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Methodology of Neo-inductivism: Critical Analysis

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***Abstract*—The main principles of the methodology of neo-inductivism are analyzed — the core of the philosophy of science of logical positivism. The main difference between neo-inductivism and Bacon-Mill classical inductivism is the new understanding of the main function of induction as a cognition method. In classical inductivism, the function of induction consisted in the discovery of scientific laws and the subsequent proof of their truth based on facts. In the methodology of neo-inductivism the fundamental impossibility of solving such problems was recognized, since the discovery of hypotheses of scientific laws based on experience is not a logical, but a creative process, and, secondly, since the truth of scientific laws cannot result from the truth of their corollaries. The only positive logical role of induction in scientific cognition consists only in confirmation of scientific laws and theories by experience. Therefore, although the construction of the inductive logic of discovery and proof of scientific laws is impossible in principle, but the solution of a weaker, but real task is quite possible: the construction of an inductive logic of confirmation of scientific hypotheses.**

Keywords—induction; scientific law; inductive proof; inductive confirmation; probability; logical probability

I. Introduction

Unlike classical inductivism, according to which scientific cognition begins with the accumulation of empirical data and represents a bottom-up path – the path of continuous inductive ascent along the ladder of generalizations from elementary truths of science to more and more general ones, modern inductivists believe that it is wrong to interpret the process of advancing scientific generalizations as the process of their logical derivation from the experimental data. Moreover, also the accumulation of empirical data is not considered here as a necessary starting point for proposing hypotheses of scientific laws and theories [1].

Based on the idea of the impossibility of creating the logic of scientific discovery, logical positivists of the 20th century (G. Reichenbach, R. Carnap, R. Braithwaite, C. Hempel and others) began to develop a hypothetico-deductive model of scientific cognition [2]. Within this model, the process of advancing and discovering scientific laws and theories is already considered as a creative and psychological process, not subject to strict methodological principles. According to logical positivists, a purely logical derivation of theories from facts is impossible, so all scientific theories are in their very essence “freely introduced hypotheses”. Another important feature of the hypothetico-deductive concept of scientific knowledge is the assumption that the choice between competing scientific hypotheses is subject to methodological regulation and is carried out by deduction from scientific hypotheses and theories of empirical consequences and by comparing them with experience. While followers of the hypothetico-deductive concept of scientific cognition believe, the discovery of scientific laws is not subject to logical regulation and, in principle, is the free creativity of the cognizing subject, the process of their acceptance is subject to logical reconstruction, making it possible to choose the most acceptable scientific hypothesis on logical and empirical grounds. So, in one of his last works, Carnap wrote: “I agree that an inductive machine cannot be created if the goal of the machine is to invent new theories. I believe, however, that an inductive machine can be built with a much more unpretentious goal. If some observations e and hypothesis h are given (in the form of, say, a prediction or even a set of laws), then I am sure that in many cases it is possible to determine the logical probability, or the degree of h confirmation on the basis of e, using a purely mechanical procedure” [3].

This sharp opposition of the process of discovery of scientific theories to the process of their acceptance, which constitutes the essence of the hypothetico-deductive concept, seems for us to be illegal. It is based on too strong assumptions, which were dictated by the philosophical attitudes of logical positivists: their strive to prove that science in principle can develop exclusively on an empirical, “factual” basis; denying by any means any positive influence of philosophical ideas on the development of scientific cognition; unwillingness to see the whole diversity of cognitive and sociocultural factors on the basis of which scientists accept or reject scientific theories. The hypothetico-deductive model of scientific cognition is erroneous both in that it does not take into account the existence of objective factors determining the activity of a scientist during advancement of a theory, and in that it considers it possible to accept theoretical hypotheses only on logical and empirical grounds. Both do not correspond to the real process of scientific cognition. Within the scientific cognition there is absolutely no sharp asymmetry between the discovery process and the process of accepting theories, and namely from this logical positivists proceeded [4].

II. Neo-Inductivism of Reichenbach

One of the first attempts to build inductive logic as logic to confirm the theories with empirical data belongs to G. Reichenbach [5]. All human knowledge, he believes, is fundamentally probabilistic in nature. The black-and-white scale for assessing knowledge as either true or false by classical epistemology is, in his opinion, too strong and methodologically unjustified idealization. The overwhelming majority of scientific hypotheses have some intermediate meaning between truth (1) and false (0). True and false are just two extreme values of an infinite number of truth values of statements in the interval (0, 1).

Considering that the truth of each scientific hypothesis can be attributed to a well-defined numerical value measured on the basis of calculating the empirical material confirming it, and that this value is a probability, Reichenbach suggested two methods for determining the probability of scientific hypotheses. Both of these methods are based on his frequency theory of probability, according to which all correct probability statements should be constructed as statements about the limit of the relative frequency in an infinite series: $p = \lim m/n$. When determining the probability of a hypothesis by the first method, the relative frequency is interpreted as the ratio of the number of corollaries of a scientific hypothesis that was found to be true when tested (confirmed by observation and experiment) to the total number of all corollaries derived from this hypothesis. For example, if, when testing a hypothesis, each of the corollaries derived from it is founded to be true (t), that is, if we have a sequence t t t t t t t t t t ..., then the hypothesis should be considered true with the degree of 1. If when testing a hypothesis, we have such a sequence of its corollaries as tfttttffffttff ..., then the probability of a scientific hypothesis (according to Reichenbach – the degree of its truth) should be considered 1/2, because only every second of the corollaries derived from it was found to be true. When determining the probability of a hypothesis by the second method, we can consider the number of known facts of a certain area of phenomena as n, and the number of those of them that are logically derived from this hypothesis as m. For example, if there are 100 facts from the field of optical phenomena, then the optical theory T, from which 80 of these facts are resulted, should be considered to have a probability of 4/5, while the optical theory T ', from which only 10 facts are derived within the examined area, has a probability equal to 1/10.

At first glance, the probabilistic-frequency conception of confirming hypotheses and theories proposed by Reichenbach seems quite reasonable. However, upon the closest critical examination, its serious methodological flaws are revealed. Its main drawback is precisely related to the frequency interpretation of the probability of hypotheses. The fact is that with limitary-frequency interpretation of probabilities, probabilistic statements can be finally neither verified nor falsified, since the series of observations on the basis of which the frequency is calculated in an infinite sequence of tests can always be considered as fluctuations. By virtue of this, any hypothesis can, in principle, be attributed to any desired truth value that cannot be refuted. Conscious of the logical groundlessness of identifying the observed frequency in a particular and finite test series (and the researcher deals only with such sequences in experience) with probability, Reichenbach suggests using the following inductive rule when determining the probability: "If the initial part n of the elements of the sequence xi is given and results in frequency fn and if nothing is known about the probability of the second level of a certain limit p appearing, assume that the frequency fi (i > n) will reach the limit p inside fn ± δ, when the sequence increases" [6]. Reichenbach believed that if you continue to use this rule for a long time, it will lead to success, if success is possible. However, such a justification of this inductive rule does not look convincing enough and, as S. Barker rightly answers, "does not give us any guarantee that after a specific number of observations we have the right to assume that our estimate of the long-term relative frequency will be within a certain specific degree of accuracy ... I cannot wait forever, and I want to know whether it is reasonable to accept this partial estimate here and now, made on the basis of data that is taking place at present" [7]. In addition, since, from the point of view of Reichenbach, the inductive rule proposed by him is a factual hypothesis, so it itself has a probabilistic nature of its truth, which requires an appropriate justification. The dangerous situation of the logical circle with the justification of induction, which D. Hume pointed out at the time, is obvious. K. Popper rightly noted: "Assessment of the hypothesis as probable is not capable of improving the dangerous logical situation of inductive logic" [8]. Reichenbach's proposal to circumvent this difficulty by correcting the probabilities of one level with the help of probabilities of a higher level does not save the situation, because getting rid of uncertainty on one level meets with uncertainty on another. We are condemned to an endless regress of uncertainty, and the most important thing is that we have no reasonable (theoretical) reason to stop.

Critics of Reichenbach noted other drawbacks of his concept of inductive confirmation of scientific hypotheses. In particular, from the point of view of the Reichenbach interpretation of the inductive probability of a hypothesis, the latter will be considered highly probable, even if it is constantly refuted by facts. So, if the corollaries of a hypothesis will be refuted in every third case, but confirmed in the others, then according to the criterion proposed by Reichenbach, the probability of the truth of such hypotheses should be considered equal to 2/3. This, of course, is an obvious absurdity from the point of view of real cognitive practice in science, because in it such hypotheses qualify not as probably true, but as knowingly false. On the other hand, if we accept the theory of inductive confirmation of Reichenbach, then the best hypothesis (having the maximum probability) would be, in fact, that which a simple description of the available facts is. But it also contradicts the very meaning of scientific hypotheses, especially the scientific laws, which are not merely a statement of observations, but are some kind of explanation schemes for these observations. The above difficulties of the Reichenbach program to develop inductive estimates of the degree of confirmation for scientific hypotheses by a probabilistic-frequency method are too significant to be accepted by the scientific community. That is why most modern philosophers of science regard the path proposed by Reichenbach as generally unpromising [9].

III. NEO-INDUCTIVISM OF KEYNES — JEFFREYS — CARNAP

Another approach to the development of the theory of inductive confirmation of scientific hypotheses was proposed in the works of J. Keynes, H. Jeffreys and R. Carnap [10] [11] [12]. The basis of this approach was the idea of building a theory for confirming hypotheses on the basis of logical rather than statistical probability. But the most complete and profound expression of this approach was realized by one of the recognized leaders of logical positivism, a famous logician — R. Carnap. Unlike Reichenbach, who, by virtue of statistical interpretation of the probability concept, the degree of confirmation of hypotheses by facts was always estimated only roughly and never was final, followers of confirmation as a formal logical relationship between hypothesis and facts considered possible to obtain absolutely accurate quantitative estimates of the degree of confirmation of hypotheses. The most powerful attempt in this direction was made by R. Carnap. He advanced the task of constructing inductive logic as an analytical theory of confirmation. “Because according to logical empiricism,” Lakatos notes, “only analytical statements can be infallible, Carnap accepts his inductive logic as analytic one” [13].

In contrast to Reichenbach, Carnap believed that science has not one, but two different notions of probability: statistical (frequency) and logical. It is the latter, according to Carnap, that should be used to construct inductive logic: “By inductive logic, I mean the theory of logical probability” [14]. What is the fundamental difference between the approaches of Reichenbach and Carnap in understanding the relation of confirming one statement by others? In Reichenbach, the degree of confirmation of the hypothesis was considered as the degree of its truth, the measure of its conformity with the available experimental data. In the understanding of Carnap, the degree of confirmation of a certain hypothesis is a purely logical relation, characterizing not the degree of its truth in relation to the available data, but the degree of its logical derivability from these data. Carnap persistently emphasized the analytical nature of logical probability, considering it a direct analogue of the basic relation of deductive logic — logical implication: “I think that probability can be considered as a partial logical implication... Inductive logic, like deductive logic, relates exclusively to the statements under discussion, and not to the facts of nature. Using a logical analysis of the established hypothesis h and the evidence e, we conclude that h is not logically implied, but so to speak, partially implied by e in a certain degree” [15].

The theory of logical probability, or confirmation, which, according to Carnap, coincides with inductive logic, is considered by him “as a restructuring of deductive logic by introducing a definition for c” [16]. Carrying out this restructuring, Carnap defines a logical (L) implication in terms of basis pairs, descriptions of states and their ranks. A basis pair is a class of two propositions, one of which is atomic, and the other is its negation. A description of state is a class containing as its elements only one proposition from each basis pair and no other propositions. A rank of the proposition i R(i) is the class of those descriptions of states in a given area of reasoning L in which i is contained. Proposition i L implies a proposition if and only if R(i) is a subclass of R(j).

If the rank of the basis is included in the rank of the hypothesis, that is, if e L-implies h, then c (h, e) = l, where 1 by convention is considered the highest possible degree of confirmation. Accordingly, if the ranks e and h mutually exclude each other, that is, if e L-implies not-h, then c (h, e) = 0, where 0 by convention is considered the lowest possible degree of confirmation. These two cases, according to Carnap, constitute the scope of deductive logic. In the same cases, when the ranks e and h only partially include each other, the deductive logic remains silent. Here inductive logic comes into force, which is intended to numerically determine the degree of intersection of the ranks of any statements and thereby the “degree of derivability” of one from the other. To this end, Carnap modifies the concept of confirmation, as it has been used to date, and introduces the notions of the regular measurable function and the regular confirmation function.

The regular measurable function m for describing the states of z in a finite range of reasoning Ln is determined by two conditions: a) for each zi in Ln, m (zi) is a positive real number and b) the sum of the values of m for all z in Ln is equal to 1.

This definition of the m-function extends from such propositions as descriptions of state to any propositions by introducing two conditions: a) for any L-false proposition j m (j) = 0 and b) for any not false proposition j m (j) = sum of m values for z. In terms of the regular measurable function m, the regular confirmation function c, which connects the hypothesis h with the data e, is defined with some restrictions as follows:

$$c(h, e) = m(e, h) / m(e), \text{ where } m(e) \neq 0.$$

The extension of the confirmation notion from a finite to infinite area of reasoning is achieved by means of the classical theory of limits.

Carnap's striving to create an inductive probabilistic logic initially had a very clear and definite goal: to find an algorithm with which it would be possible to calibrate scientific hypotheses according to the degree of their support with empirical data and thereby solve the question of their acceptability. It is not by chance that the term “inductive methodology” itself is primarily used by Carnap to denote the discipline of the application of inductive logic [17]. According to Carnap, while the direct subject of “inductive logic” is the construction of the c-function theory, the inductive methodology of science deals already with the application problems of this function. Carnap strongly believed that “quantitative inductive logic when it is fully developed... when applied to the language of physics, will allow us to determine, for example, which of the two hypotheses in physics is more supported by the data of the set of observations and, therefore, which of them is inductively preferable" [18]. It should be noted that from the very beginning Carnap did not impose any restrictions on the nature of the hypotheses, bearing in mind, first of all, the hypotheses of scientific laws. When he came to the conclusion that the degree of confirmation of universal statements (and any scientific law is a universal statement) in the system of inductive logic he built is always equal to 0, he limited the scope of application of inductive logic to calculating the logical probability of not the law itself, but only the following example of the law based on available data. This, as many have noted, was a kind of a return to the Mill's understanding of induction as a conclusion from the particular to the particular. Carnap, however, never lost sight of his original idea – the calibration of scientific laws according to the degree of their support by experimental data. In recent years, he returned to this idea, considering it possible to talk about the probability of scientific laws and theories. In particular, this turn is clearly seen in his recent works "Philosophical Foundations of Physics" [19] and "Inductive Logic and Inductive Intuition" [20]. This is largely due to the establishment by this time of the connection between the logical and subjective concepts of probability: "Inductive probability is related to the degree of belief, as Ramsey explained long ago... But in inductive logic we are not dealing with real degrees of belief that people have and not with causal connections between them and similar factors, but rather with a rational degree of belief" [21].

Thus, it turned out that Carnap's degree of inductive confirmation essentially depends on the choice of language by the subject. The objective criteria for choosing the most appropriate scientific language are entirely unclear, and Carnap left this question completely open. The American philosopher A. Pap assessed this situation as follows: "...The statement about logical probability "c (h, e) = p" may be correct in the language of L and incorrect in the language of L', which differs from L only by one additional predicate, which is not found at all in either h or e… Consequently, the value of c is determined not only by the values of its arguments, the propositions h and e... In this respect, Carnap's inductive logic seems to contain much more conventionalism than deductive logic". [22] On this basis, many logicians and philosophers of science refused to call the Carnap's theory of confirmation the "logic", believing that the logic statements should be true in all possible worlds and not depend on the choice of language by the subject. St. Kerner objected to Carnap's use of the term "logic" for the theory of c-functions in such a way: "Carnap is undoubtedly right, insisting that the relation c (h, e) is not empirical, but he is not right, considering that it is logical if we exclude too broad and therefore misleading the meaning of the word "logical". The definition of c in terms of m suggests the theory of limits and the most of the theory of sets. In the sense of how the logical principle is true in all possible worlds, the theory of sets cannot be considered as logic". [23] St. Kerner, K. Popper and many other logicians and philosophers considered in fact the concepts of "probabilistic logic", "inductive logic", "probabilistic inductive logic" as logically contradictory notions.

But even if one does not pay attention to the above-mentioned internal difficulties in implementing the Carnap's "inductive logic" program, then a pertinent question arose, how and why is it possible to use numerical estimates of the degree of inductive confirmation? After all, the philosophical-methodological part of the Carnap's program was meant to answer this question. Initially, Carnap believed that, other things being equal, the scientist would always give preference to the theory that has the greatest degree of confirmation. But how can we understand this? It should be recalled that in Carnap's interpretation "the degree of confirmation" does not mean anything more than the degree of derivability and is a purely analytical assessment. Why it is necessary to choose a hypothesis that has the highest "degree of derivability"? It is quite obvious in this case that the Carnap's "degree of confirmation" cannot serve as an indicator of the truth of a hypothesis, since from a logical point of view a hypothesis can have an arbitrarily larger number of confirmable corollaries and nevertheless be false. Conversely, a hypothesis may have a small amount of supporting material and be true. Thus, the assessment of the inductive degree of a theory confirmation, even if it could be calculated arbitrarily accurately, could in itself be neither an indicator of the truth of a theory, nor an indicator of its falsity. On the other hand, if one follows the Carnap's advice and give preference to hypotheses with the highest "degree of confirmation", then one often have to close the door to science for new hypotheses, because they will always lose out to old hypotheses in relation to the amount of supporting material. Undoubtedly, for a scientific hypothesis it is necessary that it be consistent with experimental data. From here, however, it does not follow that the degree of confirmation is the main factor influencing the choice and acceptance of this hypothesis. In this regard, one cannot but agree with the witty remark of F. Frank: "Science is like a detective story. All the facts confirm a certain hypothesis, but a completely different hypothesis turns out to be correct, after all" [24].

Serious objections to Carnap's inductionist methodology also arose from the fact that it did not answer the following two important questions: what should be considered in science as a subject of confirmation and what as supporting material? The difficulty here is, firstly, that in real science the scientists never deal with the confirmation or refutation of a single hypothesis, since the derivation of verifiable corollaries from any hypothesis always requires the use of a number of other assumptions. Pierre Duhem rightly pointed out this: "A physicist can never subject any one hypothesis to experimental checking separately, but always only a whole group of hypotheses" [25].

However, the set of hypotheses is also not something self-contained. It contains a number of prerequisites linking it with other scientific constructions and even with all human knowledge as a whole [26] [27]. With a purely logical approach, there fundamental difficulties arise in determining clear boundaries of the subject of confirmation. They turn out to be much undetermined [28].

IV. Conclusion

Thus, the attempts of both Reichenbach and Carnap to rescue the inductive methodology of science by replacing the requirement of inductive proof of laws and theories with the requirement of their inductive confirmation cannot be considered successful. Both strategies of neo-inductivism have a number of logical and philosophical drawbacks. This circumstance is recognized today by many philosophers, including representatives of the positivist orientation. Aware of the futility of the inductivism methodology, but wishing to maintain loyalty to the philosophy of empiricism, some of them saw an alternative to the inductivism methodology of confirmation in the deductivism methodology of refuting false scientific hypotheses and theories by facts. This tendency was most clearly manifested in such a prominent methodologist of the science of the 20th century as K. Popper. Unlike the logical positivists, K. Popper and his followers absolutely denied any positive role of induction in scientific cognition [29] [30] [31]. But this is another page in the history of the science methodology [32] [33].

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