Proc. Estonian Acad. Sci. Social Sciences, 1991, 40, N 4, 356—363
https://doi.org/10.3176/hum.soc.sci.1991.4.03

*Peeter MÜÜRSEPP**

SOME METHODOLOGICAL PROBLEMS OF THE APPLICATIONS OF CATASTROPHE THEORY

The birth of a mathematical method of a new nature — catastrophe theory — dates back to the year 1972, when René Thom's original book "Stabilité Structurelle et Morphogénèse" was published. Shortly afterwards, numerous applications of catastrophe theory began to appear. The most active explorer in this field has been E. C. Zeeman. Catastrophe-theoretic models can be built up for describing phenomena of very diverse nature. In this paper attention is paid to problems arising in connection with applications. The main causes of the defects that appear in the models are the following: basic mathematics has been misused, some models are based on unreasonable assumptions, experimentally untestable predictions have been made, the term *jump* is used in two different meanings, the choice of variables for a model is very subjective. The assumed dialectical nature of catastrophe theory is checked in the paper by attempting to use the theory for modelling Th. Kuhn's conception of paradigm change. Although no practical help has been received from catastrophe theory so far and in spite of quite severe criticism, our final conclusion is optimistic, because the theory can be used for describing different types of processes containing discontinuities and it can serve as a framework for certain kinds of systems.

The methodology of science has two principal historical sources. One is the Heraclitean, the other the Eleatic tradition. The considerations of the methodology of science have mostly been based upon the works of the Eleatic school (especially Parmenides). Such treatments lead to the approval of stability and stagnation. This style of thinking has been dominant in the European scientific thought. The paradoxes of Zeno have acted as a source of setting and solving several scientific problems. The methodology based upon the ideas of Parmenides leads to Newtonian science. Followers of classical science used to think that the next state of a system can be predicted by the initial values of certain parameters. There was no place for stochastic processes in such a world. During the times of the Laplacean determinism the Universe was treated as a huge machine. Mathematics seemed a convenient tool for formalizing and modelling events and processes in such Universe. For three hundred years the preeminent method in building models has been the differential calculus. Differential equations can describe smoothly and continuously changing phenomena. But the real world is full of sudden transformations and unpredictable divergences. To describe such a world, we have to find another methodological basis. We need to remember the ideas of Heraclitus, the first dialectician in the history of philosophy. His ideas of permanent change and struggle of the opposites may be used as a methodological basis of the scientific revolution of the last turn of the century. By that time it had become clear that qualitative mathematical methods were necessary to formalize processes in the real world. Progress was not easy to come. Even Einstein had to use the traditional mathematical apparatus, although by his time,

---

* Eesti Teaduste Akadeemia Filosoofia, Sotsioloogia ja Õiguse Instituut (Institute of Philosophy, Sociology, and Law, Estonian Academy of Sciences). 200105 Tallinn, Estonia pst. 7. Estonia.

Poincaré had already laid foundations to qualitative mathematics. In spite of that, Einstein made a very important methodological change. He put the spectator into the system, making the world machine dependent on the location of the spectator. But the machine still remained deterministic.[1]

In the 20th century the rapid development of new ideas in natural sciences, for example, chaos theory and synergetics, determined the progress of mathematics. The classical methods became totally inadequate to formalize new theories. Most of the new theories show that sudden jumps and divergences occur very easily in the reality. In 1962 the American meteorologist E. Lorenz discovered with the help of a computer that very slight changes in initial data can cause huge alterations in the following states of a system. Almost at the same time the French mathematician René Thom began to work out the foundations of catastrophe theory. The new method was intended to be first of all a mathematical language for biology (the morphogenesis of a cell).

Contradictory opinions have been expressed about catastrophe theory. In spite of the severe criticism, the development of a qualitative mathematical method should be called an achievement. The theory offers possibilities to model processes which were formerly inaccessible for mathematized natural science. I mean processes and phenomena that include suddenly occurring instabilities and jumps. However, numerous methodological problems arise in connection with the catastrophe-theoretic models. According to R. Thom catastrophe theory is the first coherent attempt (since Aristotelian Logic) to give a theory on analogy.[2] The actual aim of catastrophe theory is said to be the classification of all possible types of analogous situations. The major interest of the theory should be to clear all sciences of old, biologically deeply inrooted concepts, and to replace their fallacious explanatory power by the explicit geometric manipulation of morphogenetic fields.[3]

At first it seems that catastrophe theory suits for constructing a model for any nonlinear process. This is true to some extent, because we cannot say that a model is false. We may say that one model is preferable to another. So we have to find an answer to the following question: are the catastrophe-theoretic models the most suitable ones for certain processes?

The application of catastrophe theory is connected with the concept of stability. An object or a system is stable when it reacts to small changes by returning to its original state. Such stability can be modelled mathematically within the context of dynamical systems theory by means of the concepts of *stable equilibrium* and *attractor*.[4] This idea of stability exhibits some features in common with the *real life* concept. But "jumps" from one attractor to another are not allowed. We have to combine this idea with the framework of catastrophe theory. Then the treatment of such jumps becomes possible. R. Thom suggests that the notion of stability has philosophical significance and is essential for the understanding of what we mean by an *object*.[5] A real object is characterized by the values of a large number of variables. These values are constantly experiencing "random" changes. An object is said to belong to the

---

[1] *Prigogine, I., Stengers, I.* Order Out of Chaos. Moscow: Progress, 1986, 15.

[2] *Thom, R.* cited in *Zeeman, E. C.* Catastrophe Theory. Selected papers 1972—1977. Reading, Mass.: Addison-Wesley, 1977, 34.

[3] *Zeeman, E. C.* Catastrophe Theory, 36.

[4] *Sussmann, H. J.* Catastrophe Theory. — In: Synthese 31. Dordrecht: D. Reidel Publishing Company, 1975, 233.

[5] *Thom, R.* cited in *Sussmann, H. J.* Catastrophe Theory, 234.

catastrophe set if it is not stable. What about a system? There are two kinds of systems. If the system is nondegenerate, the perturbation will only cause a small quantitative change. There will be no "qualitative jump". When the original system is degenerate, a small change in the elements can cause drastic qualitative change in the properties of the solutions.[6] Thus we can say that degenerate systems are unstable. Unstable elements are those where drastic changes occur. The set of unstable elements is referred to as the catastrophe set. The real world is full of unstable systems. So catastrophe theory can be applied to describe phenomena of very diverse nature. In spite of that we face many difficulties. For instance, we are not able to predict which values of an element will give catastrophic changes. It is necessary to bring in an additional structure to apply the theory. The search for such a structure is a task for the applied mathematician and the natural and social scientist.[7]

Hector J. Sussmann and Raphael S. Zahler are of the opinion that in dealing with problems in social sciences, catastrophe theorists have

— misused the basic mathematics in ways that lead to indefensible arguments;
— offered models which are based on unreasonable assumptions and which lead to implausible conclusions;
— made predictions which are frequently vacuous, tautologous, vague, or impossible to test experimentally.[8]

Most models of catastrophe theory in the social sciences are based on the use of the cusp catastrophe. The most important aspects of the cusp catastrophe are the qualitative behaviour and the phenomenon of divergence. Extra features do not alter the basic nature of the models and we can ignore them. What appears in the model based upon the cusp catastrophe is a certain mathematical phenomenon: a discontinuity of a function. We have to find out whether the discontinuity that appears in the model resembles the behavioural discontinuity of an individual in a significant way. According to Sussmann and Zahler there is no discontinuity that corresponds to the one that we all know from direct observation.[9] They assume that the discontinuity of the mathematical function in the cusp catastrophe has little in common with what happens in reality, except for the fact that in both cases there are discontinuities.

Many forces in nature can be described by smooth surfaces of equilibrium. Catastrophes occur when the equilibrium breaks. The task for catastrophe theory is to describe the shapes of all possible equilibrium surfaces. R. Thom has solved this problem in terms of a few archetypal forms, the elementary catastrophes. One of these is the cusp. Theoretically the cusp catastrophe model can be used to describe any aspect of nature or any scientific experiment, where two factors influence behaviour, where splitting and discontinuous effects are observed and where smooth genericity may be assumed. From the model one can explain, predict and relate a variety of phenomena that previously may not have appeared to be related.[10] Many of the proposed applications of catastrophe theory involve the use of models in which some variables are "faster" than the others. This leads to the consideration of critical

---

[6] *Sussmann, H. J.* Catastrophe Theory, 237—238.
[7] *Ibid.*, 268.
[8] *Sussmann, H. J., Zahler, R. S.* Catastrophe Theory as Applied to the Social and Biological Sciences: A Critique. — In: Synthese 37. Dordrecht: D. Reidel Publishing Company, 1978, 118.
[9] *Ibid.*, 137.
[10] *Ibid.*, 156.

sets and catastrophe points. Many difficulties arise here. Catastrophe theory is supposedly best equipped to handle the ideas of jump and discontinuity. But what is a jump? A very small jump in some variable might not be perceived as a jump in some physical or biological or social system. On the other hand, a very big continuous change that occurs in a very short time interval is, for all practical purposes, the same as a jump. Catastrophe theorists prove theorems about the "technical" jump and claim that these have some meaning about jumps in our everyday sense.

Most catastrophe-theoretic models are presented as though they were based on reasonable hypotheses. By means of mathematical reasoning conclusions are drawn from these hypotheses, which say something significant about the phenomenon under study. Examination of the models shows that, in most cases, they are not reasonable. Spurious functionalization occurs throughout catastrophe theory. Catastrophe theorists themselves assert that their theory is qualitative rather than quantitative. But catastrophe theory is purely local. It is not possible to infer anything global about a curve or a surface by Thom's theorem. The mathematical jump that appears in catastrophe-theoretic models is a local phenomenon. It has little in common with the discontinuous behaviour of biological or social systems.

To apply catastrophe theory, a mathematician has first to select the variables that are relevant to his problem. The choice of such variables is very subjective and may depend on the ideological views of the explorer. Most of the models are built up using only two variables (conflicting factors). At the same time we know well that any phenomenon of the reality consists of thousands of elements. Thus it is almost impossible to distinguish two of the most significant ones. If a model is properly formulated, it should make precise forecasts of behaviour. As a matter of fact, not a single example of such a forecast exists in connection with the catastrophe-theoretic models.

In spite of the above-mentioned difficulties, R. Thom finds catastrophe theory to be an important one, because it is supposed to offer possibilities to attack the problem of the stability of self-reproducing structures, like living beings. R. Thom also suggests that the catastrophe-theoretic models have the most immediate interest on the philosophical plane. They reduce the paradox of the soul and the body to a single geometrical object.[11] The models attribute all morphogenesis to conflict, a struggle between two or more attractors. This is the idea of Anaximander and Heraclitus.

This notion leads us to the suggestion that catastrophe theory is dialectical by its nature. There exists at least one attempt to formalize dialectics by means of catastrophe theory It was made by M. Zwick.[12] M. Zwick attempts to formalize the three basic laws of dialectics: the struggle of the opposites, the transformation of quantity into quality, and the negation of negation. He uses two of the elementary catastrophes of R. Thom: cusp and butterfly. It is a very difficult task to formalize Hegelian dialectics using a mathematical method. The laws of dialectics have been abstracted from the historical development of reality. Being a local theory, catastrophe theory is not able to describe historically developing phenomena. In spite of that we can learn something useful from such formalization. We see that the basic terms of dialectics and catastrophe theory have significant similarity; for example, dialectical jump and catastrophe, Hegel's knotline and bifurcation set.

---

[11] *Thom, R.* cited in *Sussmann, H. J., Zahler, R. S.* Catastrophe Theory as, 208—209.

[12] *Zwick, M.* Dialectics and catastrophe. — In: Sociocybernetics. Leiden etc., 1978, I, 129—154.

The model based on the cusp has resemblance to the law of the transformation of quantity into quality. But the catastrophe-theoretic model is not capable of taking into account the fluctuations and therefore cannot describe adequately the processes of the real world. In this case the theory of self-organization or synergetics is much more convenient. Catastrophe theory is also applicable as mathematical apparatus for synergetics. In fact, bifurcation theory has been used in synergetics more often than catastrophe theory, although the former can be regarded as a special case of the latter.

Special attention should be paid to the category *measure*, which was elaborated by Hegel. It is a more concrete category than *quality*. The origin of *measure* dates back to the Eleatic school of ancient Greece. The paradoxes of Zeno and others rise the problem of the breaking of measure very acutely. I think that the clamp problem and the baldhead problem could be modelled using catastrophe theory.

Now about one more possible application of catastrophe theory, which is closely connected with the dialectical process. It is T. Kuhn's conception of scientific revolutions. The development of science, according to T. Kuhn, is very similar to the dialectical process of Hegel.[13] The formation of a new paradigm can be reviewed as the transformation of quantity into quality. Therefore, the cusp catastrophe model should also be applicable to the paradigm change. Half of the work to construct such a model has been made by M. Zwick and the other half by Richard X. Chase. M. Zwick has pointed to the applicability of the cusp catastrophe to the dialectical triad thesis-antithesis-synthesis. Richard X. Chase has connected the latter with the paradigm change of T. Kuhn.[14] So, it remains only to connect these two considerations. Antithesis, the dominance of contradiction, occurs in the bifurcation set. Synthesis is formed by a catastrophic jump. At the same time thesis can be interpreted as Kuhn's normal scientific activity. Antithesis or the bifurcation set denotes the competition of paradigms. The new paradigm, synthesis, is established by the revolution (catastrophic jump). The jump takes place after the paradigm testing and inter-paradigmatic debate in the bifurcation set. The divergence of the cusp offers an opportunity to formalize the small perturbations that cause the need for a new paradigm. A small alteration in some trend of scientific exploration can cause the start of a new paradigm as well as a great discovery. Resistance to our model might rise from the question: can Kuhn's scientific revolution be described as a catastrophic jump? Martin Bronfenbrenner has pointed to the "catastrophic" nature of Kuhn's paradigm hypothesis.[15] But Bronfenbrenner's *catastrophe* is not the *jump* of catastrophe theory. Bronfenbrenner's *catastrophe* takes place after the revolution. On the other hand, it is hard to agree that Kuhn has ever referred to the complete disappearance of a paradigm. Even the death of all the members of the old scientific community would not cause a complete disappearance of the framework of thought and language in some branch of science. So we can see that the result of the paradigm change can hardly be catastrophic. But what about the change itself? We have to learn whether the forming of the synthesis (new paradigm) contains a jump. Let us recall what we meant by a jump (see p. 2). I suggest that there really is a jump similar to a social revolution. The

---

[13] *Chase, R. X.* The Kuhnian paradigm thesis as a dialectical process and its application to economics. — Rivista Internazionale di Scienze Economiche e Commerciali, 1983, 9, 809—827.

[14] *Ibid.*, 323.

[15] *Bronfenbrenner, M.* The "structure of revolutions" in economic thought. — History of Political Economy, Spring, 1971, 136—151.

effectiveness of its description by the catastrophe-theoretic model depends on the choice of the conflicting factors. It seems possible to select the pair of the most relevant conflicting factors at least in some cases of the paradigm change. For example, in the case of the Copernican revolution the main points of the conflicting paradigms are very clear. As we see, we cannot eliminate the contradiction. We have learned that the jump of the paradigm change is not a mathematical discontinuity. On the other hand, we can see that the paradigm change can be described by the cusp. Such contradiction is normal because we deal with a qualitative mathematical method.

We have constructed one more catastrophe-theoretic model that rises at least as many problems as the models of E. C. Zeeman, M. Zwick, and others. It is very likely that the dynamic situations governing the evolution of natural phenomena are basically the same as those governing the evolution of society. We use the world *conflict* to express a geometrical situation in a dynamic system. So there can be no objection to the use of the word to describe quickly and qualitatively a given dynamic situation. R. Thom's aspirations are bigger. He wants to geometrize also the words *information, message,* and *plan*. E. C. Zeeman has said that catastrophe theory promises to be a major advance in making the inexact disciplines exact and scientific. Catastrophe theory has made attempts to handle precisely discontinuity and divergence. But the mathematics of quantum theory, bifurcation theory, and shock waves have also used widely methods involving these two qualities. None of the catastrophe-theoretic models is completely successful, but each one has its own benefits. A model is considered useful even if

— it rests on questionable assumptions; or
— it is based on faulty reasoning; or
— it leads to wrong conclusions; or
— it deals with ambiguous concepts; or
— it does not make testable predictions.

A model with several of these faults may still be valuable — as long as it does not have all of them.[16] In spite of such a statement it hardly makes sense to use a model that leads to wrong conclusions. The existing catastrophe-theoretic models do not make testable predictions. It is therefore hard to see what is the contribution made by the catastrophe theory to the biological and social sciences. This concerns applications. However, catastrophe theory can serve as a framework for certain kinds of systems. It can be used for describing different types of processes containing discontinuities. Although we have not been able to receive practical help from catastrophe theory it is too early to disregard the method. It may be the first and most important step towards prolific interaction between social, mathematical, and natural sciences.

---

[16] *Sussmann, H. J., Zahler, R. S.* Catastrophe Theory as, 211.

Presented by J. Rebane

Received
March 28, 1991

Peeter MÜÜRSEPP

KATASTROOFITEOORIA RAKENDAMISE METODOLOOGILISI PROBLEEME

Teaduse metodoloogia baseerub kahel põhimõtteliselt erineval filosoofia ajaloo allikal. Silmas on peetud herakleitoslikku ja Elea traditsiooni. Umbes kolmesaja aasta vältel arenes Euroopa teadus peaaegu kõrvalekaldumatult metodoloogilisel liinil, mis sai alguse Parmenidese ideedest. Nimetatud traditsiooniga olid kooskõlas näiteks Newtoni õpetus ning Laplace'i determinism. Nüüdisajal seesugune käsitlus enam teadlasi ei rahulda. Teaduse metodoloogia peab lähtuma dialektilistest ideedest, mille päritolu ulatub Herakleitose õpetuseni pidevast muutumisest ja vastandite võitlusest.

Uuel metodoloogilisel alusel väljatöötatud teaduslike teooriate formaliseerimiseks on vajalik uus matemaatiline aparaat. Hädavajalikuks osutuvad nn. kvalitatiivsed matemaatilised meetodid. Nende hulka võib liigitada ka R. Thomi katastroofiteooria, mis on välja töötatud teoreetilise bioloogia formaliseerimiseks.

Katastroofiteooria kohta on avaldatud vastakaid arvamusi. Esimesel pilgul tundub see teooria sobivat iga mittelineaarse protsessi modelleerimiseks. Katastroofiteooria abil on tõepoolest võimalik modelleerida väga erinevatest valdkondadest pärit nähtusi. Seejuures kerkib esile aga terve hulk raskusi. Näiteks pole võimalik varem kindlaks määrata, milliste muutujate väärtuste korral saavad toimuda katastroofilised muutused. Katastroofiteooria rakendamiseks tuleb sisse tuua lisastruktuure. Nende leidmine on rakendusmatemaatiku ning loodus- ja ühiskonnateadlase ühisülesanne.

Enamik katastroofiteooria rakendusi ühiskonnateadustes põhineb elementaarkatastroofil — kurrul. Kurru iseloomulikemaid omadusi on kvalitatiivsus ja divergents. Teoreetiliselt on kurd rakendatav kõigis reaalsuse sfäärides, kus süsteemi käitumist mõjutab kaks faktorit ning esineb pidevuse katkemine. Sellega seoses on väidetud, et katastroofiteooria sobib hästi hüppeliste nähtuste kirjeldamiseks. Seesugusel kirjeldamisel aetakse funktsiooni katkevus sageli segi hüppega argitähenduses, kusjuures katastroofiteooria on lokaalse iseloomuga. Thomi teoreem ei võimalda teha globaalseid järeldusi kõvera või pinna kohta. Katastroofiteoorial põhinevates mudelites esinev matemaatiline hüpe on lokaalne nähtus. Sellel on vähe ühist katkevusega bioloogilistes ja sotsiaalsetes süsteemides. Katastroofiteooria rakendamiseks tuleb kõigepealt valida muutujad, mille mõju uuritavale protsessile on suurim. Niisugune valik toimub subjektiivselt, sõltudes uurija ideoloogilistest tõekspidamistest. Põhjalikult väljatöötatud mudel peaks võimaldama ennustada süsteemi edasist käitumist. Esialgu sellised prognoosid puuduvad.

Hoolimata märgitud puudustest peab R. Thom katastroofiteooriat kasulikuks, sest see võimaldab käsitleda isetaastuvate struktuuride, näiteks elusolendite stabiilsuse probleemi. Katastroofiteooria mudelid lubavad taandada keha ja vaimu probleemi üksikule geomeetrilisele objektile.

Enamik (kui mitte kõik) katastroofiteooriale ülesehitatud mudeleist põhineb konfliktfaktorite vastasseisul. See fakt viitab katastroofiteooria võimalikule dialektilisele olemusele. M. Zwick püüdis isegi formaliseerida kolme dialektikaseadust: vastandite võitlust, kvantiteedi üleminekut kvaliteediks ja eituse eitust. Seejuures ilmnes analoogia katastroofiteooria mõnede põhimõistete ning dialektikakategooriate vahel.

Käesolevas artiklis on tehtud katse seada kurru geomeetriline interpretatsioon vastavusse T. Kuhni kontseptsiooniga teadusrevolutsioonidest. See osutub täiesti võimalikuks ning lubab tulevikus konkretiseerida mõningaid Kuhni käsitluse aspekte.

Katastroofiteooria ühe looja, E. C. Zeemani arvates annab teooria lootust muuta ühiskonnateadus täppisteaduseks. Olemasolevad mudelid ei võimalda aga teha kontrollitavaid prognoose. Seetõttu ei saa praegusel hetkel kinnitada, et katastroofiteooria annab praktilist tulu. Siiski tundub olevat enneaegne katastroofiteooria vaatluse alt välja jätta, sest ta võib kujuneda esimeseks ja tähtsaimaks sammuks ühiskonna-, loodus- ning matemaatikateaduse viljaka koostöö suunas.

Пеэтер МЮЙРСЕПП

НЕКОТОРЫЕ МЕТОДОЛОГИЧЕСКИЕ ПРОБЛЕМЫ ПРИМЕНЕНИЯ ТЕОРИИ КАТАСТРОФ

Методология науки основывается на двух принципиально различных историко-философских источниках. Имеются в виду гераклитовская и элейская традиции. В течение примерно трехсот лет европейская наука развивалась почти исключительно на методологической основе, заложенной еще Парменидом. В соответствии с названной традицией возникла наука нового времени, в частности лапласcовский детерминизм. Однако на современном этапе развития научного знания такой подход не может удовлетворить исследователей. Методологию науки целесообразно повернуть в сторону диалектических идей, восходящих к учению Гераклита о постоянном изменении и борьбе противоположностей.

Научные теории, построенные на новой методологической основе, нуждаются и в новом математическом аппарате. Возникает необходимость в т. н. качественных математических методах. Один из таких методов — теория катастроф Тома, разработанная для формализации теоретической биологии.

О теории катастроф существуют противоположные мнения. На первый взгляд кажется, что теория катастроф подходит для моделирования любого нелинейного процесса. И действительно, с помощью этой теории можно моделировать самые разнообразные явления. Однако при этом возникает немало трудностей. Например, мы не способны предсказать, какие значения переменных вызывают катастрофические изменения. Теория катастроф станет работоспособной, если к ней подключить дополнительную структуру. Поиск подобной структуры является общей задачей математика-прикладника, естественника и обществоведа.

Большинство применений теории катастроф в общественных науках основано на катастрофе сборки. Важнейшими аспектами катастрофы сборки являются качественное поведение и явление дивергенции. Теоретически сборка может быть реализована во всех сферах реальности, где два фактора воздействуют на поведение системы и где наблюдается эффект прерывности. В связи с этим теоретики катастроф утверждают, что эта теория хорошо подходит для описания скачкообразных явлений. Но при этом они часто путают прерывность функции со скачком в обыденном понимании. Кроме того, теория катастроф сугубо локальная. Теорема Тома не позволяет утверждать что-нибудь глобальное о кривой или о поверхности. Математический скачок в моделях теории катастроф — явление локальное. У него мало общего с прерывностью в биологических и социальных системах. Для применения теории катастроф сперва приходится выбирать переменные, наиболее сильно воздействующие на изучаемый процесс. Подобный выбор весьма субъективен, поскольку зависит от идеологических убеждений исследователя. Основательно сформированная модель должна подсказать исследователю дальнейшее поведение системы. Но пока в нашем распоряжении подобных прогнозов нет.

Несмотря на вышеуказанные трудности, Р. Том считает теорию катастроф полезной, потому что с ее помощью можно исследовать проблему устойчивости самовосстановившихся структур, например живых существ. Модели теории катастроф позволяют также редуцировать парадокс души и тела к единичному геометрическому объекту.

Большинство моделей теории катастроф основано на противопоставлении конфликтных ситуаций. Этот факт указывает на диалектическую природу теории катастроф. М. Цвик даже пытался формализовать три закона диалектики: борьбу противоположностей, превращение количества в качество и отрицание отрицания. При этом обнаружилось подобие некоторых терминов теории катастроф с категориями диалектики.

В статье предпринята попытка сопоставить геометрическую интерпретацию элементарной катастрофы сборки с концепцией научных революций Куна. Результаты получились вполне приемлемыми, что дает возможность конкретизировать куновский подход.

К. Зиман — один из основоположников теории катастроф — высказывал мысль, что с помощью этой теории удастся перевести обществознание в разряд точных наук. Однако существующие модели не позволяют подвергнуть прогнозы проверке. Так что трудно определить меру содействия теории катастроф развитию биологии и обществознания. Итак, конкретной практической пользы теория катастроф до сих пор не дала. Тем не менее она может стать первым и решающим шагом в направлении плодотворного взаимодействия общественных и естественных наук.