THE ECONOMIC APPROACH TO SCIENCE

DOI: 10.18267/j.pep.571

Marek Loužek*

Abstract
The paper poses the question whether the economics of science could be the key to economic methodology. First, the sociology of science, which tries to put science in social context, is described. Then, the economic approach to science inspired by Bartley, Wible, Tullock, Stigler and Becker is explained. We point out that knowledge originates in the competitive process of scientific criticism in similar way as economic wealth originates in the competitive market process and the competition among many individuals.

Keywords: economics of science, philosophy of science, sociology of science
JEL Classification: A11, A14, I21

1. Introduction

During the last decades, the sociology of scientific knowledge has been successfully developing as a new influential approach to the study of science. Unlike the traditional philosophy of science, which examines issues such as truthfulness, evaluation and logics of the choice between scientific theories, the sociology of science focuses on the social nature of scientific investigation. Most of what philosophers of science said is that science is irrelevant from its point of view because it is essentially social.

In this paper, we would like to pose the question whether the "economics of science" might not be just as stimulating for the study of science as the sociology of science and whether the sociology of scientific knowledge does not "lead" in some way to such economic analysis of science. Should we lean towards the economic theory of science based on Tullock, Stigler and Becker? Or is the humility of the traditional methodology of science more appropriate?

Section 2 of the paper outlines the approach of the sociology of science. Section 3 examines the positions within the economics of science. Section 4 regards science as a market process according to Bartley and Wible. Section 5 analyses the organisation of scientific investigation by Gordon Tullock. Section 6 deals with the supply and demand for scientific personnel according to George Stigler. Section 7 covers the scientific market.

2. Sociology of Science

While literature about the sociology of scientific knowledge draws its intellectual inspiration from a number of sources, two important influences can easily be found: the older tradition of the sociology of science based on Robert Merton, Karl Mannheim or Emil Durkheim, and

* Marek Loužek, Faculty of Economics, University Economics in Prague, Prague, Czech Republic (louzek@post.cz). Research for this article has been made possible due to financial support from the Czech Science Foundation Neglected Dimensions of Human Capital (Grant No. 14-06264S) at the Faculty of Arts, Charles University, Prague.

the more recent historical (and some would add "relativistic") turn within the philosophy of science, initiated by authors like Thomas Kuhn and Paul Feyerabend (Hands, 1994).

The original earlier sociology of science is based on the work of Robert Merton (1973), which grasped science as a fundamentally social phenomenon. For Merton, there are external social factors that support or hamper the development of scientific knowledge, factors that can be studied through the sociology of science, although the objective content of scientific theories exists independently of these social factors.

"The 'Copernican revolution' in this area of inquiry consisted in the hypothesis that not only error or illusion or unauthenticated belief but also the discovery of truth was socially (historically) conditioned. As long as attention was focussed on the social determinants of ideology, illusion, myth, and moral norms, the sociology of knowledge could not emerge… The sociology of knowledge came into being with the signal hypothesis that even truths were to be held socially accountable, were to be related to the historical society in which they emerged." (Merton, 1973, p. 11).

The original Merton's sociology of science was fairly cautious because it did not challenge the objective validity of science. Science brings reliable knowledge of the objective world and sociology focuses on examining the social and cultural context, which benefits or harms the scientific investigation. For the original Merton's sociology of science, only the context of science, not the content of science, was socially conditioned. For a number of later sociologists, even the content of science was social.

Sociologists of science replace the traditional problems of philosophy with a sociological approach (Blume, 1974). Trust in scientific results – theory and knowledge – does not stem from them alone but from something that is external in relation to them, that is, from various social conditions. In their opinion, scientific research and its results are social phenomena and must be studied and interpreted in a social context.

It was already Max Weber who focused on some of the aspects of the social and intellectual situation of an academic in his lecture "Science as a Vocation" ([1919] 1958). Weber examined the position of a scientist within a university system: a scientist is also supposed to qualify as a teacher. And yet someone may be an excellent scientist but a bad teacher or *vice versa*. Nobody can emancipate from the social environment.

The sociology of science appears in the book "Laboratory Life" (1986) by Bruno Latour and Steve Woolgar. This book enriches the sociology of scientific knowledge. Scientists invest into their own credibility. The result is formation of a market with scientific knowledge. Information has value because it allows others to make profit from investment capital. There is a demand for information on the part of investors and there is supply of information on the other side.

"If we take into account the fluctuation of this market, scientists invest into their credibility wherever it is most profitable. They investigate 'interesting problems', 'lucrative objects', 'good methods' and 'reliable colleagues'. This is the reason why scientists keep moving from one problem area to another, enter joint projects, accept and reject hypotheses depending on circumstances, shift from one method to another and thus extend credibility" (Latour, Woolgar 1986, p. 206).

The thesis that scientific theories are not about truthfulness because they are a reflection of the social situation of the given period is one-sided. Knowledge in social sciences is a real phenomenon based on interaction of the learning person with their surroundings, similar to chemical reaction between various chemical substances and to biological interaction between animals and the surrounding world. This applies to both physical and social sciences (Cole, 1992).

The sociology of science and the economics of science, although they seem to be contradictory at first sight, may shake hands because they emphasise similar motives for scientific investigation. The sociology of science operates in a world that is intellectually similar to the one observed by economists. It is a world with clear existence of economic explanations for individual behaviour just as for social phenomena (Coats, 1984).

As Uskali Mäki remarks: "It is interesting that much of the recent sociology of science is based on analogies taken from economics. In these proposals, science is viewed as being similar to market economy, in which the players are producers seeking maximisation, who compete with each other and pursue their own interests. In these concepts, emphasis is placed on scientist's actions and on the goals included in such actions." (Mäki, 1992, p. 79).

3. Economics of Science

While the sociology of science tries to put science in a social context, a parallel discipline – economics of science – emphasises the role of a scientist as a rational actor. If science is carried out in the community of scientists and we wish the social science to help to understand the behaviour of these scientists, then economics seems to be a candidate for understanding science, besides sociology, anthropology or philosophy (Dasgupta, David, 1994).

A nucleus of an economic approach to science can be found in a treatise by Charles Sanders Peirce (1967), an American pragmatic philosopher. In this treatise, Peirce discusses the "economics of research" in a way that he not only uses marginal economic analysis but he does so in a completely contemporary manner. This treatise, originally published in 1879, would be quite easily accepted for publication in a modern economic journal.

The Peirce's paper, which was influenced by pragmatic philosophy, was clearly a breakthrough in a number of respects. If we start from the difference between the *sociology of science* and the *theory of scientific knowledge*, then the *economics of science* is the application of economic theory for the purpose of explaining the behaviour of scientists or the intellectual output of the scientific community. The economics of science uses the analytical apparatus derived from the economic theory in examining scientific knowledge.

"The doctrine of economics, in general, treats of the relations between utility and cost. That branch of it which relates to research considers the relations between the utility and the cost of diminishing the probable error of our knowledge. Its main problem is, how, with a given expenditure of money, time, and energy, to obtain the most valuable addition to our knowledge." (Peirce, 1967, p. 643).

Thus, economics offers a new model of thinking, which enriches the theory of scientific knowledge. Similarly like the sociology of science argues that scientific knowledge is created in a social process, the economics of science claims that scientific knowledge is created in an economic process. A system of non-monetary rewards (such as publication or quotation) has been formed in science and these rewards motivate scientists to investigate.

Michael Polanyi (1962) contributed to the development of the economics of science. Polanyi remarks that scientists cooperate with each other similarly like players in an economic market cooperate with each other. The community of scientists is committed to truth, which transcends the market. Nevertheless, their behaviour has signs of a market process. Scientists react to each other; they publish and quote each other. The community of scientists is able to solve riddles more easily than an isolated person would be.

"Coordination of the individual efforts of scientists takes place similarly as coordination of the activities of producers and consumers on the market. It is the 'invisible hand' of coordination of independent initiatives, which contributes to progress in science, similarly like the 'invisible hand' on the market ensures the highest material satisfaction of the participants, when they act according to the price signals as independent producers and consumers." (Polanyi, 1962, p. 56)

Lawrence Boland (1971) points out that the economics of science is not looking for truth. The utility function of a scientist is combined with the wish to become famous and to make one's mark in the discipline. Rewards in the form of fame or quotations are extremely unequal and result from the person's merit for a discovery. The primacy of discovery is a form of an ownership right. Inequality in scientific productivity reflects the differences in the abilities of scientists to carry out high-quality research. Approximately 6% of publishing scientists are authors of more than half of all published papers.

The basis on which economic investigation of science builds for the most part is the theory of human capital (Becker, 1993). Scientists respond rationally to the rewards and costs of doing scientific research in the context of the complex social processes of scientific discovery. Becker focussed on a dimension of science often ignored by the epistemologists – the role of time. Scientific research takes time. Utilizing a Becker-type allocation of time model, the professional scientist is considered to be an economic agent whose choices and behaviour is sensitive to the opportunity cost of time.

Scientists will invest into their abilities particularly at the beginning of their life cycles. The number of publications increases at the beginning of their life cycles and then decreases after a certain age. Scientists often bring major discoveries when they are young and when they are not bound by the prevailing paradigm so much. Stephan (1996) heretically points out that too much knowledge can be more of a burden in research because it constrains the researcher too much.

Scientists who cooperate with others are usually more productive and produce "better" science than the one pursued by individual researchers. However, science is not only about fame but also about luck. A scientist is faltering through a jungle of ideas and facts trying to make a system out of them. It often happens that a scientist discovers something of major importance, his primacy is forgotten and his idea is eventually appropriated, perhaps in new packaging, by someone else (Radnitzky, 1987).

Science contributes to development of technology and, in turn, to economic growth. Some argue that science is a public good that a private sector would not create sufficiently. Others object that a private sector has both the incentives and abilities to support high-quality scientific research (Arrow, 1962). This is true especially for applied research while basic research may have problems with finding generous donators.

4. Science as a Market Process

Bartley (1990) conceives of an economics of science as a free market of ideas. The free market implies the right to supply and to receive ideas. As almost any thinker has experienced, the free and open competition of ideas does tend to lead, more directly than any other path, to the advancement of knowledge. And thus the institution known as the market, to the extent that it involves such competition, seems to be an appropriate model for trying to understand how knowledge, as well as other forms of wealth, increases.

"The theory of knowledge is a branch of economics… Knowledge is a form of wealth – indeed, perhaps its most valuable form. Economics and epistemology are both concerned with growth and contraction in wealth, and are further connected in that knowledge often, if not always, advances arm in arm with increase in other forms of wealth, and retreats when wealth declines. Knowledge is a primary component of capital – which makes epistemology the economics of knowledge." (Bartley, 1990, p. 89)

Society is a matrix of spontaneous orders, not created by an individual consciousness. Bartley merges the metaphorical notion of a marketplace of ideas with Hayek's notion of economic competition of spontaneous order. Hayek sees unfettered markets as the best means not only to generate more ordinary forms of wealth, but also to uncover knowledge and to better identify error, even if never fully to eliminate the latter.

Important parts of our objective knowledge are manifestations of "spontaneous orders" which were never originated or designed by anyone (Hayek, 1937). Examples are traditions, morality, science, the law, language, and institutions such as the market, in all of which a measureless amount of knowledge has been tacitly stored in the process of their evolution. No one can foresee the future consequences of any attempts to alter a spontaneous order because such consequences are unfathomable.

Bartley proposes replacing sociology of science with economics of science. One of the most important aims in science, one almost wholly neglected (where it is not denied) by the sociology of science, is the growth of knowledge and the advancement of learning – just as one of the most important aims in economic activity is the increase of wealth. Economics is also interested in social structures, but it is concerned with the way in which different such arrangements further or hinder the expansion of wealth.

"The key doctrines of economic theory as they relate to these aims – marginal utility theory, the subjective theory of value, methodological individualism, analysis of the logic of the situation, and transaction and opportunity costs - are little more than rumours, of that, in the sociology of knowledge. The key doctrine of epistemology as it relates to economics – the theory of unfathomed objective knowledge – is completely unknown to the sociology of knowledge, and contradicts virtually all its premises." (Bartley, 1990, p. 149)

In his scheme-specific book dealing with the economics of science, Wible (1998) examines various moments of scientific investigation on the assumption that a scientist is a rational economic actor. Wible shows that a scientist does not serve either to the society or to truth but primarily to himself. Scientists choose the research problems and programmes that suit them, promise the highest prestige if solved or raise their standard of living.

Economics of science is the best way to explore the thesis that science is an economic phenomenon and that scientists are rational economic agents. Such an economics of science could help explain the consequences of resource scarcity and the relative incentive structures of science. An economics of science may serve a theoretical purpose of an epistemic micro-foundation for economic processes and as a model of self-corrective non-commercial market process (Wible, 1998, p. 14–15).

"Science is difficult and costly to do well. The remarkable benefits of scientific research require the efforts, time, and talents of some of the very best minds and research teams in the world and expenditure of significant sums of material and financial resources. Consequently, science is an economic phenomenon. This book systematically creates an economics of science. Many aspects of science are explored from an economic point of view." (Wible, 1998, p. 1).

Science is a self-corrective marketplace of ideas. As a point of departure economics of science Wible begins with the general problem of misconduct in science. There are many other alternative aspects of science which could have been chosen as a starting point for an economics of science. Topics as legitimate or normal science, scientific revolutions, market failure in science, the organizations and institutions of science, theory choice, and the rationality of science might have been chosen (Wible, 1998, p. 23).

Wible examines fraud in science. Fraud in science is the deliberate violation of scientific principles for personal material gain and professional advancement. Fraud may consist of intentional misreporting of results, falsification of data, complete fabrication of unperformed experiments or deception of colleagues. In modern society such actions have not been criminalized unless misuse of public funds is involved nor has provision been made for civil penalties (Wible, 1998, p. 44).

Starting premise of the conventional economic assumption is that economists (and other scientists) are economically rational. Replication failure and a few other aspects of science may be explainable as a consequence of the rational scientist's allocation of time. Direct replication of the findings and results of others is an activity that is rarely practiced. Only in exceptional circumstances is there any reward to be gained from repeating another's work. Science reserves its highest honours for those who do things first (Wible, 1998, p. 26).

5. Organisation of Scientific Inquiry

"The Organization of Inquiry" by Gordon Tullock (1966) applies the public choice analysis to the study of science. In Tullock's view, one of the characteristic features of science is that it is carried out in a community and is mainly "presented for discussion of this community, which controls investigation". The main property of science is that it is a "system of voluntary cooperation" (Tullock, 1966, p. 90).

Gordon Tullock tries to grasp science as a social system. He suggests that his basic orientation will be more economic than sociological; nevertheless, these two approaches complement each other in his case. He starts by stating that scientific research is carried out by scattered individuals, each of whom is working on his own problem. The community of scientists is not concentrated in one place; it is indeed a global community.

There is no central scientific organisation; each individual contribution is built on the research of others. However, this unplanned process regularly and even systematically leads to discoveries and accumulation of knowledge. Tullock wants to explain why an individual scientist who feels to be completely free is led to examining problems and interests of others, while simultaneously influencing the research of others without doing so intentionally.

There are three reasons why people engage in a scientific research (Tullock, 1966). Firstly, pure curiosity and the need to understand lead to pure research. Secondly, the wish to control events leads to applied research. And thirdly, there is the "induced curiosity" when a scientist carries out research and writes articles because he earns his living in this way. He need not have any special interest in the subject of investigation and he terminates the research when he gets a better job. These motives are, of course, ideal types; in practice, they are present together.

These three motives, which drive scientific investigation, are behind the secret of success of science as a process of discovering knowledge. Pure researchers are, by definition, driven by curiosity to seek truth. Applied researchers also have an incentive to seek truth because if their practical applications fail, they will not get any revenues from this. The scientists who research for money also eventually search for truth because if they faked the results and were exposed, they would lose their reputation or, even worse, their jobs and incomes.

It is remarkable that although there is no single central organisation, scientific research generally leads to extension of knowledge. There is nothing special about the behaviour of a scientist; he behaves just like other people. Debates among scientists about their theories can be just as strong, emotional and sometimes even vile like political clashes. Defenders of their theories distort the findings of others, even carry out personal attacks and passionately cling to their own merits.

Scientists believe that they are looking for truthful laws about how the world works. They formulate their theories, while making their hypotheses more specific; then they collect data and test the hypotheses (Brock, Durlauf, 1999). According to the results of the testing, they modify their theories and repeat the testing as long as it is necessary. Progress in science is not that a specific scientist discovers the truth but that the truth becomes apparent in the discussion and confrontation between competing theories. The newer theory approximates the truth.

In Tullock's opinion, physical sciences are more successful and he claims there are a number of reasons for that. He even observes that social sciences lag behind physical sciences. The first difference is that there is no successfully applied research in social sciences that would be similar to that of physical sciences (when someone invents a new selling technique, he can hardly have it patented). In social sciences, there are far less feedbacks in the form of applied research.

The second difference is that while physical sciences study topics that are all non-controversial, social sciences study subjects, in which the general public has a vested interest and which have a strong ideological or moral background. When a social scientist finds out that a theory is not in accordance with widely accepted opinions, he will rather revise it because he cannot expect any popularity among his colleagues. In an extreme case, he can lose his donators, his chances of getting published will decrease and he will perhaps lose his job.

Unlike in physical sciences where a minority can persuade the majority about the truthfulness of their opinions by showing that the special innovation works, the matter is more complicated in social sciences (Tullock, 1966). In order to achieve innovation, a social scientist in a democracy must persuade the majority. In social sciences, there are factors (such as interests, ideology or moral considerations) that make it more difficult in many respects to seek truth.

6. Demand for and Supply of Scientists

A number of studies of the economics of science are based on the labour economics. The monograph "The Demand and Supply of Scientific Personnel" (1957) by George Stigler and David Blank carries out collection of data on the labour market, publications and quotes from scientists and emphasises the measurability of their results. The authors pose the question whether there are enough scientists in the country or whether there is an excess of them and they create models of supply and demand for scientific knowledge.

In his Nobel Prize lecture, George Stigler (1983) applies the economic approach to science to economics itself. Most economists enter the market with new economic ideas in order to procure ideas and methods for application of the economic science to the thousands of problems that they are working on. Thus, these economists are not on the side of supply of new ideas but they are on the side of demand.

Economists who are engaged in research about new ideas, rejecting them, endorsing them or replacing them with other ideas, are, in a sense, sellers of new ideas. Entering this area is very costly: it takes a huge amount of time and thinking before a new idea is examined thoroughly and before it becomes apparent whether it is promising or not. The history of economics is full of costly mistakes – new ideas that did not fall on fertile soil.

A scientific discipline is a body of knowledge, which is worked on and developed by a group of mutually interconnected operators who call themselves scientists. The intellectual objective of scientists is to extend the body of knowledge, although scientists also pursue various personal goals such as prestige, reputation or income. In the pre-scientific phase, there was no group of mutually interconnected operators who gathered knowledge and therefore no cumulative development took place.

The pre-scientific era of each discipline is driven by the practical problems of the society in which the discipline is pursued. However, Stigler does not agree with the opinion that the main problems of the scientific discipline, even after it becomes a real organised science, are directly raised by the pressing problems and political processes. Science maintains certain autonomy in relation to the environment. If the problems of the economic life changed often and radically and their essence lacked inner continuity, the economic science could not exist.

"An essential element of a science is the cumulative growth of knowledge, and that cumulative character could not arise if each generation of economists faced fundamentally new problems calling for entirely new methods of analysis. The change of problems and methods would also undermine the training of economists: if the young studied under the old, the young could be confident that they were learning things that were rapidly become obsolete. A science requires for its very existence a set of fundamental and durable problems." (Stigler, 1983, p. 533).

Scientists are systematically confronted with new circumstances, which require more than a routine application of standard knowledge. Nevertheless, the fundamental and permanent problems remain. Stigler mentions the energy crisis of the 1970s as an example. This crisis gave jobs to many economists but did not require any substantial changes in the economic sciences. Stigler claims that there is no simple correlation between the changes of the social environment and the changes in economic analysis.

"A viable and healthy science requires both the persistent and almost timeless theories that naturally ignore the changing conditions of their society and the unsettled theories that encounter much difficulty in attempting to explain current events. Without the base of persistent theory, there would be no body of slowly evolving knowledge to constitute the science. Without the challenges of unsolved, important problems, the science would become sterile." (Stigler, 1983, p. 534–535).

As soon as there are enough people working in science, science will form a firm basis and is equipped with the mechanism of intellectual exchange – journals, scientific societies and conferences; it encounters a torrent of proposals for new directions and methods of research. Science itself stimulates emergence of new ideas. Stigler quotes Robert Merton, his teacher and a sociologist, who showed the significance of primacy in the formation of new successful ideas.

Operation of science is associated with revenues but also with costs. Any new idea, a new concept of an existing problem, a new methodology or research into a new area cannot be fully handled, developed into an acceptable hypothesis and subjected to empirical tests without expending huge amounts of time, intelligence and research resources. And yet the overwhelming majority of new ideas prove to be unfruitful (Diamond, 2005).

There is continuity in the development of science. Stigler quotes Becker who claims that the tenacious resistance of scientists to accepting new ideas can be explained by investments into human capital and by aversion to risk. A recognised scholar protects his own capital capable of bearing revenue because he has mastered a certain body of knowledge. This capital would be reduced, if the scholar's knowledge became obsolete as a result of a general acceptance of a new theory.

Only in retrospective, with the full knowledge that the history sometimes gives us, it is possible to identify the really fruitful ideas of some period. Some people have a great instinct and recognise which of the new ideas of the current times it will pay off to examine intensively but nobody is infallible. Even the greatest economists sometimes pursue problems that do not lead anywhere. To err is not only human but also scientific (Zamora Bonilla, 2012).

7. Scientific Market

Allan Walstadt (2002) also made an original contribution to the economics of science. In his opinion, an economic paradigm cannot be a replacement for specialised knowledge, experience or science. The author admits that economics cannot tell a scientist whether the theory he advocates is correct or not or how to apply it or what experiment to use any more than physics can instruct an automobile engineer on how to adjust an engine. In spite of that, he views science as a market process.

Cooperation in science takes place with the use of barter process, which has some common as well as dissimilar properties of other barters, which is indicated, for example, by the following quote: "Scientific inquiry is characterized by a market (the 'scientific market') that is distinct from the market of traditional economics (the 'traditional market'). This scientific market is indeed the focal point of the activities of the community of scientists, where they offer the results of their own research and acquire access to the research of others, where they give and receive proper credit." (Walstadt, 2002, p. 9).

Walstadt assumes that scientists are driven by the desire for recognition from colleagues in their profession. Even in science, it is true that actions include choosing between alternatives and that people prefer earlier revenues to later revenues, that they communicate and cooperate with each other but that they also compete with each other. Traditional and scientific markets have some common properties (Walstadt, 2002, p. 14–22): specialisation, exchange, investment, production, entrepreneurship and organisation.

The specialisation originates naturally when individuals pursue their own interests. On a traditional market, each person can achieve greater wealth through specialisation and trade than by trying to be self-sufficient. On the scientific market, specialisation is the key to achieving success and recognition, too, because nobody can hope to master sufficiently all the scientific disciplines or sub-disciplines.

Specialisation is accompanied by exchange because when someone specialises in offering certain goods and services, he must satisfy the rest of his needs with goods purchased from others. The traditional market is an arena where supply and demand meet goods and services. On the scientific market, barter also takes place, and the use of the works of other scientists requires payment in the form of a citation.

On the scientific market, we must invest time and effort into obtaining cognitive capital, just as we accumulate the traditional forms of capital on the traditional market. Cognitive capital is a form of human capital. Scientists make long-term investments when they develop systematic research and contribute to the progress of knowledge in a certain area. When the investment stops paying off, there is no sense in researching here any further and scientists shift their focus and invest elsewhere (Tollison, 1986).

In science, we can find a structure of production, which, with certain simplification, is similar to production in the traditional economic area. The observational and experimental data are raw materials that science obtains and transforms – using specialised tools, analytical techniques and the existing theory – into a new or perfected theory. Thus, a scientific theory and data have the nature of capital goods.

Science is similar to entrepreneurship. An entrepreneur who launches a new product on the market faces uncertainty and possible loses because the costs of development and production precede the presentation of the production on the market. A scientist contributing to a new or old research area is facing a similar problem. Although he may be able to complete the research successfully, someone else may become the first to obtain the same results, or the results may become obsolete or lose their significance in the meantime (Walstadt, 2002).

However, there are fairly few individuals working on the market as independent entrepreneurs. Most consider it to be advantageous to join forces with others and to organise into more formal, structured associations, partnerships or hierarchical companies. Similarly, there are research teams in science where better results can be achieved through cooperation or co-authorship than through independent work. Direct communication is more efficient than formal communication in professional journals.

Money is not the main motivation of scientists. The desire for fame is. Coordination is ensured by credible quotations and anonymous verification of results. After someone came up with a research contribution and published it, he can no longer regard it as his property. Unlike patents and copyrights, which protect intellectual property in business, scientific results are open and any other scientist can draw on them (subject to quotation rules, of course).

The thesis that even scientific knowledge is governed by economic laws irritates or provokes a number of scientists. In spite of that, there is a possibility of combining the economic approach to science with the scientific standards of the Popperian type (Popper, 1968). It is the recognition that even a scientific activity is an economic activity of its kind (*i.e.* that a scientist maximises utility) but that this view itself does not decide which theory is true.

Why do certain scientists insist on the established paradigms even in spite of negative empirical evidence? When is it rational to prefer one scientific theory to another? The economic approach cannot "resolve" any of the philosophical problems but the cost and benefit analysis may raise an interesting scheme, which helps the researcher to see what kind of questions he should take into account when examining such problems (Radnitzky, 1986).

It is not probable that truth will ever be displaced from science. Scientists seek truthful knowledge in their investigation. Struggle for truth has a strong motivational and inspirational spark, similarly like the desire for a happy life. Truth is the guide of scientific artefacts, the achieved scientific results; it characterises the success or failure of scientists, both at the level of an individual and the society (Rosenberg, 1988).

In spite of the fragility and fallibility of the economic theory and economic testing, the empirical relevance is the final arbitrator for the economic science (Blaug, 1994). Pluralism cannot mean tolerance to dubious or even refuted theories. Nobody owns the truth. It rather tends to be the unintentional result of the interaction of thousands and millions of scientists. Only in their competition it will be shown which theory is correct and which is not.

8. Summary

Besides the sociology of science, the economics of science has also become popular in the last decades. While the sociology of science is trying to put a scientist in a social context, the economics of science examines the human motivations of scientists. For the original Merton's sociology of science, only the context and not the content of science was socially conditioned. For a number of later sociologists, the content of science was socially conditioned, too.

The economics of science is an analogical approach, which views a scientist as a rational actor maximising utility. James Wible, George Stigler, Gordon Tullock and Gary Becker examine the framework of scientific research, the supply and demand on the scientific market and progress in science. The traditional and scientific markets have common characteristics: specialisation, exchange, investments, production, entrepreneurship and organisation.

Knowledge originates in the competitive process of scientific criticism in similar way as economic wealth originates in the competitive market process and the competition among many individuals. The economics of science is compatible with the evolution theory of knowledge, according to which only the strongest theories survive. A scientist is a person who maximises his utility. However, only objective criteria can be found for choosing between theories.

In spite of the fragility and fallibility of the economic theory and economic testing, the empirical relevance is the final arbitrator for the economic science. Pluralism cannot mean tolerance to dubious or even refuted theories. Nobody owns the truth. It rather tends to be the unintentional result of the interaction of thousands and millions of scientists. Only in their competition it will be shown which theory is correct and which is not.

References

Arrow, K. (1962). The Economic Implications of Learning by Doing. *Review of Economic Studies*, 29(3), 155–173, http://dx.doi.org/10.2307/2295952

Bartley, W. W. (1990). *Unfathomed Knowledge, Unmeasured Wealth. On Universities and the Wealth of Nations*. La Salle, Ill.: Open Court. ISBN: 0812691067.

Becker, G. (1993). *Human Capital. A Theoretical and Empirical Analysis, with Special Reference to Education*. Chicago – London: The University of Chicago Press. ISBN: 0226041204.

Blaug, M. (1994). *The Methodology of Economics. Or How Economists Explain.* Cambridge: Cambridge University Press. ISBN: 9780521436786.

Blume, S. B. (1974). *Toward a Political Sociology of Science*. New York: London, Macmillan.

Boland, L. A. (1971). Methodology as an Exercise in Economic Analysis. *Philosophy of Science*, 38(1), 105–117, http://dx.doi.org/10.1086/288344

Brock, W. A., Durlauf, S. N. (1999). A Formal Model of Theory Choice in Science. *Economic Theory,* 14(1), 113–130, http://dx.doi.org/10.1007/s001990050284

Coase, R. (1974). The Market for Goods and the Market for Ideas. *American Economic Review*, 64(2), 384–391, http://www.jstor.org/stable/1816070

Coats, A. W. (1984). The Sociology of Knowledge and the History of Economics. *Research in the History of Economic Thought and Methodology,* 2, 211–234.

Cole, S. (1992). Making Science. Between Nature and Society. Cambridge, Mass.: Harvard University Press. ISBN 9780674543478.

Dasgupta, P., David, P. (1994). Toward a New Economics of Science. *Research Policy,* 23(5), 487–521, http://dx.doi.org/10.1016/0048-7333(94)01002-1

Diamond, A. M. (2005). Measurement, Incentives and Constraints in Stigler's Economics of Science. *European Journal of the History of Economic Thought,* 12(4), 635–661, http://dx.doi.org/10.1080/09672560500370292

Hands, D. W. (1994). The Sociology of Scientific Knowledge. Some Thoughts on the Possibilities, in Backhouse, R., ed., *New Directions in Economic Methodology*. London - New York: Routledge, pp. 75–108.

Hayek, F. A. von (1937). Economics and Knowledge. *Economica*, 4(13), 33–54, http://dx.doi.org/10.2307/2548786

Latour, B., Woolgar, S. (1986). *Laboratory Life. The Construction of Scientific Facts*. Princeton: Princeton University Press. ISBN: 069102832X.

Mäki, U. (1992). Social Conditioning in Economics, in Marchi, N.*, ed., Post-Popperian Methodology of Economics. Recovering Practice*. Boston: Kluwer, pp. 65–104,

Merton, R. (1973). *The Sociology of Science*. London: University of Chicago Press.

Peirce, C. S. (1967). Note on the Theory of the Economy of Research. *Operations Research,* 15(4), 643–648, http://dx.doi.org/10.1287/opre.15.4.643

Polanyi, M. (1962). The Republic of Science. Its Political and Economic Theory. *Minerva*, 1(1), 54–73, http://dx.doi.org/10.1007/bf01101453

Popper, K. R. (1968). *The Logic of Scientific Discovery.* New York: Harper & Row.

Radnitzky, G. (1986). Towards an "Economic" Theory of Methodology. *Methodology and Science,* 19, 124–147.

Radnitzky, G. (1987). The "Economic" Approach to the Philosophy of Science. British Journal for the Philosophy of Science, 38(2), 159–179, http://dx.doi.org/10.1093/bjps/38.2.159

Rosenberg, A. (1988). Economics Is Too Important to Be Left to the Rhetoricians. *Economics and Philosophy,* 4(1), 129–149, http://dx.doi.org/10.1017/S0266267100000377

Stephan, P. E. (1996). The Economics of Science. *Journal of Economic Literature,* Vol. 34(3), 1199–1235. Available at: http://www.jstor.org/stable/2729500

Stigler, G., Blank, D. M. (1957). *The Demand and Supply of Scientific Personnel*. New York: National Bureau 'of Economic Research.

Stigler, G**.** (1983). Nobel Lecture: The Process and Progress of Economics. *Journal of Political Economy*, 91(4), 529–545, http://dx.doi.org/10.1086/261165

Šťastný, D**.** (2010). *Economics of Economics: Why Economists Aren't as Important as Garbagemen (but They Might Be)*. Torino: Instituto Bruno Leoni.

Tollison, R. D. (1986). Economists as the Subject of Economic Theory. *Southern Economic Journal*, 52(4), 909–922, http://dx.doi.org/10.2307/1059153

Tullock, G. (1966). *The Organization of Inquiry. Durham*. NC: Duke University Press.

Walstadt, A. (2002). Science as a Market Process. *Independent Review*, 7(1), 5–45. Available at: https://www.independent.org/pdf/tir/tir_07_1_walstad.pdf

Weber, M. (1958). Science as a Vocation. *Deadalus*, 87(1), 111–134. Available at: http://anthropos-lab.net/wp/wp-content/uploads/2011/12/Weber-Science-as-a-Vocation.pdf

Wible, J. R. (1998). *Economics of Science. Methodology and Epistemology as if Economics Really Mattered*. London: Routledge.

Zamora Bonilla, J. (2012). The Economics of Scientific Knowledge," in Mäki, U., ed., *Philosophy of Economics*. London – New York: Elsevier, pp. 823–862.