parameter tuning that can be applied to all problems. The efficiency of the process can be increased if the system is restarted or reheated several times.

Tabu Search

Tabu search is another metaheutistic method. It works with one solution and applies random reach methodology. The word tabu comes from the Polynesia Islands to indicate holy things and places that cannot be touched or visited. Its fundamental idea, based on stochastic hill climbing approach, is as follows: the visited points of the search space are put on a tabu list. The newly chosen point is examined and is accepted only if it is missing from the list. Naturally, the size of the list cannot be enlarged to an unmanageable size, so the length of the list corresponds to a totally random whole number *n*. If the list length reaches *n* and the next point is to be put on the list, the oldest element on the tabu list is deleted. Swarm intelligence is a complex collective form of behaviour in which the agents belonging to a swarm make decisions taking their own environment into consideration. Yet, in the end, intelligent global behaviour emerges. In the following unit two key representatives of the swarm intelligence method are introduced.

The basic idea of the ant colony algorithm was taken from the nature. The concept is based on food-searching behaviour of ants. Ants apply very sophisticated methods for communicating with each other, since they mark the paths from the source of food to the colony by leaving pheromone hormones. These pheromone markers are smelled by other ants, who are likely to follow the path with great probability. The established paths to the food source can be of various characters and may even be blocked by obstacles. Ants' aim is to collect as much food as possible. Individual agents have limited opportunities, but a whole colony can resolve problems very efficiently. There are ants that move separately and along a random path, but if they find a pheromone trail, they will follow the mark with great probability. In the meantime, they also release pheromone and its concentration on the trail increases. As a result, the attraction force of the trail also grows. The pheromone level of the frequently used trail increases, while that of rarely used one decreases. Over time, however, the pheromone trail starts to evaporate, and thus, the pheromone level on a trail left without reinforcement continuously declines. The ants taking a shorter path march faster and increase its pheromone level while ensuring a stronger 'attraction' force. As a result, other ants also start using the shorter trail and after some time most ants will march along it, whereas the pheromone level of the longer trail will decrease.

The ant colony algorithm is usually applied to combinatorial optimization problems. In one of its possible implementations ants are agents.

Pheromone strip values are ordered to state space edges shown as a directed graph. Successful or less successful solutions may decrease edge values. The paths successful in the past are stored by a matrix of a pheromone stripe value. The agents build the path step by step. They estimate the possible following steps and chose one with a certain probability.

Choice probabilities depend on heuristic values ordered to steps and on the pheromone strip value. Particle swarm optimization is a population-based optimization technique modelling collective movements of bird flocks, fish schools, bee swarms or other particles. Swarm individuals make one movement each in the search space and are connected to each other according to a certain topology. All particles know the best values (actual local optimum) of their topology neighbouring particles (and naturally their own) and their swarm's best value.

Evolutionary Algorithms

By taking a step agents change their positions and combine their local and global optimum as well as their positions in the past. While combinations are developed, random values are also used. Evolutionary algorithms make up the next large metaheuristic group of global optimal methods. Evolutionary algorithms are optimization methods that incorporate biological mechanisms and a population of data structures (codes) representing search space points Features such as mutation, recombination, selection and survival of agents being better at adapting to the environment (fitness) attempt to reproduce a population of a higher quality from iteration to iteration (generation steps). (Schöneburg et. al., 1994)

The evolutionary algorithm family has four key members:

- Genetic algorithms are evolutionary algorithms that cover the search space with the help of bit strings. The latest genetic algorithms manage to cope with strings containing real values (vectors).

- The aim of genetic programming is to develop computer programs solving a given computational problem.
- Evolutionary programming is similar to genetic programming, but has a fixed program structure and the search space is expanded only by program parameters. It merged with genetic programming and other evolutionary methods more than a decade ago.
- Evolution strategies search optimum in the search space by coding agents in the form of real vectors.

A question may arise as to why there are so many types of algorithms that apply metaheuristics approach. The theory formulated for optimization and search algorithms, stating that there is no such a thing as free lunch, may provide the answer to this question. The theory holds that there is no algorithm that would offer a more efficient solution than any other method to all types of problems. In practice, it means if there is a special optimizing method for a certain type of problems, it can be more effective than a genetic algorithm that is applicable and effective in a wide range of problems.

CONCLUSION

Based on the introduction of the most significant models of conventional economics it can be stated that a theory tries to explain complex social, human and organizational forms of behaviour with the help of simple models. However, these models are only sufficient for understanding basic economics processes and are not very appropriate when dealing with more complex problems.

Due to methodological deficiencies, methods of conventional economics are insufficient for describing complex, dynamic economics processes. To eliminate these deficiencies it is necessary to widen the interdisciplinary sphere of the theoretical aspects of research.

From the discussion of optimization processes it was established that evolutionary algorithms are applicable for modelling real economics processes, based on the analogy of modelling biological evolution. Economics model modelled with genetic algorithms combine basic genetic processes with analyses of environmental management.

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