CHAPTER 6: CONCLUSION

6.1 Scientific Realism and the Problem of Theory Choice

Over decades, scientific realism has been challenged by Duhemian underdetermination of theory by data. The denial of empirically distinguishable rival theories and the effectiveness of crucial experiment, by the underdetermination thesis, has rendered scientific realism in the predicament of theory choice. For scientific realists, crucial experiment is assumed to be effective in arbitrating between rival theories. The threat posed by the underdetermination thesis to them is that the entailment of the indistinguishable observational consequences in rival theories renders rational theory choice impossible. As the scientific realist criterion of rational theory choice is truth, the chosen theory is supposed to be able to explain and predict the physical phenomena in an objective and accurate way. It is this stringent criterion of rational theory choice that puts scientific realists into trouble. As it is implausible for any scientific realist to give away the notion of truth, he has to take up the challenge to account for how rational theory choice is possible in the face of the underdetermination of theory by data. Failure to do so will endanger scientific realist account of science, for it becomes senseless (for scientific realists) to talk about scientific progress if one cannot demonstrate that the chosen theory is truly depicting the phenomena.

Another difficulty in the thesis of theory choice that is faced by scientific realists is due primarily to the acceptance of an absolute true (or a single true) theory. According to the scientific realist's correspondence theory of truth, mind and reality are assumed to be

independent from each other. Scientific theory is the bridge that connects these two independent entities. As reality is conceived ontologically as a single entity (i.e. only one world exists), only one scientific theory that bridges up the gaps between mind and reality can be true. Given two empirically equivalent rival theories as candidate for theory choice, scientific realists cannot accept the case where both theories are epistemically on a par in depicting the phenomena in the same truly manner. In other words, the consequence of a rational theory choice, according to scientific realists, is a decisive determination on the epistemic merits of the rival theories. They cannot tolerate the fact that there plausibly exist two equally true rival theories, because it would imply that conflicting theories are plausible to truly account for a single reality, which is counterintuitive to the tenet of scientific realism. Thus, scientific realists have a burden to convincingly demonstrate that all empirically equivalent rival theories can be ranked according to their epistemic merits, that is, a ranking that clearly identifies the degree of how each theory is truly depicting the reality. Based on this ranking, scientists can rationally decide which theory is the true one, and should be chosen among the rivals. Such a non-ambiguous ranking is a pre-requisite to prove that scientific realist notion of rational theory choice is feasible. Unfortunately, it is implausible for scientific realists to clearly and objectively rank each empirically equivalent theory with reference to their correspondence theory of truth.

Most scientific realists choose not to face directly the acute challenge of rational theory choice. Instead, a wide variety of defensive strategies have been adopted to dismiss the threats from the thesis of theory choice. Some scientific realists, Psillos being one of

them, claim that the problem of rational theory choice will be dismissed by future evidence. They hold that future evidence will break the stalemate state of empirical equivalence of rival theories. Unfortunately, this promise of the determinative power of future evidence is issued a priori. Others, such as Putnam, who hold fast to the "no miracle" argument dismiss the thesis of theory choice by arguing that the success of science has shown that the threat of non-progression posed by the thesis of theory choice is a fantasy. They point to the fact that the explanatory and predictive power of theory do not make the success of science a miracle. They thus conclude that the success of science can be deduced from the success of scientific theories, which lead them to conclude that rational theory choice is plausible. The fact overlooked by the proponents of "no miracle" argument is that they have assimilated the concept of rationality with that of success in science. They have excluded the possibility of contingent success in science (e.g. the discovery of X-ray), which could not be attributed as a consequence of rational theory choice. Although science appears to be progressive and successful at the macro level, failure in experiments and theory predictions is more common in the daily practice of scientists. The proponents of "no miracle" argument have not considered, and unable to account for, the problem of rational theory choice faced by individual scientists in their daily practice of science.

Other recourse to dismiss the thesis of theory choice has taken place in the argument for unobservables. The assumption of the existence of unobservable entities is the tenet of entity realism, which is a version of scientific realism. Entity realists believe that unobservables, such as quarks, are real entities that determine the observable phenomena.

However, they agree with antirealists that the inference to the best explanation on which the classical scientific realism is based is not valid. By disconnecting the reality of the unobservables from the truth of the theories that account for them, the rejection of a theory does not pose a threat to the reality of unobservables. For entity realists, what makes an unobservable real is that it is manipulable and can be used as a tool to produce observable phenomena. Thus, the problem of theory choice for entity realists is not about a choice for true theory. As opposed to other scientific realists, the criterion of rational theory choice is the manipulability of the unobservable. For entity realists such as Hacking, experiment is value-independent. An experimenter does not need to take a stance between two rival theories before carrying out her experiment. In other words, theories have no role to play in explaining the unobservables. However, to decide which background theory can best support the manipulability of the unobservable (e.g. the background theory that supports the operation of a microscope in the observation of genetic materials), the result of an experiment is the determining factor. A background theory which grounds a successful manipulation of the unobservables is apparently superior to its rivals. Nonetheless, the result of an experiment is subject to explanation, which requires reference to theories. Entity realists have provided us no clues how rational theory choice is possible in the face of two equally good rival theories that account for the experimental results. They have no way to evade from recognizing the explanatory role of theories for the experimental results, for unexplained experimental results are mere raw data which cannot be added to the stock of knowledge. Apparently, entity realists have failed to provide a satisfactory account of rational theory choice.

The major challenge faced by scientific realists in the face of the problem of theory choice is their tenet which claims that real theory must be singular. The objection of the plurality of true theory forces them to rank the rival theories according to the epistemic merit, prior to making a theory choice. However, the criteria of the ranking, which is truth or approximate truth, do not make such ranking plausible. The best ranking a scientist can provide is always ambiguous in terms of the epistemic merits of rival theories. There is no rational way to producing an objective ranking, for in most of the time the ranking is made out of the individual preference of scientists. Different scientists may value the truth of each theory differently, as this is evidenced by the emergence of scientific debates in scientific communities. Scientific disputes will not arise should the epistemic merits of rival theories could be rank-ordered in an unequivocal and objective way. Hence, the implausibility of producing an objective theory ranking has rendered the plausibility of rational theory choice a question.

6.2 Antirealism and the Problem of Theory Choice

Antirealists repudiate the realist conception of the correspondence theory of truth. They do not agree with scientific realists that theoretical entity is real and can be captured by fundamental theories and laws. Although some antirealists (e.g. Cartwright) hold that unobservables are real entities, they do not think that a single fundamental law accounting for theoretical entities is available. Because of the rejection of the fundamental reality, antirealist such as van Fraassen tends to accept that empirical adequacy should be the epistemic criterion of a scientific theory. Antirealists do not need to subscribe to the truth-valuability of theories in theory evaluation.

By detaching truth (and approximate truth) from theory evaluation, antirealists do not have the pressure to adhere to a strict criterion of theory choice as scientific realists do. As seen in Chapter 3, antirealists do not need to consider as a criterion how faithfully a theory could depict the deep structure of the reality. Constructive empiricists are contented to show that empirical adequacy is a sufficient criterion for theory choice. Historical school of antirealist does not see the problem of theory choice an issue, for they hold that any impasse in theory choice can be resolved when science progresses. This group of antirealists (e.g. Laudan) holds that the rationality of theory choice is justified by the history of science. Pragmatists, another group of antirealists discussed in Chapter 3, claim that there is no single fixed criterion in deciding between rival theories. Putnam, one of the pragmatists, has rejected scientific realists' assumption of God's eye viewpoint. He asserts that pragmatism is a principle that allows alteration of beliefs and practices when required. Flexibility is allowed in the practice of science, including in the criteria of theory choice. Hence, pragmatists have lesser burden confronting a dilemma of empirically equivalent rival theories, for according to them the most pragmatic theory should be advocated in order to make progress in science. However, Putnam still maintains that the chosen theory must be objective. Hence, we can anticipate that the pragmatists would favor a theory which has a wide range of merits (e.g. true, simple, elegant, coherent, etc.) provided that the objectivity of the chosen theory is warranted. Anti-fundamentalists (e.g. Cartwright), which is the fourth type of antirealists discussed in Chapter 3, endorse the adoption of multiple models and laws in science. They oppose the notion of a single model/law that accounts for the fundamental reality, which is

claimed non-existent. Hence, anti-fundamentalists do not have a pressure (as scientific realists do) to ensure that only *one* theory/model is the legitimate choice, for they do not have to commit to a view that there is only one theory/model which can be true about the physical phenomena. In fact, more than one theory/model could be legitimately chosen, claimed anti-fundamentalist, to account for the different aspects of a complex physical phenomenon.

Despite the rejection of truth-valuability, antirealists share a commitment of objectivity-valuability as a criterion for theory choice. They would allow more than one theory/model to explain the physical phenomena, without having an intention to reduce to one, with the proviso that these theories must be objective in accounting for the reality. For antirealists, it is acceptable that (contra to scientific realists) there exist more than one objective way to depict the world, provided that the explanatory theories are not contradictory to each other. This antirealist commitment will not be challenged if the competing candidate theories are not contradictory to each other, but predicament will rise if otherwise. Given an array of contradictory rival theories, antirealist's objectivity-valuability serves no better criterion than scientific realist's truth-valuability. Although it is not a requirement for antirealists to stipulate their criteria to pick only a single theory out of the rivals, they are challenged to demonstrate which theory is more objective to deserve for being chosen. Similar to the case of scientific realists, antirealists are required to provide a ranking for the candidate theories, based on the degree of objectivity of each theory. As elaborated in Section 6.1, a satisfactory ranking is implausible.

Some antirealists, especially those from the historical school, may argue that a satisfactory ranking for the candidate theories can be made possible by the history of science. We just need to sit tight and wait, they may argue, history of science will tell us which theories are more objective than the rests, and thus should be chosen as the plausible theories. They may go further by enumerating the surviving theories that are retained by the history of science, and claim that these survival theories are more objective than their rivals.

Unfortunately, this rebuttal misfires, by mistaking theory change for theory choice. Although there is a connection between theory change and theory choice, they are not the same. Theory change requires theory choice, but the reverse is not true. Moreover, theory change is the (behavioral) consequence of theory choice, and it is not intimately related to the (conceptual) criteria of theory choice. Theory change endures in time, while theory choice does not. Transition from a theory to another sometimes take years, for it is not a transition of concept per se, it is also a process of acceptance and belief transition in scientific community. Thus, theory change involves arguments for and against the new theory that takes place in a scientific community. It is fair to say that theory change is a historical process and the transition of theories is justifiable by the history of science.

However, theory choice is more of a conceptual rather than a historical process. It is intimately tied to the criteria of choice. Theory choice is justifiable by the conceptual

reasons, not by the historical factors. A justifiable choice must provide reasons why a particular theory is preferable to its rivals. These reasons should base on the epistemic merits of the theory. A theory choice is justifiable and rational if its criteria are necessary and sufficient to ensure that any theory being chosen is the best one among the rivals. Those who have attributed the criteria of theory choice with historical dimensions have overlooked the fact that history is full of contingency. The success of a theory in the past cannot guarantee its continuous success in the future, not to mention that the cause of success may have occurred by accident (e.g. the discovery of X-ray or the discovery of a new species). Historical success of a chosen theory cannot justify the rationality of the criteria for theory choice, for we cannot ensure that the historical success of any theory is not determined by contingent factors.

I have demonstrated in the previous chapters that the antirealist account of theory choice is not without problem. Antirealists need to find a solution to ensure that their criteria of theory choice are capable of singling out the objective theory (i.e. empirical adequacy, etc). A ranking of the degree of objectivity of the candidate theories is required to ensure that only the right theory will be chosen. Without such a ranking, antirealists cannot claim that their criteria of theory choice are rational. Unfortunately, having an objective ranking of theories requires an objective criterion of ranking, which is implausible to formulate because there is no reference for producing an objective criterion of ranking. There is no way to resort to the definition of objectivity of theories in setting out an objective criterion for theory ranking, for it would incur circularity in the argument. The problem of theory choice is still a hard nut to crack for antirealists.

6.3 Relativism and the Problem of Theory Choice

Relativists understand the notion of truth from the pluralistic perspective. They maintain that it is not reasonable to stipulate a priori the monolithic nature of truth, for some relativists believe that there exist more than one reality (e.g. Goodman), while other relativists hold that a single reality could be represented in multiple forms (e.g. Kuhn). Notably, relativists that are discussed in Chapter 4 (i.e. Goodman, Kuhn, and Feyerabend) are self-claimed rationalist in their accounts of scientific progress. They hold that a relative attitude toward scientific theory should be advanced for the benefits of scientific development. Apart from embracing a normative relativism, they also demonstrate that relativism is prevalent in the history of science.

Relativists who hold that there are more than one reality, or more than one version of reality (e.g. Goodman's pluralistic view of "world-version"), incline to maintain a pluralistic notion of scientific theory. They find no good reason to believe a priori that the correspondence theory of truth will hold given the pluralistic ontology of reality. Historical examples were used by ontological relativists to further support the notion that scientists in different epochs or different cultural backgrounds are working in different worlds with different theories. The pluralistic reality appears to be reflected by the pluralistic framework of knowledge. The severe problem that challenges relativists is that they have no recourse to validate whether the framework-dependent knowledge genuinely depicts the reality. This challenge, if not handled satisfactorily, would lead to agnosticism and skepticism, which is detrimental to the development of science.

However, the relativists that were discussed in Chapter 4 are neither agnostics nor skeptics. Kuhn, for example, holds that the development of science is possible even though it proceeds in a discontinuous manner. Feyerabend, on the other hand, stresses that relativism and pluralism can promote scientific progress. In Chapter 4, I have demonstrated that the relativism of the discussed philosophers is premised with the aim of science, which is scientific progress. This premise, though in a relativistic flavor, corresponds to Laudan's anti-realist notion of "axiological heterogeneity" (i.e. diverse aims of science) (Laudan 1986). Notably, relativists hold that the diversity of aims of science justifies relative criteria of theory choice; whereas Laudan rejects relativism and maintains that the criteria of choice are justified by the scientific theory and the world (Laudan 1986). The main difference between relativists' and Laudan's notion of the aim of science, according to Laudan, is that the former notion is irrational while the latter is rational. If this is the case, as supposed by Laudan, we then have a valid reason to believe that the relativist's criteria of theory choice is irrational, whereas Laudan's (and some other anti-realists') criteria of theory choice is rational. Interestingly, as I have elaborated in Chapter 4, relativists such as Kuhn and Feyerabend argue that rationality is an integral part of the contexts in which scientists are working. For them, there is no single definition of rationality. Pursuing a universal definition of rationality, as propounded by scientific realists and anti-realists, is an irrational endeavor since relativists think that it does not reflect the diversity of the world and scientific theory. On the contrary, relativists claim that only relativism (with context-dependent rationality) can account for the world and science in a faithful way. They thus conclude that relativism is a rational approach to science, and to the criteria of theory choice.

Apparently, there is no hope for conciliation between scientific realists and relativists on the issue of rationality and the criteria of theory choice. However, there is a point of convergence between anti-realism (especially Laudan's philosophy) and relativism on this issue. Both camps are divergent on what constitutes the rationality of the criteria for theory choice, whereas they are in agreement on the source of the constitution of rationality. As shown above, Laudan holds that the rationality of the criteria for theory choice is derived from the scientific theory and the world. Similar arguments are seen in the writings of relativists such as Goodman, Kuhn, and Feyerabend. Goodman, for instance, asserts that the rationality is world-version-dependent. Rational theory choice is possible within a world-version, according to Goodman, since each world-version grounds its own rationality and does not allow the conflicting definition of rationality to co-exist within a single world-version. However, Goodman grants that different world-version might have different definition of rationality. For relativists, the co-existence of different contexts (i.e. world-version, paradigms, etc) does not imply irrationality in science because the context-dependent rationality promotes the scientific progress by shaping the context-dependent criteria of theory choice. This is closely associated with Laudan's view that the criteria of theory choice are dependent on the scientific theory and the world. As Laudan explicitly agrees that our world and science are changing, it is reasonable to assume that Laudan would grant that our world and science are not the same in different temporal points. As such, our world and science are distinct in different temporal *contexts*. Hence, physics in 1800 was in a different temporal context when compared to physics in 2012. Since Laudan has claimed that the rationality of science is

rooted in scientific theory and the world, he has no reason to reject the view that what constitutes the rationality of physics in 1800 is different from what constitutes the rationality of physics in 2012. Conceivably, Laudan would have no reason to repudiate the view that the rationality for the criteria of theory choice in 1800 is different from 2012. Hence, Laudan's conception of rationality is relativized. Importantly, the relativization of Laudan's notion of rationality not only brings anti-realism and relativism into convergence, rationality is also preserved in relativist's and anti-realist's criteria of theory choice. This concept of rationality grounds the aim of science, that is, the progress of science. This aim, commonly held by anti-realists (e.g. Laudan) and relativists (e.g. Feyerabend), is undeniable by scientific realists and any rational agents. Because the relativist's notion of rationality grounds the aim of science, the relativist's criteria of theory choice may as well be seen rational by any rational agents.

Granting that relativist's criteria of theory choice is rational, and should be pursued, it is apparent to see the flexibility that the relativist has in tackling the problem of theory choice, as compared to scientific realist and anti-realist. For relativist, any criterion of theory choice is rational as long as the aim of science (i.e. scientific progress) is warranted by that criterion of choice. Given an array of diverse criteria of choice which are on a par in terms of rationality, relativists would have a greater leeway in applying the criteria to rival theories. As relativists are not constrained by strict criterion (e.g. truth, empirical adequacy) as faced by scientific realists and anti-realists, it is legitimate for them to adopt a pragmatic approach in applying the criteria of theory choice. To illustrate, it is legitimate for a relativist to embrace simplicity as a criterion of theory

choice in context C_1, while embracing coherency as a criterion in another context C_2, with the proviso that the selected criterion in different contexts can promote the aim of science (i.e. scientific progress). Scientific realists and anti-realists do not have the same flexibility that is enjoyed by relativists. Although both scientific realists and anti-realists would not disagree that the aim of science should be promoted by the criteria of theory choice, they would not allow non-epistemic standards (e.g. simplicity, elegance of theory) to be the criteria of theory choice, even if these non-epistemic standards could promote the aim of science.

The challenge faced by relativists is that their criterion of theory choice, regardless of what it is, is insufficient to determine the choice in an affirmative way. Relativists such as Kuhn and Feyerabend assume that the final choice among rival theories involves socio-psychological factors such as persuasion. In other words, relativist's criteria of choice are necessary but insufficient to determine the actual choice, as the actual choice can be influenced by non-rational socio-psychological factors. The indetermination of relativist's criteria of theory choice, which requires the supplement from socio-psychological factors, is seen as an evidence of irrationality in the doctrine of relativism. Critics may reasonably argue that the rationality of theory choice is not warranted when the actual choice is determined by non-rational factors such as persuasion.