THE PROBLEM OF SCIENTIFIC METHOD IN LIGHT OF POPPER's, KUHN's AND LAKATOS' ARGUMENTS

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To my father and mother…

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Abstract

The boundary between science and pseudoscience dates back to the time of Aristotle. In particular, this boundary caused a demarcation problem in the nineteenth and twentieth centuries. One of the great advancements was attempted by logical positivists to draw a line between science and pseudoscience. Afterwards, Popper's philosophy was shaped by the demarcation problem. In light of Popper's philosophy, Kuhn's and Lakatos' scientific views have taken their place in the philosophy of science. Hence, great discussions have been initiated to address each of these philosophies.

This dissertation is an examination of the problem of scientific method in Popper's, Kuhn's and Lakatos' methodologies in the philosophy of science. The main purpose of this study is to compare and analyse Popper's, Kuhn's and Lakatos' scientific views in terms of their similarities and differences, and to show how Lakatos' scientific view is more plausible than Popper's and Kuhn's philosophies. In particular, in the first chapter of the dissertation Popper's falsificationism is examined. This is because falsificationism as a scientific method forms the premise for shaping Kuhn's and Lakatos' scientific views. In the following section, the idea of paradigm and scientific revolution are addressed to explain Kuhn's scientific view. Some similarities and differences between Popper's and Kuhn's scientific views have been evaluated by comparing the two. In the last chapter of the study, Lakatos' scientific research programme is discussed in light of Popper's and Kuhn's philosophies, and is proposed as a plausible scientific method in the philosophy of science. In this study, in particular, Popper's, Kuhn's and Lakatos' philosophies have been chosen to examine them in terms of their scientific methods, because this might be a new perspective to fill a gap in the literature.

Keywords: Scientific method, Popper, falsificationism, Kuhn, paradigm, scientific revolutions, Lakatos, scientific research programme

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Introduction

In *The Methodology of Scientific Research Programmes, 'scientia'*, which is a Latin word, refers to science. In addition, the meaning of science is stated as 'knowledge' or 'to know' (Lakatos, 2009). The use of science dates back to the time of Aristotle. According to Aristotle, metaphysics is 'the Queen of Sciences', and it deserves this definition. This is because the first causes of presence have been grasped in this way. As argued by Aristotle, the central point of any discussion was metaphysics, which was a long-standing issue. However, this understanding has changed and metaphysics has since been rejected. It is suggested that the concept of science, as a meaning, did not change rapidly. The process has taken a long time, hence attaining scientific knowledge also takes a long time. Kant, in the preface to 'Critique of Pure Reason', paid attention to this situation. He pointed out that our experiences are an essential circumstance for the beginning of our knowledge (Kant, 1929). He also argued that it is not pure reason but our experiences which determine our scientific knowledge. In this sense, scientific knowledge is limited in terms of a criterion. Over the last few decades, many philosophers have attempted to introduce a criterion and a method for scientific knowledge. In this respect, scientific method and criterion have been a problem among philosophers for years.

The history of the natural sciences and the history of philosophy have been considered together for years, hence the philosophy of science has been formed through this togetherness. Besides this, the boundary between science and non-science was a fundamental problem in the twentieth century, and this boundary became a demarcation problem in Popper's philosophy. Afterwards, the boundary between science and pseudoscience has been called a demarcation criterion, which is essentially a philosophical problem rather than a scientific problem. There is no conflict among scientists, because for them the criterion is certain. However, this criterion is ambiguous for philosophers, so they have attempted to introduce a criterion for scientific knowledge. This problem, as with other philosophical problems, has been revealed to have been solved. In this case, different scientific methods have occurred in the philosophy of science.

In light of these, the first criterion was to draw a boundary between science and pseudoscience, and this criterion was put forward by logical positivists. Their criterion was called *verification.* According to logical positivists, each theory must be verified by the method of induction. Thus, scientific knowledge can be determined by inductive method. In addition, if a theory can be verified by experiment, this theory can be accepted as scientific. As a result, if a theory is not verified by experiment, then it is meaningless. Popper rejected this understanding. Lakatos thought that Popper proposed a great criterion for science with his scientific view. This criterion is called *falsificationism*. According to Popper, the logical positivists' criterion scorned some scientific arguments. In addition, this criterion was used to show some non-scientific arguments in terms of scientific propositions, such as astrological arguments. In Popper's view, if a theory is accepted as scientific, it must be testable. According to this criterion, astrological propositions do not involve scientific knowledge, because such a proposition is constantly looking to confirm itself, and ignores science. For this reason, to Popper, these propositions are not scientific. On the other hand, Kuhn argued that there are paradigm shifts in the history of science, and these changes cannot be explained by Popper's falsificationism. Kuhn pointed out that these changes were like a change in religious change, so this bears on people's beliefs. Hence, Kuhn's philosophy was based on irrationality even though he did not accept this. Beside this, Kuhn offered a scientific criterion which was called a *paradigm*, and *normal science* was described as a puzzle-solving activity in paradigms. In this case, paradigms are a conceptual framework which offer a world-view and beliefs. For this reason, Lakatos claimed that Kuhn's philosophy was irrational, and scientific revolutions were offered as rational progress by Lakatos.

Lakatos argued that the boundary of science and pseudoscience is important in terms of the rational anomalies in the philosophy of science. Lakatos also pointed out that the philosophy of science supports neither Popper's nor Kuhn's philosophy. Either Popper's experiments or Kuhn's scientific revolutions are a myth (Lakatos, 1980). Lakatos' philosophy was different to its predecessors, because not only one theory but a series of theories were considered in his scientific view. Therefore, Lakatos' scientific view offered us a new scientific criterion.

In this dissertation, I will aim to scrutinise the problem of scientific criterion and methods in the philosophy of science. In particular, this problem will be examined in light of three great philosophers of science, who are Popper, Kuhn and Lakatos respectively. The demarcation problem, the problem of induction, falsificationism and the progress of science in Popper's philosophy constitute the first phase of this dissertation. My hypothesis is that Popper's scientific view is the central point of this discussion, and his scientific criterion is not sufficient on its own to understand the process of science. In this respect, his philosophy requires to be scrutinised to be compared with Kuhn's and Lakatos' scientific views in the philosophy of science. In Chapter II, the importance of scientific progress in Kuhn's philosophy will be evaluated, and some relevant points will be compared with Popper's philosophy. In the first part of Chapter II, Kuhn's philosophical background will be borne on the history of science, and his scientific criterion will be exemplified in terms of this point. In the following section of the chapter, Kuhn's scientific method will be laid out, and at the end of the chapter some similarities and differences between Popper's and Kuhn's scientific methods will be discussed. In the last chapter, a new scientific criterion in the philosophy of science will be proposed in light of Lakatos' scientific view. This chapter is the heart of the dissertation, because these three philosophers, Popper, Kuhn and Lakatos, will be compared, and I will attempt to criticise why Lakatos' scientific method is more plausible than other scientific views in the philosophy of science. I shall examine the literature review before starting these chapters.

Literature Review

General Overview

Many scholars in the philosophy of science have argued that science is effectively different to other disciplines in terms of its methods. Scientific method has been treated in a cumulative and progressive way by some approaches, however it has been rejected by others. In the twentieth century in particular, Thomas Kuhn, Karl Popper and Imre Lakatos brought different approaches to the field of scientific knowledge and scientific progress. The discussion over scientific method has been dominated by these three philosophers in the philosophy of science.

Scientific method in the philosophy of science was treated in a different way by Popper, Kuhn and Lakatos. Popper's falsificationism (Popper, 2009), Kuhn's paradigms (Kuhn & Hacking, 2012), and Lakatos' scientific research programmes (Lakatos, 1978) are at the heart of this debate.

Here I will try to bring a different perspective to their arguments, and my explication will take the following purpose: I will start by looking at Popper's method of scientific progress in the philosophy of science. After that, I will move on to Kuhn's paradigms and his explanation of 'normal science'. Finally, Lakatos' scientific research programme will be evaluated in the same manner. Their arguments will be examined and I will try to highlight points that have been missed in the previous literature.

Scientific Methods as presented by Karl Popper

Karl Raimund Popper tried to find a criterion for scientific knowledge like that of the positivists in the philosophy of science, however his criteria were different to the positivists because he rejected their scientific method. In 1919, Popper started to think about scientific knowledge and its criteria. In *Conjectures and Refutations*, he explained his starting point by saying, “After the collapse of the Austrian Empire there had been a revolution in Austria: the air was full of revolutionary slogans and ideas, and new and often wild theories. Among the theories which interested me Einstein’s theory of relativity was no doubt by far the most important. Three others were Marx’s theory of history, Freud’s psycho-analysis, and Alfred Adler’s so-called ‘individual psychology’” (Popper, 2009 p. 472)

Here, Popper compared Einstein’s relativity and three other theories. 1919 was quite a significant year for relativity. In that year, there was a solar eclipse which enabled scientists to test the theory of relativity. Until that time, verification was the first criterion for scientific knowledge, but this was not important to Popper’s theory. Popper pointed out that it is easy to find an empiric assistance for theories, however to Popper this was not right, as scientific criteria should be related to falsification. This is because if a theory can be falsified then it can be accepted as scientific. Hence, Popper introduced his falsification criteria as a scientific method in the philosophy of science (Chalmers, 1982; Popper, 2009; Lakatos, 1978; Larvor, 1998).

Popper’s demarcation criterion

The demarcation problem was at the heart of concern for Popper’s philosophy of science. This problem refers to the differences between science and pseudo-science. Popper introduced the demarcation problem to criticise logical positivists, because logical positivists argued that induction is the only method for scientific knowledge. On the other hand, logical positivists claimed that metaphysics is meaningless, because it is not testable. Popper criticised logical positivists in terms of these ideas. To Popper, “the distinctive logical fact about science is that its theories can be tested against empirical evidence” (Larvor, 1998, p. 47). Whilst logical positivists claimed that the boundary between science and pseudo-science is verifiable, Popper rejected this argument, this is because if verifiability is taken as the criteria, some problems can arise. Ordinarily, scientific theories should be conformed to matter of fact, and matter of fact should support theories. However, this conformity does not mean that these theories are scientific (Larvor, 1998).

At this point, Popper put forward his own theory. According to him, if a theory is scientific, it should be falsifiable. For this reason, the criterion for demarcation is not verifiability, it should be falsifiability (Popper, 1971). Hence, a scientist can simply infer from an experiment that a theory is false. According to Popper, even the best theory can be falsified, and for this reason he argued that falsifiability is among the criteria for scientific methods. As Nicholas Maxwell pointed out, “At any given stage the best theory is the theory of highest empirical content which has stood up best to all our attempts at experimental refutation” (Maxwell, 1972, p. 132). At the same time, he emphasised how empirical content is significant for a scientific theory. If there is an old theory which is replaced by a new theory, the empirical content which was in the old theory should also be in the new theory. Popper argued that empirical content is less present in the theories of Marx and others, and so those theories cannot be accepted as scientific (Larvor, 1998). Popper argued that theories cannot be verified, because verification just brings scientific dogmatism. To him, scientists should treat the new theory in relation to the old theory, and then the new theory should be tested through experimentation and observation. Therefore, scientific progress develops from experiments on theories, and this method was called 'deductive' by Popper. In such cases, scientists can examine whether a theory can be falsified or not. Criticism is the keystone for Popper. Scientists criticise situations and theories, and then test theories to falsify them. In so doing, dogmatism can be refused, because there is no certain truth for theories (Magee, 1985).

Scientific Methods as presented by Thomas Kuhn

In 1962, *The Structure of Scientific Revolutions* was published by Kuhn. After publication of the book, many philosophers accused Kuhn of being relativist and irrationalist. Brendon Larvor (1998) quoted from Lakatos: "For Kuhn scientific change … is a mystical conversion which is not and cannot be governed by rules of reason and which falls totally within the realm of the social psychology of discovery" (Lakatos & Musgrave, 1970, as cited by Larvor, 1998). However, Kuhn studied, in particular, physics and the history of science. In light of this, Kuhn argued that scientific progress is developed in two ways: revolution and social change. According to Kuhn, Popper's view of falsification was wrong, because if a theory is accepted by the scientific community, then this explanatory theory will not normally be discarded, even if the results are not as expected. These kinds of theories, which were called 'paradigms' by Kuhn, are explained by Kuhn as follows: "…once it has achieved the status of paradigm, a scientific theory is declared invalid only if an alternative candidate is available to take its place" (Kuhn & Hacking, 2012, p. 77). Paradigms govern the scientific community and their methodology in 'normal science', and also give solutions to puzzles (problems). However, when paradigms are developed and purified, there can be some contradictions and this can cause a crisis in the scientific community. At that time, the process is suspended until a new paradigm can be found. Kuhn pointed out that normal science is a kind of puzzle which can be solved with current paradigms (Cottingham, 1984). However, in scientific anomalies an alternative paradigm can be accepted, and then the new paradigm should supplant the current one or there will be a scientific revolution. Gary E. Jones also emphasised this situation, saying, "He states that new paradigms are considered for replacing the old only when an anomaly in the old theory is for various reasons considered a 'crisis', A new paradigm succeeds it only if what was an 'anomaly' under the old paradigm can be shown to be a 'predicted phenomenon' under the new paradigm" (Jones, 1981, p. 392). Therefore, according to Kuhn, scientific progress is not developed accumulatively; conversely it develops with revolution. Kuhn also argued that each era has its own conceptual system, and Kuhn called this system a paradigm. A paradigm includes certain theoretical beliefs, scientific hypothetical ideas, and a certain model system and method. Briefly, each paradigm has different perspectives and different world views. Each paradigm has a different attitude towards matters of fact, and answers questions differently. To Kuhn, paradigms draw a line in which 'normal science' works. Theories are established to solve discrepancies, however if a paradigm cannot solve current anomalies, then a new paradigm is constituted to solve any such puzzles. Science develops with this circulation: paradigm, normal science, anomaly, crisis, revolution, and new paradigm.

This process circulates like a dialectic in the philosophy of science (Kuhn & Hacking, 2012). There is no logical or rational method required to constitute a new paradigm. This is a kind of revolutionary jump, and it follows a crisis. New paradigms do not need to include old paradigms, and so new paradigms try to find totally new answers for new problems. There is no certain space and time in Kuhn's paradigms, and for this reason there is also no certain true or false. Hence, according to Kuhn, there is no verification or falsification of theories.

Kuhn also argued that our interpration of scientific progress bears on our perception of the history of science. He said that some invalid theories can be seen as myths, however we cannot discard those theories and nobody can assert that those theories are not scientific. This is because each theory should be considered by the scientific community in society (Kuhn & Hacking, 2012). It is assumed that before the Kuhnian arguments scientific progress continued acumulatively, however there were no historical and cultural traces. Cultural structure was accepted as contant, and scientific progress was treated as linear. Kuhn did not accept this kind of argument. As stated above, he argued that each theory should be treated and examined in its cultural society, and proposed the idea of paradigms

In light of this, Kuhn argued that paradigms cannot be interrogated, and in addition experiments are just for puzzles, not for theories. If there is a fault, it does not belong to paradigms but to individual scientists. John Worrall, in Normal Science and Dogmatism, Paradigms and Progress: Kuhn 'versus' Popper and Lakatos, quotes Kuhn's comments on this situation as follows: "…if [this 'personal conjecture'] fails the test, only [the scientist's] own ability not the corpus of current science is impugned. In short, though tests occur frequently in normal science, these tests are of a peculiar sort, for in the final analysis it is the individual scientist rather than current theory which is tested" (Kuhn, 2009, as cited by Worrall, 2003, p. 69). Larvor (1998) described the reason for this argument by saying, "The nature of [scientific] communities provides a virtual guarantee that both the list of problems solved by science and the precision of inidividual problem-solutions will continue to grow" (Kuhn & Hacking, 2012, as cited by Larvor, 1998, p. 43). On the other hand, Kuhn was blamed as a relativist by some philosophers. This situation was also shown when Kuhn said that "there is some one full, objective, true account of nature and that the proper measure of scientific achievement is the extent to which it brings us closer to that ultimate goal" (Kuhn, 1962, & Hacking, 2012, as cited by Larvor, 1998, p. 43). Kuhn also argued that there is no mutual certain criterion which can be used to choose a paradigm from given paradigms. He said that if a paradigm is changed, persuasion should be the method used. This is because there is no logical or mathematical foundation to choosing paradigms. In addition, there is no evidence to surpass from one paradigm to another. Each paradigm has its own scientific community who bear on different principles and concessions. They treat and interpret problems from different perspectives, and their languages for interpreting the world are also different. Hence, nobody can claim that there are universal criteria for scientific rules (Kuhn, 1962, & Hacking, 2012). This argument is opposed to the Popper's falsificationism. According to Popper, there is no one way to solve problems and theories are criticised using tests, and science progresses in this way. While Kuhn argued that theories cannot be criticised, and that only the scientific community is responsible for faults, Popper argued that theories should be criticised, because "criticism is the unifying theme of his entire life's work" (Larvor, 1998, p. 45).

Scientific Methods as presented by Imre Lakatos

Imre Lakatos, in *Falsification and the Methodology of Scientific Research Programmes,* tried to bring a rational criterion to scientific method in the philosophy of science. According to Lakatos, a rational criterion is quite significant, and if there are no criteria in science, this is not only a danger for physics but also a considerable danger for ethics and politics. This is because it causes relativism. For this reason, it is important to bring criteria to scientific knowledge.

A philosophy of science theory and its solution to problems

Lakatos used a different method to write his own articles or books. Ordinarily, when he treated a general subject, he chose a theory at the start of a text, and reached totally different points by the end. For instance, in Falsification and the Methodology of Scientific Research Programmes, he started by supporting Popper and tried to strengthen his weak points. However, at the end of paper he discussed completely different arguments to Popper. In doing so, he looked like a supporter of Kuhn's argument on paradigms and he created his own research programmes, but again at the end of the text he put forward totally different arguments to Kuhn. In other words, at first Lakatos eliminated the weak and irrational aspects of the other theses, and he then established his own thesis based on the rest of the strong aspects. This is quite important to our understanding of Lakatos' arguments.

Lakatos constituted a rational scientific method to solve three fundamental problems. The first one was the demarcation problem; the second one was the evaluation of scientific theories as normative; and the third one was the explanation of scientific progress and changing theories.

Critics of Methodological Falsificationism

Lakatos pointed out that methodological falsificationism is a kind of improved conventionalism. This approach argued that useless theories should be discarded. According to this approach, if a theory can be falsified, then it can be said that this theory is scientific. This is the criterion for methodological falsificationism (Lakatos & Musgrave, 1970). However, Lakatos claimed that methodological falsificationism is not enough to explain scientific issues. Here, the criterion for drawing a line between science and pseudo-science can be constituted from the history of science. Lakatos tried to return to rationality in the philosophy of science. Lakatos argued that the purpose of the philosophy of science is to give a rational explanation for scientific progress. In other words, if we want to understand scientific progress, we need to consider logical and rational methods. Other factors, such as political, cultural and social factors, cannot be the main factors used to understand science

The Methodology of Scientific Research Programmes

According to Lakatos, scientific research programmes are constituted of four main elements, which are ‘hard core’, ‘protective belt’, ‘negative heuristic’, and ‘positive heuristic’. Hard core is a kind of main axiom. A protective belt protects the hard core, and has a more flexible hypothesis which can be tested and examined. Negative heuristic does not allow us to digress from the hard core, and if there is an anomaly, negative heuristic decides which theories cannot be discarded in the hard core. In other words, it shows what scientists should do. Positive heuristic states which theories should be constituted and developed, and, if there is an anomaly, how theories should be changed or improved in a programme. In other words, it governs scientists (Lakatos, 1978; Lakatos & Musgrave, 1970; Larvor, 1998; Schuster, 2009). According to Lakatos, “all scientific research programmes may be characterized by their ‘hard core’. The negative heuristic of the programme forbids us to direct the modus tollens at this ‘hard core’” (Lakatos & Musgrave, 1970, p. 133). To Lakatos, the most succesful theory is Newton’s gravitational theory. “In Newton’s programme the negative heuristic bids us to divert the moduls tollenss from Newton’s three laws of dynamics and his law of gravitation.” (Lakatos & Musgrave, 1970, p.133)

Lakatos’ understanding of rationality is parallel to his understanding of science. To him, rationality is scientific rationality, and this emerges as scientific progress. According to him, when research improves either rationally or empirically, it represents scientific progress. In this case, each development in the history of science provides these two conditions. Lakatos used these methods in his articles. He believed that each theory brings rational progress, and in so doing, he provided a rational criterion for his own theory.

Evaluation

Popper introduced a new term with his theory of falsificationism in the philosophy of science. Hence, justification and verification lost their significance. Falsification was the keystone for Popper’s philosophy. If a theory cannot be falsified then it can be put away, according to Popper. This method also rejected induction, because induction bears on to justification. On the other hand, Popper defended rationality in his theory. In light of this, Watkins argued that Popper’s philosophy was non-inductive and rational in the philosophy of science (Lakatos & Musgrave, 1970). Popper’s arguments and scientific method, in particular falsificationism, were not accepted by Thomas Kuhn. Kuhn criticised either Popper or others in terms of the notion of a certain method in scientific progress. Kuhn argued that if there is a certain method in science, it should be incommensurability. In other words, he did not propose a scientific method, but his paradigms were kind of his own methodology. In Kuhnian methodology, social change is the keystone to understanding and explaining his philosophy. Each paradigm should be taken in the context of its society, so paradigms can be different in terms of their directors, who are the scientific communities. Social, political and cultural factors are decisive in their understanding of science. At the start of his methodology, Lakatos addressed Popper's and Kuhn's philosophy, however his result was totally different to their methodology. Lakatos established his own research programmes to return rationality to the philosophy of science. According to Lakatos, the philosophy of science aims to bring a rational explanation for scientific progress. Rationality is the keystone of his philosophy. In *Criticism and the Growth of Knowledge*, he stated that Kuhnian philosophy is non-inductive and irrational. For this reason, he rejected Kuhn's methodology.

CHAPTER I.

1.1. General overview of the problem of demarcation in the philosophy of science

The differences between science and pseudo-science go back to the beginning of Western philosophy (Anderson, 1983), and during the nineteenth century in particular these differences were put forward by positivists who tried to create a boundary between science and metaphysics. In their view, scientific knowledge can be only obtained through observation and experiment. Logical positivists also argued that inductive inferences should be used as a scientific method, because induction was quite important to the positivists' philosophy in terms of it being a verification criterion (Gärdenfors, 1990). According to them, theories are supported by facts, science is progressing by adding the cumulative knowledge of new facts and theories, and this process continues with inductive inferences. In so doing, they attempted to eliminate metaphysics from science. Positivists tried to form reasonable and experimental principles using experiments. This is because, according to them, scientific principles should be empirically proven; however, non-scientific principles can never be proven in this way. Hence non-scientific principles are irrelevant because they are not suitable as a verification criterion (McGrew et al., 2009).

Popper also assessed the differences between science and pseudo-science, however he called these differences the problem of demarcation, and he asserted that this is one of the most important issues in the philosophy of science (Anderson, 1983). According to Anderson (1983), "The problem of demarcation is inextricably linked with the issue of scientific method." (p. 18) In light of this argument in particular, Popper's scientific method bears on the problem of demarcation and also the problem of induction. Before discussing his scientific method, we need to address these two crucial arguments. So in this chapter, first of all I will explain and discuss whether or not the demarcation problem and its criterion are crucial in Popper's philosophy. After proposing this, I will address whether or not there is a problem with induction. This discussion will take place after I have analysed the demarcation problem in this chapter, because Karl Popper also treated these problems using this process (see also Popper, 1971). Following this section, falsificationism will be presented as Popper's scientific method, and it will be discussed in terms of its different aspects. At the end of the chapter, scientific progress in Popper's philosophy will be addressed. First, I shall discuss the demarcation problem in Popper's philosophy.

1.2. Demarcation criterion and Karl Popper

Popper's philosophy was described as 'critical rationalism' by Popper himself (Musgrave, 2004). Looking at his scientific method, classical empiricism and inductive inferences are rejected by this term. Popper criticised the logical positivists' philosophy in terms of their scientific criterion and methods. According to the logical positivists' scientific criterion, a matter of fact is observed and generalised by inductive inferences. Afterward these are tested by experiment. As a result of this, if a matter of fact or proposition is verified, it is accepted as sensible and scientific. However, Anderson pointed out that "logical positivism soon ran headlong into the age-old 'problem of induction'." (Black, 1967; Hume, 1911, as cited by Anderson, 1983)

In Conjectures and Refutations, Popper explained this point by saying, "I knew, of course, the most widely accepted answer to my problem: that science is distinguished from pseudo-science – or from "metaphysics" – by its empirical method, which is essentially inductive, proceeding from observation or experiment. But this does not satisfy me." (Popper, 2009, p. 472) Popper rejected this criterion, because according to him verification is not the only scientific criterion for propositions. To Popper, scientific criteria should be relevant in terms of falsifiability and refutability (McGrew, et al., 2009; Popper, 2009). Popper argued that simply understanding a scientific criterion does mean that it is true; even if we believe something, we cannot rely on it to be true. Popper also criticised the logical positivists' induction method. To him, making a generalisation from premises is not possible, because there is no logical certainty there, only possibility. Hence induction can never be a scientific method in the philosophy of science. The problem of induction is quite crucial to understand Popper's philosophy, so it will be discussed in the following section.

Popper pointed out that the logical positivists' method of obtaining scientific knowledge was incorrect. According to Popper, first of all, a problem is determined, then a theory is created, and observation is made depending on the theory. Making observation is meaningless without any theory, so experiment and observation are used solely for testing theories. While logical positivists claimed science progress to be cumulative, Popper argued that it is accomplished by extracting the false theories in science. This situation contributes to the growth of scientific knowledge through the trial and error method (Popper, 2002). Here, Popper's understanding of scientific knowledge shows that scientific knowledge is only relevant with falsificationism.

In *Conjectures and Refutations*, Popper pointed out, "After the collapse of the Austrian Empire there had been a revolution in Austria: the air was full of revolutionary slogans and ideas, and new and often wild theories. Among the theories which interested me, Einstein's theory of relativity was no doubt by far the most important. Three others were Marx's theory of history, Freud's psycho-analysis, and Alfred Adler's so-called 'individual psychology'." (Popper, 2009, p. 472) According to Popper, among these theories Einstein's theory of gravitation was particularly important compared to the others, because Einstein's theory was opposed to Newton's one. In other words, Einstein rejected Newton's theory. In so doing, Einstein's rejection introduced the idea that there is no such thing as a certain and successful theory. Scientific theories are always treated as conjectures. Popper argued that Einstein's attitude was successful because Einstein did not try to verify his own theory like others did. Einstein took a critical attitude, and he just tried to address what was unacceptable and falsifiable in his theory. Popper highlighted this by saying, "Einstein's theory of gravitation clearly satisfied the criterion of falsifiability." (ibid. p.474) Therefore, this makes Einstein's theory superior to the other three theories (Popper, 2009). Popper did not deal with the truth of a theory. Popper knew that science often errs, so his aim was to distinguish between science and pseudo-science. For this reason, he did not accept that science is distinguished from pseudo-science with inductive inferences. According to him, the problem of demarcation is the problem of finding criterion between mathematics and logic, and scientific knowledge and metaphysical knowledge. On the other hand, Popper pointed out that the Vienna Circle tried to create a boundary between science and metaphysics rather than science and pseudo-science, and he claimed that his demarcation criterion was better than the Vienna Circle's criterion. This is because Popper never attempted to verify propositions and never made a generalisation from premises. Popper highlighted the differences between science and pseudo-science by saying, “Thus the problem which I tried to solve by proposing the criterion of falsifiability was neither a problem of meaningfulness or significance nor a problem of truth or acceptability. It was the problem of drawing a line (as well as this can be done) between statements, or systems of statements, in the empirical sciences, and all other statements – whether they are of a religious or of a metaphysical character, or simply pseudo-scientific. Years later – it must have been in 1928 or 1929 – I called this first problem of mine the “problem of demarcation”. The criterion of falsifiability is a solution to this problem of demarcation, for it says that statements or systems of statements, in order to be ranked as scientific, must be capable of conflicting with possible, or conceivable, observations.” (Popper, 2009, p. 475).

1.3. Is There a Problem of Induction?

Aristotle’s *Metaphysics* starts with a glorious sentence, which is, “All men naturally desire knowledge.” (Aristotle, 1933, p. 3). Human beings always desire to know, but how? It is known that human beings are a part of nature, so they want to know about it. When a man raises his head and looks at the sky, he would like to know about the sun, the clouds and the sky. At night, he would like to solve the mystery of the stars. The history of philosophy, in the particular the history of science, includes this kind of investigation into nature. In so doing, a question arises from this point. When installing the relationship of human nature, when searching for answers to the questions, is there a certain method in scientific or philosophical activity? In other words, does the human mind achieve knowledge with a certain methodology? This question was answered by Francis Bacon in *Novum Organum*, in which he argued that there might be two ways to investigate and discover the truth. One of them starts from the senses and particulars, which move rapidly towards the most general principles of this movement, and progresses from supposedly unquestionable reality to general axioms to find intervening axioms. According to Bacon, this was the method used at that time. Another one starts from the senses and particulars and gradually rises up to the most general axioms to establish its own axioms. Bacon said that this was the right way but was as yet untested (Bacon, 1994, pp. 47-48). Here, the ‘untried way’ is probably referring to inductive method, and the aim of the history of science was to investigate whether the inductive method is reliable or not. In this investigation, undoubtedly, philosophers would show the right way in the philosophy of science. In light of the history of philosophy, human beings infer certain principles from their logical laws, without consulting experiments and observations. This is the first way as argued by Bacon. This way is also one of the methods which are used by human beings to achieve knowledge. However, Bacon in particular addressed the second way, which is also implies that this true method, induction, was discovered by Bacon (Cohen, 1926). As has been argued, when we look at the history of science and the philosophy of science, Bacon and his method would be considered as the right method, because the human mind always runs towards general principles. Bertrand Russell, in *The Problems of Philosophy*, gave prominence to this problem. He pointed out, “Have we any reason, assuming that they have always held in the past, to suppose that they will hold in the future?” (Russell, 1998, p. 35) However, if there was a possibility to answer this question, then induction would not be a problem in philosophy. Indeed, the problem of induction was based on the possibility proposed by Russell, and it is argued by some that Russell also solved the problem of induction with possibility. In The Problems of Philosophy, he stated this situation by saying, “Under the same circumstances, a sufficient number of cases of the association of A with B will make it nearly certain that A is always associated with B, and will make this general law approach certainty without limit." (Russell, 1998, p. 37) However, this is an unacceptable claim for Karl Popper. In *The Logic of Discovery*, he argued that even if we observe a multitude of white swans, we cannot generalise them and cannot say that all swans are white. If we saw a black swan, this proposition would be falsified, thus the method should be called falsification (Popper, 2002). At that point, Russell did not argue that he reached certain results, he just assumed that observations are nearly close to certainty. However, Popper's rejection of induction continued, and he stated, "Now this principle of induction cannot be a purely logical truth like a tautology or an analytic statement. Indeed, if there were such a thing as a purely logical principle of induction, there would be no problem." (Popper, 2002, p. 5) It is obvious that induction is a problem according to Popper, because there is no certainty and it just bears to observations and experiments. This situation can be explained as the 'idea of probability' (ibid. p. 6). Bertrand Russell also expressed the validity of induction in the same way. He stated, "We can never use the experience to prove the inductive principle without begging the question." (Russell, 1998, p. 38) It seems that Russell's idea of induction was based on logical probability, however this was inadequate and not acceptable to Popper (Jones & Perry, 1975). According to Popper, there was a problem, which was called the problem of induction.

Popper argued that this most important problem, the problem of induction, was formulated by himself in the history of philosophy (Howson, 1984; Musgrave, 2004; Popper, 1971; 1979). To Popper, this formulation was a success and the problem of induction was solved. He published many books in which his assumption of the solution is highlighted, in particular The Logic of Scientific Discovery. (Popper, 1971; 2002). When we look at his formulation of induction, we see that it bears on Hume's argument of induction. It is known that Hume's idea of induction is underpinned by two problems: logical and psychological. Hume argued that while logical problems bear on justification, psychological problems bear on our experience (Hume, 2009). Popper found some problems with Hume's argument. He argued that there are differences between knowledge of logic and knowledge of psychology. Many philosophers treated them together, but Popper said that confusion over the problem of induction had arisen from this point. We believe that natural laws show that there is a problem with induction in terms of common sense. Common sense answers this problem by referring to experience, however this also raises a problem. As mentioned earlier, Hume put forward two problems with induction. One of his answers, in terms of logical problems, was negative. Hume pointed out that we cannot be alive without a psychological mechanism. Therefore, this is only a belief, and so cannot be defended by rationalism. For this reason, Bertrand Russell asserted that Hume's philosophy represents the bankruptcy of rationalism in the eighteenth century, and his answers to the logical problem caused a conflict between rationalism, empiricism and scientific research (Popper, 1971; 1979). The problem of induction as argued by Popper, in my opinion, arose from this confusion. First of all, as Russell argued, the idea at the centre of Hume's theory is based on the idea of repeated similarity. Hence logical principle in induction was discarded, and induction became a psychological principle. In response to this, Popper brought forward his argument and asserted that we try to discover some similarities in the world and then interpret them in the context of our laws. Without looking at the premises, we wait for conclusions. This method is based on trial and error – or conjectures and refutations (Popper, 2002; 2009).

1.4. Falsificationism

Karl Popper argued that there is no specific method in philosophy. There are lots of arguments to understand the world; however, there is only one method which is more valuable than the others. This emerges as the critical method which forms the basis of philosophy, and this method is called as falsificationism. The main argument of falsificationism is that induction does not have a role in reasoning. According to this approach, there are two reasons for this. One of the reasons is that theories and hypotheses are not verified, which means that universal propositions can never be verified. However, they can be falsified with a contradictory instance. Another reason is the differences between justification and discovery. Popper argued that justification and discovery are different from each other. To Popper, discovery is a psychological situation, and it does not bear on a logical foundation, so it is related to possibility. In addition, philosophers do not deal with how theories should be formed, they just need to deal with how theories should be tested. For these two reasons, Popper argued that induction cannot be used as a method of scientific reasoning (Popper, 2002).

The falsifiability principle is the basis of Popper's theory of science. In Popper's scientific attitude, all theories need to pass a difficult test in order to select a suitable method. According to other approaches, which had been adopted by Popper's time, scientific results were achieved through experimentation and observation, rather than logical analysis. For example, 'all crows are black' is a universal proposition which bears on experimentation and observation. However, its truth cannot be proved. This is because all of the crows in the world can be observed, neither at the present time nor in the future. As a result of this condition, Popper argued that universal propositions, which bear on experiments, cannot be verified, because he rejects induction. In this example, the proposition can be refuted by the appearance of a single white crow. For this reason, he pointed out that induction is not justified and theories never can be verified by experiment (Popper, 2002; 2009). Popper also asserted that logical positivists put forward two issues, and these should be rejected in order to apply falsificatonism. The first one was the rejection of dogmatism; the other was the rejection of the idea of induction. These two issues should be rejected, because there is no critical understanding in dogmatism, hence propositions cannot be falsified because all propositions are accepted as truth in this argument. Moreover, the idea of induction also does not include a critical understanding. The aim is just to verify and make a generalisation from a premise. This argument also does not allow for the falsification of propositions. Popper argued that even if a theory is accepted as an unchanging argument, it should be criticised. According to this argument, as summarised by Popper, "The criterion of the scientific status of a theory is its falsifiability, or refutability, or testability" (Popper, 2009, p. 474). Popper did not mean that falsifiable propositions are scientific propositions; this is just a process for eliminating false propositions. In this process, the testing of propositions is required in order to put forward propositions of mistakes. Here, to test or examine is another crucial notion in Popper's philosophy, because if a theory is not testable then it cannot give new knowledge. According to Popper, trying to solve the problem of falsifiability is not the same as the problem of meaningfulness. In some cases, the aim is not to ignore false theories, the aim is to set up new theories. Therefore, when the target is setting up new theories, it is necessary to test them. However, if theories cannot be falsified, then it can be said that these theories are able to withstand severe tests. In addition, if we do not have a critical attitude, we find the things that we always want to find (Popper, 1960). Popper argued that falsified and rejected theories are equal, and if a theory is falsified but helpful, then this theory can be used to find a new theory. It is important to find out mistakes from accepted and verified theories. This does not mean that searching for verification is wrong, because we can benefit from the derivation of mistakes; in this way, each recovered mistake provides real progress in knowledge. The important thing is that science is fallible; this is because science is also a human product.

Popper's scientific view has some similarities with the history of science. Previously, all evidence supported Newtonian physics in the observable world. However, Einstein put forward a different theory to Newton's, and Einstein's theory was accepted instead of Newton's theory. This situation depicted how even though a theory is supported by observations, a better theory might replace it. For example, Newton's theory conflicted with Kepler's or Galileo's theories. In the same manner, Einstein's theory conflicted with Newton's theory (Popper, 2009). In such cases, a contender theory among these can exclude all other theories, and this theory can be selected as the right theory. According to Popper, this attitude is a kind of critical and rational attitude. On the other hand, Popper emphasised that induction was constructed quite weak. 'All swans are white' is a universal proposition, and when we treat it we need to ask how we have reached this universal proposition. First of all, we look at a swan, then we look at one more swan, and one more, and so on. We can look at a thousand swans in this way. Even if these thousand swans are white, nobody can assert that another one is going to be white, because this belief comes from our experience, as argued by Hume (Hume, 2009). However, in this instance, this does not mean that there is no black swan outwith our observation, even if we have not had this experience. In this case, if a black swan is found then this generalisation will be falsified. In brief, it is a mistake to dogmatically connect to theories and generalise them. It is easy to find verified propositions in a theory, because of our experiences in the past. However, it is difficult and important to find falsified propositions. In addition, it should be noted that, according to Popper, theories cannot be verified but reinforced. When a theory withstands tests, then it is strengthened and reinforced. Popper also argued that there is no certain right or false theory, because we cannot guarantee certain knowledge. Scientific objectivity requires that scientific propositions should always be tentative. All theories are conjectures, so they can collapse. Science consists of conjectures, and everything is a conjecture. (Popper, 2002; 2009).

1.5. The Process of Science

All of Popper's criticisms, ideas and descriptions are based on two characteristics of human beings, which are dogmatism and criticism. Animals and humans are born with a way to respond to formed situations and expectations. This shows that both humans and animals need this regularity, and a lack of regularity causes us to do experiment on regularities. It also causes us to dogmatically believe our expectations. Inborn knowledge could be wrong, no matter how strong it might be. Human beings do not want to stumble, so they strongly believe their predictions in a dogmatic period, or as Popper's expressed it, in a pseudo-scientific period. Therefore, according to Popper, science starts with predictions and conjectures. Observations and experiments make no sense if there is no problem or conjecture about its solution.

> "Thus, science must begin with myths, and with criticism of myths; neither with the collection of observations, nor the invention of experiments, but with the

critical discussion of myths, and of magical techniques and practices." (Popper, 2009, p. 480)

According to Popper, the second inborn feature of humans is creative thinking, which bears on criticism. People who have the level of scientific thinking regularly address mistakes with a critical attitude and leave them aside. "Criticism, I said, is an attempt to find the weak spots in a theory, and these, as a rule, can be found only in the more remote logical consequences which can be derived from it. It is here that purely logical reasoning plays an important part in science." (Popper, 2009, p. 481) When a theory is viewed from the outside as critical, it makes that theory an objective conjecture, not a subjective belief of the people. The purpose of science, for Popper, is to give causal explanations, and this infers a proposition with a deduction from laws and initial conditions. Science offers causal explanations and proceeds with critical evaluation and rules out false propositions in this process. If a theory is completely refuted while trying to eliminate its mistake, then a new theory can be put forward and criticised. If this new theory can be refuted and eliminated, after that another one replaces it. Therefore, science proceeds with criticising, testing and refutation. Meanwhile, theories are tested by experiment and observation (Popper, 2002; 2009). There is a problem, and a tentative theory offers a solution to this problem. Then this theory is criticised and its mistakes are eliminated, and this causes a new problem. This problem is also addressed with a tentative theory, then it is criticised, its mistakes are eliminated, and it causes a new problem, and so on. Science proceeds like this and the process indicates that there is no such thing as a certain theory. Popper did not talk about certain knowledge. This is because all knowledge of human conjectures and simply objective knowledge can be criticised. The method of falsification, according to Popper, separates damaging and useful theories from each other. In that case, if a theory is not falsified, there is no mention of its benefit. Popper examined scientific criterion and the basis of experimental knowledge, however he differed from the Vienna Circle in terms of the explanations provided. As has been indicated, observations and experiments for testing theories do not create a new theory, so scientific criterion is related to conjectures and falsifications. Pseudo-science cannot be falsified, because a scientific attitude is a kind of critical attitude, and science is completely a result of critics.

CHAPTER II.

2.1. General overview: Progressing in the Philosophy of Science - T.S. Kuhn

The history of science is an area that is considered to occur earlier than the philosophy of science. Scientific studies from the past to the present have been conducted with a chronology (Kuhn, 1977; Hoyningen-Huene, 1992), and the history of science has been treated independently from the philosophy of science. In particular, the history of science in the early twentieth century only considered the success and importance of scientific studies. In this case, it is difficult to say that a study of the history of science has not been conducted in terms of the methods of scientific areas. As already discussed in Chapter 1, the success and importance of scientific studies were treated by logical positivists, therefore the role of history was incorporated into the philosophy of science as a new approach. In light of this, first of all the importance of history in the philosophy of science will be treated with regards to different arguments, and in particular Kuhn's argument of history in the philosophy of science will be scrutinised. In the following section, Kuhn's concept of the scientific method will be evaluated deeply within three subtitles, which are *paradigm, pre-science and normal science and crisis and revolutions*. At the end of the chapter his claim will be compared with Popper's philosophy in terms of their similar arguments.

2.2. What is the role of history in the philosophy of science?

A basis for Thomas Kuhn's philosophy of science.

The philosophy of science became an independent approach in the twentieth century, and logical positivists and empiricists in particular aimed to bring new approaches to this philosophical discipline. Logical positivists and empiricists pointed out that the philosophy of science is an auxiliary attitude for science, and in this sense some philosophy of science was accepted as being more crucial than the other disciplines of this century. However, logical positivists only paid attention to the success and importance of science in the philosophy of science, and the role of history was not considered by them. According to Hoyningen-Huene (1992), Thomas S. Kuhn was one of the important philosophers, and in the twentieth century the role of history became the main topic in the philosophy of science put forward by Kuhn. As a historian of science, Kuhn brought a new perspective for the philosophy of science. In so doing, he also designed his own philosophical approach to science. Kuhn's historical approach to the philosophy of science was shaped by his two books, *The Copernican Revolution* (1990) and *Black-Body and the Quantum Discontinuity* 1894-1912 (Kuhn, 1978). In *The Copernican Revolution*'s preface, Kuhn pointed out that even if the revolutions refers to a single name, the scope of revolution is huge. This means that the Copernican Revolution can be based on mathematical astronomy, however different disciplines were affected and changed conceptually, for example cosmology, physics, religion and philosophy (Kuhn, 1990). Here, Kuhn drew attention to Copernicus's attempts in this book, which not only related to those disciplines (cosmology, physics, religion and philosophy), but also showed us a historical scientific concept. As a consequence, this book showed how historicity should be related to scientific research. Kuhn's other book, the Black-Body and the Quantum Discontinuity 1894-1912, tried to show how his understanding of the history of science was close to the existing quantum theories (Kuhn, 1978; Brush, 2000; Nickles, 2003; Marcum, 2005). This book also examines Max Planck's understanding of physics, and whilst this section is not detailed in this study , it is worth mentioning with regards to the importance of history in the philosophy of science.

In 1962, *The Structure of Scientific Revolutions*' first edition was published, and after that this book became one of the most important sources in the philosophy of science. As quoted by Hoyningen-Huene (1992), the first chapter of The Structure of Scientific Revolutions starts with this sentence:

> History, if viewed as a repository for more than anecdote or chronology, could produce a decisive transformation in the image of science by which we are now possessed (p. 487).

Kuhn stated that history has been seen as a kind of storing place, however, in this repository a new image of science can be produced by history, and stereotypes can be changed in this way. Kuhn's first sentence in his book reminds us of another explanation of history in *The Essential Tension*. Kuhn remarked that some facts about the past are collected and arranged chronologically by historians (Kuhn, 1977). In this case, it can be said that history is a story of arranging the facts of science. However, at this point chronology is not the core issue for the history of science. This is because Kuhn claimed that if there is a gap between science and the philosophy of science, this gap can simply be filled by the history of science, but not chronologically. In my opinion, Kuhn's rejection of accumulation started to give a signal in this direction. In other words, chronology in the history of science allows us to accumulate knowledge, However, this is not acceptable for scientific progress in Kuhn's philosophy. Kuhn also argued that even if the history of science and the philosophy of science have different goals, it does not mean that they cannot be treated and practised at the same time. Hence, the history of science and the philosophy of science can be evaluated together (Kuhn, 1977, p. 5). For this reason, Kuhn pointed out that scientific events can be examined in this way. In light of this, his aim was to make science more explainable.

Therefore, the history of science and the philosophy of science should be treated together. (Kuhn, 1977; 2012). Here we can say that there is a dialogue between the history and philosophy of science, but this dialogue does not need to be inter-disciplinary; according to Kuhn, this relationship might be intra-disciplinary. For example, some historians are interested in the philosophy of science, as Kuhn himself argued, whilst on the contrary some philosophers of science are also interested in history. They can take different exams from different disciplines, such as history and philosophy, and they might gain different degrees from these disciplines. This relation does not give any damage to the bases of these fields. This is because each of them has particular characteristics, and their aims are different from each other. For example, the aim of history is to attempt explanations, however it is difficult to find any general laws in these explanations.

On the other hand, philosophers of science are not story tellers, and their purpose is to explain universal laws, but not in terms of a certain time (Kuhn, 1977). It is obvious that Kuhn's aim was to establish a new perspective on the history of science and the philosophy of science, rather than the history of philosophy. Kuhn argued that philosophy necessary for historians of science, because philosophy is a special tool, like the 'knowledge of science' (Kuhn, 1977, p. 10). In this respect scientists are not philosophers, but some scientists in the history of science, for example A.O. Lovejoy and Alexandre Koyré, were philosophers before they turned to the 'history of scientific ideas' (ibid. p.11). These scientists have played an important role in modern historiography. As a consequence, there is no relationship between science and historical historiography. In this case, a new interpretation of history is required in order to understand science. As already stated above, chronological history is not significant in our understanding and treatment of scientific historical ideas, and it is possible with an accurate historical examination to transform an idea on to the image of science. Each scientific activity should be treated within each separate period of its transformation (Kuhn, 1977; 2012). As stated above, Kuhn’s aim in the philosophy of science was to bring a new understanding to the history of science. For this reason, thehistory of science and the philosophy of science should be treated together. This is necessary because scientific methods, or in other words scientific inquiries (Nickles, 2003), can be understood within an inter-disciplinary context. Kuhn often referred to the importance of history in his books, The Essential Tension and The Structure of Scientific Revolutions, however he strongly denied the presence of an accumulated process in the philosophy of science (Kuhn, 2012). In light of this, he brought forward a new understanding of scientific methods. Even though he did not propose a specific scientific method, his studies in the philosophy of science show us his own scientific method. In the following section, I shall start to explain his concept of scientific method.

2.3. Kuhn’s concept of scientific method

Kuhn’s general scientific ideas in the philosophy of science were gathered in his book *The Structure of Scientific Revolutions*, which was published in 1962. Almost a million copies have been sold, it has been translated into twenty languages, and according to Google Scholar it is one of the most-cited publications in the field of social sciences. According to these results, Kuhn’s *The Structure of Scientific Revolutions* has been cited 81,313 times (Fuller, 2006; Green, 2016). Reisch (1991), stated that Kuhn’s *The Structure of Scientific Revolutions* is much more popular than Stephen Toulmin's *Foresight and Understanding* (1961), Norwood *Russell Hanson's Patterns of Discovery* (1961) among these kind of books (p. 264). For this reason, this book can be accepted as a new vision in terms of the new concepts of the philosophy of science and historical scientific approaches it proposed. Kuhn claimed that the image of science from the past to the present needs to be interpreted within a historical approach. In this case, this book caused a new debate in the philosophy of science. This is because Kuhn tried to explain how scientific activity should be scrutinised in the philosophy of science, and to make this explanation he treated the concept of paradigm (Kuhn, 2012).

In the second chapter of *The Structure of Scientific Revolutions*, Kuhn (2012) pointed out that there is a close relationship between the concept of paradigm and normal science (p. 10). In the twentieth century, according to Kuhn, science could not bring new solutions to the existing puzzles. For this reason, Kuhn introduced his critics to traditional scientific methodology, and he also criticised the historical understanding of science in the philosophy of science (Kuhn, 2012). As stated above, the historical understanding of science was related to the accumulation of scientific progress, and for this reason this point is citicised by Kuhn. In light of this, it can be said that Kuhn was against cumulative progress in science, so he developed a new scientific method. Paradigm is the heart of this scientific method, and scientific progress continues with this concept in Kuhn's philosophy of science. Chalmers (1999), in his work *What is this thing called Science?*, summarised Kuhn's scientific progress as indicated below;

> pre-science – normal science – crisis – revolution – new normal science
> – new crisis (p. 108)

In this progress, as stated above, paradigm takes a predominant place, and old theories are reinterpreted within new standards. In other words, paradigm is the key point and it governs whole theories in this process. Therefore, old accumulated evidences do not become a base for new theories, hence accumulation is not valid for this progress (Jones, 1981). The fact remains that this revolutionary progress does not follow a linear route, it takes a circular place in which paradigm specifies its own techniques to be applied to the scientific community. Each paradigm in the scientific community, such as Aristotelian dynamics, Newtonian mechanics or Maxwell's equations, constitutes 'normal science', as Kuhn argued (Shapere, 1964; Chalmers, 1999; Kuhn, 2012). Normal science in the scientific community establishes the grounds to develop a paradigm. In this case, falsifications are created by experiences. If falsifications continue, then a crisis occurs. This process is also called an anomaly. When these difficulties are resolved, then a new paradigm arises and the progress continues in this process, which was called a scientific revolution by Kuhn (Shapere, 1964; Jones, 1981; Chalmers, 1999; Kuhn, 2012). Let us now move on details of this progress, in order to understand Kuhn's scientific method in the philosophy of science.

2.3.1. *Paradigm: A conceptual meaning in the philosophy of science*

Chalmers (1999), in *What is this thing called Science?,* stated that, "A mature science is governed by a single paradigm." (p. 108) What is a mature science, and why does a paradigm govern it? When we look at Kuhn's *The Structure of Scientific Revolutions,* this question is answered by Kuhn. First of all, paradigm is defined as the accepted universal achievements of the scientific community in the philosophy of science (Kuhn, 2012). Paradigm, as a notion, is mentioned on almost every page in the book, so it was also a kind of revolution for the philosophy of science. This is because paradigm has special meanings for Kuhn, and for this reason it should be scrutinised to understand his idea of the philosophy of science. Kuhn's attempt to identify paradigm has been criticised by some. In *The Nature of Paradigm*, Margaret Masterman pointed out that paradigm in *The Structure of Scientific Revolutions* is identified more than twenty-two times, no less (Masterman, 2014). However, in 1969 a postscript was added to *The Structure of Scientific Revolutions* in which Kuhn mentioned Masterman's criticism of the different explanations of paradigm. Kuhn argued that these contradictions about paradigm were related to his character, and that these contradictions could be solved easy (Kuhn, 2012). Here, this point needs to be explored in more detailed. The contradictions of paradigm, in my opinion, also referred to the scientific community. This is because Kuhn already was a member of the scientific community, and his character was shaped by this community's rules and laws. If his character caused a contradiction, it means that the scientific community implicitly caused this contradiction. Hence there is no distinction between the scientific community and Kuhn's character. This situation is also related to each member of the scientific community. As Kuhn pointed out in the postscript of *The Structure of Scientific Revolutions*, "A paradigm is what the members of a scientific community share, and , conversely, a scientific community consists of men who share a paradigm." (Kuhn, 1970, p. 176) On the other hand, in the postscript of the book Kuhn gave a second meaning of paradigm, in which he indicated, "It denotes one sort of element in that constellation, the concrete puzzle-solutions which, employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal science." (Kuhn, 1970, p. 175) According to Kuhn, this explanation of paradigm is deeper in terms of its philosophical assumptions. It is obvious that Kuhn's concept of paradigm did not follow a narrow pattern as criticised by some. It is more important and comprehensive in terms of science. The meaning of paradigm as conceptual is more important than its meaning in terms of traditional laws, so Kuhn insistently attempted to give a different meaning to paradigm in the book (Kuhn, 1970). Another crucial issue arises at this point. It is known that, as stated in the first chapter, logical positivists attempted to draw a line between science and pseudo-science, and Popper also raised the problem of demarcation for this difference. When we look at Kuhn's explanation of paradigm, there is also an attempt to provide a basis for the philosophy of science. In this case, Kuhn's attempt can be evaluated as drawing a line between science and non-science, however, his different expressions of paradigm did not give any certainty to indicate this. Even though he did not specify a demarcation for science in particular, paradigm provides a base for us to draw this line. For this reason, paradigm is the key concept of Kuhn's scientific method in the philosophy of science. Let us move on to his scientific progress, in order to understand the basis of his method of science.

2.3.2. *Pre-science and Normal Science*

As stated in the previous chapter Chalmers (1999) stated, "A mature science is governed by a single paradigm." (p. 108) I think that this sentence is the key concept of Kuhn's philosophy. One reason is that paradigm has a key role to govern science because, as Chalmers states, it organises scientists into a "puzzle-solving" movement. On the other hand, 'mature science' refers to a pre-science period in which there is no paradigm, hence there is also no methodology. The period of pre-science is just as important for preparing scientific studies, because this period is accepted as the starting point of science by Kuhn (Chalmers, 1999; Kuhn, 2012). According to Kuhn, scientific studies must be governed by a paradigm, so the period of pre-science is an immature area of science. The lack of a paradigm causes crises, and scientific studies never can be solved in this situation. Problems and crises can only be solved using normal science, so normal science is also called a puzzle-solving activity (Shapere, 1964; Chalmers, 1999; Kuhn, 2012). In this process, certain plans and programmes of scientific activities are continued regularly by an active paradigm which solves problems within a scientific community. For example, all of Newton's theories compose Newtonian paradigms, which also encompass some of the methods and techniques to apply. It is obvious that Newtonian laws, as paradigms, constitute general methodology in astronomy, so Chalmers (1999) stated, "All paradigms will contain some very general methodological prescriptions." (p. 109-110) In other words, a "strong network of commitments (conceptual, theoretical, instrumental, and methodological)" is involved in a paradigm (Kuhn, 2012 as cited by Shapere, 1964, p. 385). In 'normal science', there is an obedience for the existing paradigm in the scientific community. Noncompliance can never be allowed in this period, and the only precondition of science is to develop a paradigm. The aim of normal science is not to discover new rules or laws. In any case, scientists' purpose is also not to discover new things (Kuhn, 2012). I think that this might be a rejection of accumulated knowledge in science. This is because, in particular, logical positivists put forward induction as a scientific method, and accumulation is the key concept of the method of induction. For example, according to logical positivists, scientists attempt to discover new things, and in this sense they need to follow their predecessors' theories. As a consequence, science continues with this progress and scientific knowledge is developed via accumulation. On the other hand, in the period of normal science, scientists' aim is simply to solve puzzles, and criteria for solving puzzles are determined by paradigms. However, there is no necessity between criteria and paradigms. As stated by Kuhn, "The determination of shared paradigms is not, however, the determination of shared rules.” (Kuhn, 2012, p. 43) These rules determine the quality of science, however; “Normal science ia a highly determined activity, but it need not be entirely determined by rules,” (*ibid*. p. 42). Paradigms already include those rules, hence, “Paradigms do not depend on upon the formulation of rules and assumptions.” (*ibid*. p. 44). Scientists find those rules already with the application of science. It is assumed that normal science is determined by paradigms, however some puzzles insist upon being solved and Kuhn called them ‘anomalies’ . This attitude shows that Popper’s falsificationism was rejected in this way (Chalmers, 1999). It is supposed that there is no single solution in Popper’s falsificationism, because theories should be criticised, and so criticism is accepted as an important criterion for falsification in Popper’s philosophy. However, Kuhn claimed that paradigms cannot be criticised; if there is a fault which is not paradigms’ fault, this fault is caused by the scientific community. If the scientific community cannot bring a new solution to an existing puzzle, then there should be criticism, since as already stated paradigms cannot be criticised by a normal scientist (Chalmers, 1999). Criticism just arises with anomalies. As stated above, normal scientists do not discover new things, they just attempt to find solutions using existing paradigms. However, there would be some anomalies when scientists attempt to solve puzzles. In this case, scientists cannot get the expected results. In other words, if solutions are not convenient for paradigms, it means that the puzzle-solving is at fault. This failure does not seem to be the paradigms’ fault; it is derived from the scientific community. Hence, this failure causes anomalies in paradigms. We shall move on to the next section to explain how these anomalies cause crises and revolutions in Kuhn’s theory on the philosophy of science.

2.3.3. *Crisis and Revolutions*

In the period of normal science, paradigms determine a specific place in which scientists work. In that place, all problems are defined with rules and methods, and scientists then attempt to solve these problems in a confident manner. However, if there is a failure in the puzzle-solving process, scientists cannot accuse the paradigm, because it might be nonsense. For example, this accusation might be considered the same as the tools being blamed by a sculptor when a statue is not finished as planned (Chalmers, 1999; Kuhn, 2012). In such cases, Kuhn did not claim that the whole process would be positive. For this reason, in particular, in the period of puzzle-solving there would be a crises when theories are insufficient to solve problems. When scientists are faced with this situation then the existing paradigm can be rejected to be replaced by a new paradigm. In this sense, in the period of normal science researchers are not satisfied, and this complexity continues until a new paradigm is found. This period is called the scientific crisis, to pass from normal science to a period of new normal science (Chalmers, 1999; Kuhn, 2012). Kuhn claimed that the success of normal science is to find no anomalies. Hence, in my opinion, anomalies are indispensable in paradigms. This is because, if there are no new facts, then existing paradigms will be treated again and again by scientists. This situation will continue and then paradigm change will arise within anomalies. The period of crisis is different from the period of normal science. In the period of crisis, in general, rules and laws are inherent in scientific activities and so scientists fail to obtain real knowledge. Hence the scientific community is in chaos in this period. In this respect, when we look at this from a historical perspective, the differences between the current scientific term and the period of normal science are clearly visible. It is almost impossible to do science within the boundary of the existing paradigm at the end of the period of normal science. In this context, the shaped understanding of science in the same paradigm appears as a factor to change that paradigm. Anomalies are actually the basic dynamics of scientific developments, and are the most crucial elements in a paradigm change. Anomalies are not just unsolved puzzles, they may also contain facts about an area of interest for the existing paradigm. After this point, contradictory attitudes will be shaped by the presence of different scientific communities, therefore general acceptance and beliefs will not determine the progress of science (Kuhn, 2012). The period of crisis is the most important stage of the scientific revolution. In this period, it is necessary to find new tools to solve puzzles, because they already belong to the existing paradigm. In this context, it is important to distinguish this period from normal science. However, it is difficult to distinguish them from each other. One reason arises from the nature of a paradigm which cannot solve whole puzzles. It is not necessary to interrogate this paradigm. As already stated above, if there is a failure it is scientists' fault, not the paradigm's (Kuhn, 2012). In the period of normal science, each anomaly does not cause a crisis. It is normal to see some anomalies in this period, so sometimes scientists may wait until they disappear. Therefore, each anomaly does not always cause a crisis (Kuhn, 2012). If a new paradigm begins to emerge, then it is not possible to talk about a new anomaly. In the period of crisis, scientists continue to solve problems which have emerged from existing paradigms. At this point, it is necessary to move past the period of new normal science to talk about new anomalies. This is important, because scientific crisis is a basis for scientific revolution. In addition, the scientific community is also another significant factor to determine the general frame for scientific activity. This border indicates that anomalies caused by an existing paradigm can begin to be interrogated with new methods and tools. The existing theory and tools are replaced with new ones after a scientific revolution. In this case, it can be said that scientific revolutions figure out the beginning of the new normal science period (Kuhn, 2012). After a scientific revolution, the activities of normal science continue during this period. When we look at Kuhn's philosophy, the period of new normal science is an important stage in the progress of scientific studies. In this respect, the importance of Kuhn's view should be sought in the process of anomaly and crisis. In terms of looking at history, the establishment of the relationship between two different paradigms and the importance of the idea of scientific revolution only belong to the period of crisis. In other words, the contradiction between the new normal science and normal science becomes more clear in the period of crisis. For example, according to Kuhn's claim, Newton's theory had some contradictions which could not solve puzzles. In this case, a crisis appeared and a new period of science was required. However, this period was not possible without a scientific revolution. As a consequence, there was a scientific revolution and a period of new normal science with Einstein's theory. This idea has great importance for scientific progress in Kuhn's philosophy. This is because if a period of crisis does not result in a scientific revolution, then the period of normal science can be accepted as another perspective on the classical understanding of science. In this respect, it can be said that a period of crisis is a kind of trigger for a scientific revolution (Kuhn, 2012).

In *The Structure of Scientific Revolutions*, in *part IX*, Kuhn stated, "Scientific revolutions are here taken to be non-cumulative developmental episodes in which an older paradigm is replaced in whole or in part by an incompatible new one," and he asked the question, "Why should a change of paradigm be called a revolution?" (Kuhn, 1970, p. 92) According to Kuhn, a paradigm is eroded in its own process, which is normal science, and cannot work properly in the period of crisis. He also added that this period ends with paradigm change, in this case the old paradigm is replaced by a new one. This change is discussed in terms of accumulation in traditional philosophy.

Kuhn asserted that accumulation might be possible in normal science. However, after a revolution this is not possible in the period of new normal science. This is because paradigm change and the new paradigm determines not only science, but also the world of scientists. This situation can stressed as follows: “Neverthless, paradigm changes do cause scientists to see the world of their research-engagement differently.” (*ibid.* p.111) In this case, scientists begin to see the world in a different way in Kuhn’s argument. For example, when Aristotle and Galileo looked at the same pendulum, they probably saw two different things. In addition, their interpretations would be different from each other. In other words, in Ptolemaic theory the term ‘Planet’ did not refer to the earth, it referred to the sun. However, in Copernician theory this belief completely changed, and it referred to the earth, not to the sun. This situation brings us to the ‘problem of incommensurability’, in which scientists can use different terms in different meanings. For example, Priestley and Lavoisier saw the same oxygen, but they interepreted it in a totally different way. This analogy was examined in Gestalt switch by Kuhn (and Feyereband) (Oberheim & Hoyningen-Huene, 2013, sec. 2, par. 2-3). In this prototype, “What were ducks in the scientist’s world before the revolution are rabbits afterwards.” (Kuhn, 1970, p. 111) In this case, these kind of transformations are necessary in the scientist’s world. This is because a new paradigms’ rules and laws, which govern science, also change with revolutions, and scientists’ perceptions also change. For this reason, “The scientist’s perception of his environment must be re-educated – in some familiar situations he must learn to see a new gestalt.” (*ibid.* p.112). In other words, their ducks must be transformed to rabbits after revolutions. This is the major point in Kuhn’s incommensurability, because this term directly attempts to stand against the “cumulative characterisations of scientific advancement.” (Oberheim & Hoyningen-Huene, 2013, sec. 1, par. 1).

2.4. Evaluation

The scientific revolution in Kuhn’s philosophy is a kind of rebellion to the empiricists’ cumulative method. This point is similar to Popperian philosophy. As already pointed out above, either Popper or Kuhn attempted to bring a criterion for the scientific method, and discrepancy is a key point for their philosophy. In my opinion, Popper’s argument might be distinguished from Kuhn’s view in terms of their scientific methods. First of all, Popper’s method was based on falsification. According to Popper, there is no one solution to solve problems, because scientists should criticise theories to falsify them. In addition, testability is another important point for Popper’s philosophy. As a consequence, Popper tried to bring a criterion for science. However, this might be different to the logical positivists’ criterion. From the past through to Popper’s philosophy, scientific criterion was accepted as justificationism, and if a theory could not be verified by experiment, the theory was accepted as non-scientific. For example, metaphysical propositions are non-scientific, because according to this view, these propositions cannot be justified by experiment. Popper also argued that scientific propositions should be tested with experiments, however there is a nuance between logical positivists and Popper. In Popper’s philosophy, the criterion is replaced jusificationism with falsificationism. For this reason, falsificationism took its place as a new scientific view in the philosophy of science. Theories in the philosophy of science must be testable. Afterward they must be falsified, because scientists’ aim is not to justify these theories. When a theory is falsified, then scientists can find a new theory to falsify, and science progresses in this way. On the other hand, when we look at Kuhn’s view, the period of crisis is a milestone for his philosophy. Even though Kuhn’s method and Popper's method seem different from each other, in my opinion there is a similar point, which is related to contradictions. Either Popper's or Kuhn's philosophies claim that contradictions cause new scientific studies to start. I think this is a major similarity between their philosophies. There might be different scientific views to introduce a criterion to science, however, their philosophies lead to a rebellion when we compare them to the logical positivists' criterion and their criterion in the philosophy of science.

CHAPTER III.

3.1. General Overview: The Design of Scientific Methodology – Imre Lakatos' syntheses

Popper, Kuhn and Lakatos, as post-positivist philosophers of science, occupy a significant place in the twentieth century. Among these philosophers of science, Lakatos' main subject was the philosophy of mathematics, however he tried to synthesise Popper's and Kuhn's philosophies in a different conceptual framework, and he constituted his own approach in *The Methodology of Scientific Research Programmes.* Lakatos' philosophy was mentioned as a synthesis of Popper's and Kuhn's philosophies, because he attempted to treat Popper's falsificationism and Kuhn's historicity together. Lakatos methodology lies on a criticism of Popper's falsificationism, which will be examined in this chapter. In addition, in 'History of Science and its Rational Reconstructions', Lakatos starts with a famous sentence: "Philosophy of science without history of science is empty; history of science without philosophy of science is blind." (Lakatos, 1971, p. 91) This sentence will not be scrutinised in this chapter, however, it is important to understand Lakatos' syntheses between Popper's and Kuhn philosophies in the philosophy of science. In this chapter, first of all, we will treat Lakatos' criticism of falsificationism under three different titles, which are dogmatic, methodological and sophisticated methodological falsificationism respectively. In the following section, Lakatos' own methodology will be scrutinised in terms of its acceptability in the philosophy of science. At the end of the chapter, criticisms of Kuhn and Popper will be evaluated using Lakatos' argument. Now, let us move on the first part of the chapter.

3.2. Lakatos' methodology: A rational model for science

In the seventeenth and eighteenth centuries, various different methodologies were used by different philosophers of science (Lakatos, 1971). As already mentioned in the first chapter, induction, for example, was used as a scientific methodology by logical positivists. Lakatos, in *History of Science and its Rational Reconstructions*, denominated logical positivists' methodology as inductivism (ibid. p. 92). According to inductivists, scientific propositions are proven inductively, and other scientific propositions are also proven by such propositions. In addition, inductivists claimed that if scientific propositions cannot be proven by experiments, then they are non-scientific. In other words, these propositions are false and are not worthy of discussion. In such cases, Lakatos stated that sceptics do not deny inductivists. This is because sceptics also claimed that scientific propositions must be proven, otherwise nobody can talk about knowledge. In other words, sceintific propositions should be tested by induction. Hence, proven propositions must be accepted as scientific, and scientific knowledge is obtained in this way.

For this reason, Lakatos accused inductivists of being sceptical, and he added that inductivists "opened the door to irrationalism, mysticism, superstition" (Lakatos, 1971; 1980, p. 11). On the other hand, Lakatos treated Popper's and Kuhn's philosophies in terms of their methodologies. He argued that Kuhn's philosophy is based on the rejection of accumulated knowledge, and scientific revolution represents his main issue in the philosophy of science. While the idea of scientific revolution was founded as permanent by Popper, Kuhn claimed that this idea was of great significance. As stated in the first chapter, criticism was at the heart of Popper's philosophy. Lakatos also pointed out that criticism was “the heart of scientific enterprise” (Lakatos, 1980, p. 9) in Popper’s philosophy. However, when we look at Kuhn’s philosophy, criticism only appears in a period of crisis. At this point, in *The Methodology of Scientific Research Programmes*, Lakatos highlighted that Kuhn’s argument is irrational because any scientific change was based on a social discovery in Kuhn’s philosophy, so it is psychologically changed and accepted as a religious change (Lakatos, 1980).

However, this situation is different for Popper’s philosophy in which he describes the notion of a rational scientific change, one which is based on the logic of discovery (*ibid*. p. 9). To Lakatos, rationality is quite important in the philosophy of science, so he claimed that his methodology “offers a new rational reconstruction of science” (Lakatos, 1971, p. 99). This is important, because rationality is a criterion which can be used to reconstruct science. For this reason, sometimes the expressions “scientific”, “rational” and “progressive problem shift” were used as synonyms by Lakatos (Bernstein, 1981, p. 428). In other words, science and rationality have the same meaning in Lakatos’ philosophy. In this case, Popper’s falsificationism was gathered under a different status, and Lakatos argued that only one of them, naïve falsificationism, was understood by Kuhn (Lakatos, 1980). Lakatos attempted to treat three different kinds of falsifications, and his methodology was established on one of them (Ball, 1976). Let us now move on to looking at more explanations of these in the following section.

3.2.1. Dogmatic Falsificationism

In *‘The Methodology of Scientific Research Programmes’*, Lakatos stated that dogmatic falsificationism is one of the important fields of falsification, and also “the weakest brand of justifications” (Lakatos, 1980, p. 12). According to justificationists, scientific knowledge is derived from proven propositions. These propositions must bear on facts or proven deductive or inductive propositions. Lakatos argued that both rational and empirical justificationists had failed. He pointed out:

> Kantians by non-Euclidean geometry and by non-Newtonian physics, and empiricists by the logical impossibility of establishing an empirical basis (as Kantians pointed out, facts cannot prove propositions) and of establishing an inductive logic (no logic can infallibly increase content). It turned out that all theories are equally unprovable (Lakatos, 1980, p. 11)

At first glance, this might seem to be a regression, however it is worthy of reconsideration because of rationality. Even though falsificationism seems to be a regression, “it was a retreat from utopian standards”, therefore “it represented an advance” (*ibid*. p. 12). According to Lakatos, dogmatic falsificationists must accept that there is only one authority for ‘empirical counter-evidence’, and only this authority can judge a theory. Thus, each theory can be equal as a hypothesis for dogmatic falsificationists. A theory might not be proven in science, however it can be falsified empirically. In this case, a demarcation is drawn between the theoretician and the experimenter by dogmatic falsificationists. Two assumptions are asserted by dogmatic falsificationists. The first one draws a psychological line between ‘theoretical and observational propositions’. The second one is related to a psychological or observational criterion. If a proposition has this criterion, then it can be proved and accepted as true. However, Lakatos claimed that these assumptions are not true. The first one is false because, for example, as empiricists argued, the mind is not a tabula rasa. This argument draws a psychological line. Even if this assumption is accepted as true, indeed, the second one is not logically true. Lakatos asserted this point by saying, “No factual proposition can ever be proved from an experiment.” (ibid. p.16) When we look at this understanding, it can be argued that a theory is neither verified nor falsified. It is obvious that this falsificationism is different from Popper’s falsificationism, in which scientific propositions must be falsified. For this reason, in my opinion, Popper’s argument, at least, is more plausible than dogmatic falsificationism. This is because Popper, at least, chose a criterion by which to evaluate scientific propositions. In this case, he chose falsificationism as the criterion. Scientific propositions are tested in a theory, and if they are falsified than a new theory is chosen to falsify them. Hence, science progresses in this way. However, there is no determined criterion in dogmatic falsificationism, so this might not be accepted in the philosophy of science.

3.2.2. Methodological Falsificationism

Popper’s falsificationism was evaluated by Lakatos within ‘inductivism’ and ‘conventionalism’ (Bernstein, 1981), so methodological falsificationism is explained as another field of conventionalism. Lakatos stated that it is necessary to consider conventionalism to understand methodological falsificationism (Lakatos, 1980). According to this understanding, if a theory does not work properly, then it can be ignored. This is because if the theory does not work, then it cannot be falsified. Therefore, it cannot be accepted as scientific. In this case, the scientific criterion for theories is related to their falsifiability. If a theory has an empirical base, then this theory is accepted as scientific. To Lakatos, even though methodological falsificationism is better than dogmatic falsificationism, it is also insufficient to explain scientific explanations. Hence, the demarcation criterion between science and pseudoscience can be derived from the history of science. It is assumed that Lakatos attempted to bring rationality to his own philosophy, and for this reason an understanding of internal history was taken as a basis for his philosophy. The aim of the philosophy of science, to Lakatos, is to provide a rational explanation for scientific progress. Another criterion, such as a social, political or cultural criterion, cannot be taken as a basis on which to understand science (Lakatos, 1980). According to Lakatos, these criteria are not a part of internal history, so they cannot be taken as a basis. In my opinion, social, cultural and political criteria are the product of people, and they are not part of the internal history or the history of science. There is a subjectivity to these criteria, and this is unacceptable for rationality and also for Lakatos' philosophy. The importance of internal history is stated by Lakatos thus:

> But rational reconstruction or internal history is primary, external history only secondary, since the most important problems of external history are defined by internal history. (Lakatos, 1971, p. 118).

From this point, it can be said that the meanings of rationality and internal history are the same. A difference between Kuhn's and Lakatos' philosophies arises here. It has been asserted that Kuhn is blamed as being irrationalist. Lakatos also supported this idea, because he argued that Kuhn's philosophy includes 'beliefs, personalities or authority' (ibid. p. 118). In other words, he critised the scientific community and Kuhn's sociological approaches in the philosophy of science in terms of subjectivity. To Lakatos, internal history or rational reconstruction is not formed on these criteria, so Lakatos did not accept external history as a criterion for scientific theory.

Lakatos argued that there are two situations here, which are incompatible methodological and dogmatic falsificationism. The first one is related to theory and experiment. Lakatos stated that theory and experiment must be like they are in a competition, and at the end they must be face to face. The second one is related to the result of this competition. To Lakatos, the expected result is, of course, falsification. This is because "[the only genuine] discoveries are refutations of scientific hypothesis" (Lakatos, 1980, p. 31). However, these two situations are false for the history of science. When we look at the history of science, this competition is not only between one theory and one experiment, it is between at least two theories and two experiments. The criterion of falsificationism is also an indefensible assumption in these approaches. This is because the history of science shows that at first glance some results of experiments are in confirmation, even though the expected result is in falsification. This explanation shows us that neither verification nor falsification are enough to obtain scientific knowledge. For this reason, in my opinion, there is a synthesis in Lakatos' philosophy, and Lakatos brought a new version of falsificationism which is called sophisticated falsificationism (Phillips, 1973, p. 19). This understanding is crucial to understand Lakatos' scientific theory.

3.2.3. Sophisticated Falsificationism

In '*The Methodology of Scientific Research Programmes'*, Lakatos stated the differences between sophisticated falsificationism and naïve falsificationism. However, we will just focus on sophisticated falsificationism in this section. According to sophisticated falsificationists, a theory must include more empirical content than its predecessor, and at least a part of the empirical content must be able to be verified. In this case, Lakatos proposed some criteria to falsify a theory. First of all, a theory must include empirical content over that of its predecessor. In addition, if something is forbidden by the old theory (T), the new theory (T') must predict this in light of the novel facts. Secondly, the success of the old theory (T) must be explained by the new theory

(T'), and the new theory (T') must also include all of the unrefuted content of the old theory (T). Finally, some parts of the new theory (T') must be verified in terms of its excess parts (Lakatos, 1980). At this point, Lakatos started to reveal his own theory of science. As explained above, sophisticated falsificationism states that not only one theory is treated, but a series of theories are treated and evaluated in this case (Phillips, 1973; Lakatos, 1980). In other words, an evaluation of only one theory is not satisfactory according to sophisticated falsificationists. This is because the scientific criterion is not only relevant to one theory, and this is a categorical mistake. In such cases, "Sophisticated falsificationism thus shifts the problem of how to appraise theories to the problem of how to appraise series of theories." (Lakatos, 1980, p. 34) To understand this situation, let us have a look Lakatos' example. According to this example, Einstein's theory did not refute Newton's theory, and we did not accept Einstein's theory for this reason. On the contrary, Einstein's theory was chosen, because it represents a rational advance over Newton's theory. If we express this situation according to sophisticated falsificationism's criterion, Einstein's theory already explained everything about Newton's theory, and in addition it explained some novel facts in relation to Newton's theory. This point might be considered an example of accumulated knowledge, and might be rejected by Kuhn in terms of the idea of accumulation. This is because scientific progress is not made in this way according to Kuhn's scientific view. However, to Lakatos, each new theory is established on an existing theory. In light of this, Newton's theory was not refuted and falsified, it was just that the new theory was more comprehensive in terms of its explanations and novel facts. In my opinion, this understanding is beyond Popper's and Kuhn's philosophies. Neither Popper nor Kuhn argued that useless theories can be thrown away, however, they also did not mention this kind of scientific progress. In this case, Lakatos's argument might be more plausible than Popper's and Kuhn's arguments. However, these explanations are not sufficient to understand Lakatos' philosophy, so let us move on to scrutinise Lakatos' methodological research programme as a new breath for the philosophy of science.

3.3. A Methodology of Scientific Research Programmes

In 'History of Science and its Rational Reconstruction', Lakatos stated that his methodology was a success, which was explained as his research programme. Lakatos added that 'progressive and degenerating problemshifts' must be considered for scientific growth. According to Lakatos, "This methodology offers a new rational reconstruction of science." (Lakatos, 1971, p. 99) This point refers to Popper's falsificatonism, because Lakatos' methodology is a synthesis of 'falsificationism and conventionalism' within their contrasts. Lakatos also asserted:

> The methodology of research programmes presents a very different picture of the game of science from the picture of the methodological falsificationist. The best opening gambit is not a falsifiable (and therefore consistent) hypothesis, but a research programme. (*ibid.* pp.99-100)

From this point, it can be examined how Popper's falsificationism is a kind of support unit, however it was not the only source for Lakatos' research programme. This shows that Lakatos' methodology incorporated several different arguments from others, for example Popper's, Kuhn's and Duhem's philosophies (Lakatos, 1971; 1980). However, these arguments were synthesised to provide a new perspective in the philosophy of science. In light of this, when we look at Lakatos' research programme we see that it is based on four crucial points, which are *hard core, protective belt, negative heuristic* and *positive heuristic* respectively (Lakatos, 1971; 1980; Bernstein, 1981). In '*The Methodology of Scientific Research Programmes'*, Lakatos stated, "All scientific research programmes may be characterized by their '*hard core'.*" (Lakatos, 1980, p. 48). In other words, the *hard core* is a kind of basis of axioms (Chalmers, 1999). When the attempts are made to change the *hard core*, then scientists waive from the research programme in this way. This is because the *hard core* includes some factors which are determined by the scientific community's beliefs, and these factors cannot be refused. Briefly, the *hard core* is a metaphysic factor and it consists of beliefs (Lakatos, 1980). For example, according to evolution programmes, all species come from common ancestors (Mayr, 1957; Darwin, 2008). This asssumption is the basic factor of *hard core* in the programme of evolution.

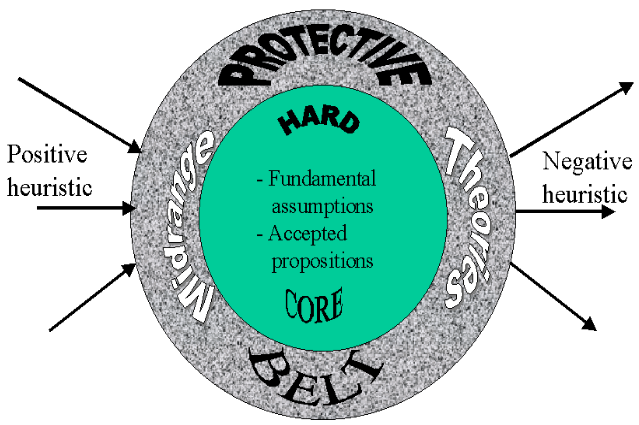
The *hard core* can be different in different research programmes, however it cannot be changed in each of these programmes. For instance, while the *hard core* is "social change in terms of class struggle" in Marx's historical materialism, it is the "three laws of motion and law of gravitational attraction" in Newton's physics (Chalmers, 1999, p. 131). Even though research programmes are different, their *hard core* cannot be changed in their own programmes. In addition to this, if there is an anomaly between observation and the result of an experiment in a research programme, this contradiction needs to be solved by an auxiliary hypothesis. On the other hand, 'auxiliary hypothesis' constitutes a *protective belt*, which also protects the *hard core*. For this reason, the *protective belt* is always changed and improved, however the *hard core* remains the same. Therefore, some changes in the *protective belt* are possible without a change in the *hard core* in a research programme. In this case, some theories can be replaced with new ones (Lakatos, 1980). For example, Newton's theory was replaced with Einstein's theory in terms of several differences between the two. However, the programme itself was not changed when Newton's theory was replaced with Einstein's theory, only certain factors of the *protective belt* were changed. Another example might be the Copernican programme. Chalmers (1999) states that "the *protective belt* within the Copernican programme was modified by substituting elliptical orbits for Copernicus's sets of epicycles and telescopic data for naked-eye data" (p. 132).

Lakatos also characterised a new term - 'heuristic' - for use in terms of research programmes. This term means to discover or invent new things, and it includes the notion of a 'set of rules'. In addition, the term 'heuristic', as a concept, is split up into two fundemantal elements, which are *negative heuristic* and *positive heuristic* (Chalmers, 1999)*. Negative heuristic* determines that a theory should not be discarded when a clash is arises in a research programme. In other words, it draws a boundary for scientists over what they should or shouldn't do. *Negative heuristic* does not allow the *hard core* to be interrogated. This is the irrefutable part of a research programme. However, if the *hard core* is waived by scientists, in this case the *hard core* must be modified. Otherwise it is not possible (*ibid.* p.133). According to Lakatos, Newton's theory is the best example of a research programme, because of Newton's methodology. As Lakatos' exemplified, "In Newton's programme, the *negative heuristic* bids us to divert the *modus tollens* from Newton's three laws of dynamics and his law of gravitation." (Lakatos, 1980, p. 48)

In other respects, *positive heuristic* shows us how scientists can proceed in scientific research. In other words, *positive heuristic* addresses "what scientists should do rather than what they should not do within a programme" (Chalmers, 1999, p. 133), and it also leads to scientists establishing how a theory needs to be improved and changed in a research programme. If a theory has contradictions, scientists have to solve these contradictions. If these contradictions cannot be solved, then the theory can be ignored, however it cannot be removed from the research programme (Lakatos & Musgrave, 1970; Lakatos, 1971; 1980; Larvor, 1998; Schuster, 2009). All of these explanations can be summarised by this quote:

> The negative heuristic specifies the '*hard core*' of the programme which is 'irrefutable' by the methodological decision of its proponents; the positive heuristic consists of a partially articulated set of suggestions or hints on how to change, develop the 'refutable' variants of the research programme, how to modify, sophicticate, the 'refutable' protective belt (Lakatos, 1980, p. 50)

Figure 1: The model of Lakatos' Scientific Research Programme (Bharadwaj, 2000)



In '*What is this thing called Science?*', Chalmers (1999) attempted to examine Lakatos' methodology with regards to the Copernican Revolution. In this section, his explanation will be provided in order to understand Lakatos' methodology. In the eighteenth century, a new astronomy was established by Copernicus. When Copernicus put forward his astronomy, he claimed that the earth was not stable in the universe. However, his theory challenged the Aristotelian and Ptolemaic astronomy.

According to Aristotelian astronomy, there were two different places in the universe. These were split out as sublunar and superlunar. The sublunar district was from 'the central earth to inside the moon's orbit'. The superlunar district presented 'the finite universe', and 'was extending from the moon's orbit to the sphere of the stars, which marked the outer boundary of the universe'. This does mean that there was nothing beyond the sphere (*ibid.* p. 93). The sublunar region was formed of four basic elements, which were fire, air, earth and water. Each element moved towards its natural regions. On the other hand, the uperlunar region was formed by ether, which was an indissoluble element. Ether's movement was circular, and it moved around the centre of the universe (*ibid.* p.94). In this system, the earth was in the centre of the universe, and all orbits moved around the earth. These views were the basic principles of Aristotelian astronomy. However, Copernican astronomy was contrary to Aristotelian astronomy in terms of the movement of the earth. In his astronomy, the earth was not stable, and was moving around the sun. Indeed, Copernicus' astronomy was criticised and some arguments against the Copernican system arose. The most famous argument was the *tower argument*. According to this view, the movement of the earth was not possible. This is because if the earth moved around its axis, when an object was thrown away from a tower it should fall away from the tower. However, experiments did not support this argument. If an object was thrown away from a tower, it always fell down in front of the tower. According to this argument, Copernicus' theory was false. In addition, there was another argument against the Copernican system. This argument claimed that if the earth moved around its axis, as argued by Copernicus, why were objects not dispersed from the surface of the earth. These questions were not answered by Copernican astronomy. In this sense, the Copernican system was not accepted succesfully (Chalmers, 1999). However, a new system appeared to defend Copernican astronomy. This system was formed by Galileo, and was done in two ways.

First of all, the sphere was observed by telescope. In so doing, he observed several stars which could not previously be observed with the naked eye. In addition, he saw that there was an orbit on Jupiter, and that the moon has some craters and mountains. Furthermore, Galileo proved Copernicus right by showing that the size of Venus and Mars would change. It was also confirmed by Galileo that the locations of Venus and Jupiter were not as had been argued by Ptolemaic and Aristotelian astronomy.

Secondly, he brought a new mechanics instead of Aristotelian mechanics. He rejected Aristotelian causation. In Galileo's mechanics, momentum and velocity divided each other. He analysed the movement of 'projectile motion' (*ibid.* p.99). In this sense, Galileo's new mechanics answered the unsolved problems of Copernican astronomy. However, Galileo's system was also insufficient to answer some questions. For example, the idea of 'the complex system of epicycles' were also important for Galleo, as claimed by the Copernican and Ptolemaic systems. This view was changed by Kepler, who discovered that "planets move in elliptical movements around the sun" (*ibid.* p.100). In so doing, Kepler found 'three laws of planetary motion', which opened the door for Newton's system (*ibid.* p.100). As a result, Newton established his new physics in light of Galileo's and Kepler's systems.In this part, the Copernican Revolution has been used as a comprehensive example to examine Lakatos' methodology of scientific research. It is obvious that these developments took a great time in the history of science. In these research programmes, the *hard core* was always protected, however, new hypotheses were added during the research. In this way, rival theories can be eliminated. Some theories progressed with falsificationism, some of them progressed with justificationism. There was established a synthesis between them. The progression in the history of science and the philosophy of science matches Lakatos's methodological scientific research. Science has been progressed neither with falsification nor revolutions, as claimed by Popper and Kuhn. Therefore, Lakatos did not deny accumulation in his philosophy. According to Lakatos' philosophy, while the *hard core* is protected, new theories need to be supported with old theories, and then new theories can be improved in this way. For example, Galileo's astronomy was established on the Copernican system, and Kepler's astronomy was established on Galileo's system. In other words, their research programmes progressed based on the existing theories. In this case, if a research programme does not work properly, then it can be left. However, if a theory is waived, a new theory must be established before leaving the old theory. Therefore, the criterion is not arbitrary to leave a theory. The criterion is completely rational, so Lakatos' methodology of scientific research is based on rationality in the philosophy of science.

3.4. Evaluation

'The Methodology of Scientific Research Programmes' is a kind of synthesis of Popper's and Kuhn's philosophies in the philosophy of science. As already stated above, Lakatos rejected neither falsificationism nor justificationism. In his methodology, both of these are considered for scientific research. According to Lakatos, the history of science is important to understand the philosophy of science. For this reason, Lakatos did not ignore the importance of the history of science, as argued by Kuhn. At this point, there is a difference between Kuhn's and Lakatos' understanding of history. In my opinion, the importance of the history of science in terms of the difference between Kuhn's and Lakatos' philosophies can be compared

in terms of several points. As mentioned in the second chapter, historiography is important for Kuhn's philosophy, because Kuhn argued that each theory should be considered in relation to the history of science. According to Kuhn, the aim of the history of science is to fill a gap between science and the philosophy of science, but not chronologically (Kuhn, 1977). Kuhn did not accept the chronological approach. However, Lakatos did not reject accumulation. Contrary to Kuhn, when we look at Lakatos' *'The Methodology of Scientific Research Programmes'*, science progresses with accumulation, and each theory is established on an old theory. Among these theories, to Lakatos, the Copernican system is one of the most successful systems in the history of science. This is because the Copernican Revolution is rational in terms of its explanation. This revolution contained more novel predictions, hence it was scientifically superior to its predecessors (Lakatos, 1980; Chalmers, 1999).

When we look at Popper's, Kuhn's and Lakatos' philosophies there are three huge scientific criteria for the philosophy of science. These are falsificationism, paradigm change or incommensurability, and the methodological scientific research programmes respectively. All three of them attempted to bring a new scientific view, and they succeeded. Their criteria might be accepted as correct in terms of several points, for example, Popper's criticism of justificationism, Kuhn's scientific revolution and Lakatos' methodology. Among these criteria, in my opinion, Lakatos' methodology is more plausible in terms of its understanding of the scientific process. This is because we can see Popper's and Kuhn's philosophies in Lakatos' methodology. In other words, it involves either falsificationism or the importance of the history of science, even though there are some nuances. In addition, he did not reject the idea of accumulation. In brief, if someone were to take any of the ideas from Popper's or Kuhn's criteria, they can also be found in Lakatos' methodology, apart from irrationality. Lakatos' whole endeavour was to reconstruction rationality in the philosophy of science, so he simply rejected irrationality. Hence, he critised Kuhn's philosophy as irrational. According to Lakatos, in the history of science, where Kuhn saw irrational change, historians can actually show rational change. For this reason, the history of science should be reconstructed rationally.

Conclusion

In this dissertation, I have attempted to demonstrate three different perspectives of scientific view in the philosophy of science. In particular, I have aimed to examine the differences between Popper's, Kuhn's and Lakatos's scientific views, and criticised whether these scientific views are a methodology in their philosophy or not. In light of this, I have tried to compare these philosophers' scientific views in terms of the progression of science. In the first chapter of the dissertation, Popper's demarcation criterion, critics of induction and the method of falsification were evaluated. The demarcation problem dates back to the beginning of western philosophy (Anderson, 1983). In particular, logical positivists attempted to draw a line between science and pseudoscience, hence 'the demarcation problem' became one of the fundamental issues in the philosophy of science. When logical positivists put forward the differences between science and pseudoscience, they also asserted a scientific method to determine scientific knowledge. The method was called induction. The important role of Popper's philosophy arises at this point. This is because, according to logical positivists, each scientific theory must be tested with inductive method, and if a theory is not justified then it is accepted as being non-scientific. In so doing, logical positivists became supporters of induction. However, Popper's critics appeared at this point. As already stated, Popper was interested in using the problem of demarcation to find a scientific criterion for theories. In this sense, logical positivists' verifiication criterion is not an acceptable criterion for Popper's philosophy. Hence, Popper also rejected logical positivists' methods in the philsophy of science. This is because the scientific criterion for propositions is falsification. This does mean that the only method for science is falsification, even though any specific method was not proposed by Popper. There is a reason to argue this approach. To Popper, making a generalisation from premises is difficult, because scientists work on universal propositions which cannot be justified, even though they bear on experiments and observations. When we look at the example of the 'black swan' from chapter I, Popper's argument becomes more clear. As he argued, even though we observe white swans from the past to the present, when we see a black swan all previous generalisation will be falsified. Popper also stated that each theory must be tested, and if a theory is falsified then a new theory should be considered. Afterwards, this new theory should be subjected to falsification attempts. In this sense, science is progressed by falsification. Hence, Popper put forward his new scientific view. In my opinion, Popper's attempy in the philosophy of science could be accepted in some respects, however it can not be used for all universal propositions. Making generalisations might be difficult, and on this point I agree with Popper, however experiments and observations are not always sufficient to falsify universal propositions. In this case, sometimes scientists might try to use the inductive method to get scientific knowledge. This means that either induction or falsification might be used as scientific methods in the philosophy of science. In other words there would be a syntheses, as argued by Lakatos. In brief, Popper's scientific view– falsificationism – might be plausible in terms of obtaining scientific knowledge, however it is not sufficient. For this reason, some alternative views are also discussed in the philosophy of science. One of these views is Kuhn's scientific revolution.

In the twentieth century, Kuhn brought forward a new scientific perspective for the philosophy of science. Kuhn's new view was formed on a historical approach, hence Kuhn is accepted also as both a historian of science and a philosopher. This is because, according to Kuhn, if there is a gap between science and the philosophy of science, the history of science can fill this gap. Kuhn also asserted that the history of science and the philosophy of science can be treated together. Hence, scientific theories can also be analysed in this way. This understanding shows that Kuhn's scientific view bears on a historical approach in the philosophy of science. On the other hand, Kuhn's new perspective has been scrutinised with the term *paradigm.* Kuhn's concept of scientific method was shaped on this term. In other words, *paradigm* is a kind of data recorder for Kuhn's scientific journey. It involves what a scientific theory needs in terms of scientific progress. *Paradigm* determines new standards, and the scientific community works with these standards in normal science. If these standards become useless to solve problems, then a crisis occurs in the scientific process. Hence, the crisis provides a basis for scientific revolutions. After a scientific revolution, a new paradigm and a period of new normal science occurs, and the process of science continues with this circulation, so scientific progress is not linear in Kuhn's philosophy. The scientific revolution and the period of new normal science reminds me Popper's scientific view. There is a similarity between them. I have realized that Popper's falsificationism might be like Kuhn's scientific revolution. However, there are some nuances. First of all, criticism is important for Popper's and Kuhn's methods, but in Kuhn's philosophy it is only possible in period of crisis. On the other hand, criticism must be continued during the process in Popper's philosophy. It is obvious that, while Popper's philosophy is a process of falsification, Kuhn did not mention this in his view. For this reason, Kuhn's view might be accepted as a kind of verificationism, because of the puzzle-solving involved. In this activity, scientific communities are only focused on solving problems. In addition, it can be said that anomalies trigger new scientific research in both Popper's and Kuhn's philosophy. In my opinion, Popper's and Kuhn's scientific views are uniqe from their predecessors', yet their method, probably aren't sufficient to understand the process of science. So, a new method was introduced to the philosophy of science by Lakatos.

Popper's and Kuhn's scientific views have been criticised by Lakatos, and his philosophy has taken a significant place in the philosophy of science. In fact, Lakatos was studying the philosophy of mathematics, however he attempted to synthesise Popper's and Kuhn's philosophies. In particular, Lakatos drew up a conceptual framework in light of Popper's falsificationism and Kuhn's historicity. Thus his own methodology was shaped on these two approaches. In Chapter I, I examined how criticism is crucial for Popper's philosophy. Lakatos also suggested that criticism is "the heart of scientific enterprise" (Lakatos, 1980, p.9). In addition, Lakatos pointed out that Popper's philosophy is rational, because of criticism. I think that the importance of criticism is required to reconstruct rationality for Lakatos' philosophy. In this respect, Kuhn's philosophy was accused of being irrational, because criticism is ignored in Kuhn's view. When we consider Lakatos' methodological scientific research, in my view it seems more plausible than Popper's and Kuhn's philosophies. First of all, he mixed both justificationism and falsificationism in his own method. Secondly, he also considered the history of science as argued by Kuhn. However, one point in Lakatos' view is more important than Kuhn's view of the history of science. This crucial point is the idea of accumulation. In Lakatos' methodology, science proceeds in this way. On the other hand, Lakatos pointed out that not only one theory but a series of theories must be considered in terms of scientific growth. To Lakatos, a scientific research program, not just a theory, should be evaluated. In addition, Lakatos argued that if a scientific research programme makes novel predictions novels, then this programme offers growth in scientific knowledge. I think this is the most unique point in comparison to his predecessors. Therefore, Lakatos brought forward a totally different criterion for the philosophy of science. In fact, we have already come across Lakatos' scientific research programme in various different disciplines. This is a success in the philosophy of science.

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