Chapter 2
From a Micro–Macro Framework to a Micro–Meso–Macro Framework

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Abstract At the beginning of the twenty-first century, the philosophy of engineering is becoming its own distinct branch of philosophy. The growing importance of philosophy of engineering cannot be overemphasized, since it has raised or will raise considerable and fundamental issues that challenge traditional ontology, methodology, and epistemology. Engineering is extremely complicated. Without initiating and advocating a new conceptual framework or paradigm, including a number of new categories, neither philosophers nor engineers could comprehend or demonstrate the essential characteristics of engineering. In particular, some social scientists pay significant attention to the relationship between micro (at the level of individuals) and macro (at the level of institutions or the social whole) issues, and as a result, a variety of micro–macro frameworks have advanced. There are four approaches for scientists to investigate social phenomena: micro-theory-based approach, macro-theory-based approach, micro–macro approach, and micro–meso–macro approach. As for engineering phenomena, scholars should focus on engineering facts, engineering acts, and engineering results, which comprise the three layers. A great number of perspectives contribute to a more complete and deeper understanding of engineering practice as a kind of multiple social construction assemblage. Engineering as a tangible architecture of social reality should be explained as a kind of multiple construction undertaken at micro, meso, and macro levels. The traditional micro–macro framework is obsolete. As such, it is time to establish a new kind of micro–meso–macro framework.

Keywords Engineering • Philosophy of engineering • Micro–macro • Micro–meso–macro • Social reality • Social construction • Engineering reality

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Introduction

At the beginning of the twenty-first century, philosophy of engineering is becoming its own distinct branch of philosophy that is considered as parallel to philosophy of science and philosophy of technology. Tracing the history of philosophy of technology, Carl Mitcham finds that four authors, Ernst Kapp (1808–1896), Peter K. Engelmeier (1855 to ca. 1941), Eberhard Zschimmer (1873–1941), and Friedrich Dessauer (1881–1963), employed the term "philosophy of technology" as the title of a book at the beginning of philosophy of technology (Mitcham 1994, pp. 20–33). Ernst Kapp, the first author, published Grundlinien einer Philosophie der Technik (*Grounds for a Philosophy of Technique*) in 1877, and Dessauer published Philosophie der Technik (*Philosophy of Technique*) in 1927. The philosophy of technology mainly arose in Europe, particularly in Germany, as demonstrated by the fact that Ernst Kapp, Eberhard Zschimmer, and Friedrich Dessauer are German philosophers or engineers, and Peter K. Engelmeier, a Russian engineer, who having lived in Germany for many years, first used the phrase "philosophy of technology" in a German newspaper in 1894 (Mitcham 1994).

In contrast to the situation that philosophy of technology developed slowly during the first 50 years, philosophy of engineering developed quite rapidly during the last 10 years. Supporting this contention is that at the beginning of the twenty-first century, four books entitled philosophy of engineering or its synonym, namely, Gongcheng Zhexue Daolun (*An Introduction to Philosophy of Engineering*, by Li Bocong 2002), *Engineering Philosophy* (by Louis L. Bucciarelli 2003), Gongcheng Zhexue (*Philosophy of Engineering*, by Yin Ruiyu et al. 2007), and Philosophy in Engineering (by Steen H. Christensen et al. 2007), were published during a 5-year span, rather than the 50 years it took for philosophy of technology to become as established. Another important point is that the authors of the four books are Chinese, American, Danish, Dutch, French, and so on, rather than scholars from only one or two European countries, which is quite different from the situation for the first 50 years of writings on the philosophy of technology. Therefore, it seems clear that philosophy of engineering rises and emerges simultaneously in China, USA, and Europe rather than only in one continent.

The conditions in the first decade of the twenty-first century for philosophy of engineering were quite different from those in the first 50 years of philosophy of technology. Furthermore, it is utterly different from the environment about 20 years ago when philosophy of engineering was at the embryonic stage of its development. In the early 1990s, Steven L. Goldman wrote two excellent articles on philosophy of engineering (Goldman 1990, 1991). Here, he said that philosophy of science at that time was a fully accepted and highly respected branch of philosophy, while philosophy of engineering still carried as much professional distinction as philosophy of parapsychology.

However, Goldman took an optimistic view of the future for philosophy of engineering. He held that philosophy of engineering should be the paradigm for philosophy of science, rather than the reverse (Goldman 1990, p. 140). In the current academic

field, due to the fact that philosophy of engineering is still a fledgling subdiscipline, engineers and philosophers who study in the domain of philosophy of engineering often have to use paradigmatic and categorical approaches from philosophy of science. For instance, to promote the development of philosophy of engineering, following the example of philosophy of science and other subdisciplines of philosophy, scholars raised the issue of context in engineering which appears parallel to the issue of context in science (Christensen et al. 2009). Nevertheless, just as the Goldman's claim quoted above, it is possible that some new issues, even a new paradigm, will be raised in the field of philosophy of engineering in the future.

Goldman argues,

> In the absence of an institutionalized and fertile science, engineers generate their own theoretical knowledge in the course of solving their problems. They have been doing so for millennia, and continue to do so today. Furthermore, as Layton has shown, even where engineers did explicitly borrow from science, in thermodynamics and in electrical theory, for example, they had to rethink the abstract scientific knowledge and reformulate it as concrete engineering knowledge. If we then add to this the knowledge, the conclusion must be that science is not either chronologically or logically prior to engineering.
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> (Goldman 1990, p. 143)

Although philosophy of science predates philosophy of engineering, it does not follow that categories and frameworks of philosophy of science are logically antecedents to those of philosophy of engineering. On the contrary, it is possible that some new categories and frameworks are raised or discussed in the field of philosophy of engineering more fundamental than those arising from the philosophy of science. Since philosophy of engineering is raising or will raise some fundamental issues which challenge traditional ontology, methodology, and epistemology, I believe that Goldman's forecast on the future of philosophy of engineering will come true.

Engineering is extremely complicated phenomena. Without initiating and advocating a new conceptual framework or paradigm, including a number of new categories, neither philosophers nor engineers could comprehend or demonstrate the essential characteristics of engineering. In this chapter, I will devote a brief discussion to a new topic that concerns a micro–meso–macro framework or, you might say, a micro–meso–macro theory. Although the micro–meso–macro framework concerns almost all aspects of engineering, such as philosophical, economic, sociological, managerial, ethical, institutional, and psychological issues, the focus of this chapter will be mainly upon philosophical aspects.

Although the three different levels, namely, micro level (typically concerning the level of individual actors within organizations), meso level (intermediate level of organizations), and macro level (level of social institutions), can be easily found in engineering practice and engineering studies, a number of scholars have concentrated mainly on the micro level or macro level for a long time. Only recently have scholars paid attention to the meso level. Most important of all, there have been few scholars who have addressed the integration of the micro level and the macro level or the integration of the three levels. Therefore, a theoretical and methodological shift from a micro or macro theory to a micro–meso–macro theory takes place in some disciplines but is not a marked movement. Should we establish a

micro–meso–macro framework or a micro–meso–macro theory in philosophy of engineering? From my point of view, the answer is definitively yes.

Micro Frameworks/Macro Frameworks in Some Disciplines

Some scholars pay great attention to micro and macro issues in ethics, sociology, economics, and philosophy. Thus, a variety of micro frameworks or macro frameworks are put forward. Due to variety of micro, macro, and micro–macro frameworks, the topic of frameworks is beset with difficulties. When the topic is discussed, many scholars find that they have gone into a jungle of concepts. In the first place, different scholars usually have various opinions on a conception. In this chapter, the differences among scholars cannot be analyzed in detail. Another difficulty lies in the situation in which scholars from different academic fields illustrate the same topic from various perspectives. Last but not least, different scholars often used different words or terms for an underlying concept, even within the same academic field.

The fact has to be noted that there is no unified micro–macro framework in the domains of different disciplines. That is to say, a micro or macro framework of a discipline may be quite different from one discipline to another. For example, a framework established in ethics is quite different from another in economics or in sociology. The discussion on the issue of frameworks has to be simplified to some extent. In this chapter, the topic will only be analyzed in terms of the main trend or new trends, and it is unavoidable that some details are overlooked.

Some ethicists hold that a kind of micro framework is dominant in the field of morality. According to the traditional theory, moral issues, such as responsibility, honesty, friendship, and duty, are always attributed to individual characteristics that hint that a micro framework has been regarded as the sole one by the majority of ethicists. Only recently, a few ethicists have begun to pay attention to some macro issues. For example, Mike W. Martin and Roland Schinzinger write,

> Micro issues concern the decisions made by individuals and companies. Macro issues concern more global issues, such as the directions in technological development, the laws that should or should not be passed, and the collective responsibilities of groups such as engineering professional societies and consumer groups. Both micro and macro issues are important in engineering ethics, and often they are interwoven.
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> (Martin and Schinzinger 2005, p. 6)

Although a few scholars in ethics raised and began to advocate a micro–macro framework, it seems that a great number of ethicists have been advocating a mere micro framework and neglecting the micro–macro framework, not to mention a micro–meso–macro framework. Different from the field of ethics in which a micro framework generally prevails, both a micro and a macro framework prevail in the field of sociology. Some sociologists advocate the former and others advocate the latter. As a result, two subdisciplines of sociology, namely, macro-sociology and micro-sociology, came into existence. Generally speaking, micro-sociology and macro-sociology means that micro and macro frameworks exist in sociology.

Similar to sociology, economics is also divided into two subdisciplines, microeconomics and macroeconomics. As to the definitions of microeconomics and macroeconomics, the majority of economists hold a unified opinion. Wikipedia provides the following definition of microeconomics:

> Microeconomics (from Greek prefix micro- meaning "small" + "economics") is a branch of economics that studies the behavior of how the individual modern household and firms make decisions to allocate limited resources. Typically, it applies to markets where goods or services are being bought and sold. Microeconomics examines how these decisions and behaviours affect the supply and demand for goods and services, which determines prices, and how prices, in turn, determine the quantity supplied and quantity demanded of goods and services.

Although there are micro and macro subdisciplines, both in the field of economics and in the field of sociology, the situation in which two subdisciplines developed in economics is in sharp contrast to what happened in sociology. For example, in the field of economics, a variety of microeconomics textbooks and macroeconomics textbooks have been published. On the contrary, in the field of sociology, few micro-sociology and macro-sociology textbooks can be found. On the basis of this sharp contrast, it would seem to be a logical conclusion that microeconomics and macro-economics are two true subdisciplines of economics while micro-sociology and macro-sociology are only two important issues or approaches in sociology.

Although ethicists, economists, and sociologists have built their own micro frameworks or micro theories, an important fact must be noted that an economic micro framework is not comparable to the ethical micro framework or the sociological one. Indeed, the economic micro framework differs from both of them to a large extent. It should be noted that a micro framework in economics often distinguishes itself from a micro framework in other discipline such as ethics. For example, both an individual and a firm are regarded as a micro unit in economics, while only individuals are regarded as an ethical micro unit. A firm or an enterprise is not regarded as a micro unit in ethics by some scholars. From the economic point of view, a micro subject in the economic field means an economic "individual agent," which could represent an entire company or household. However, a micro subject in the sociological or moral sense means respectively a sociological individual or an ethical individual. Generally speaking, an economic "actor" acts differently from a sociological individual and an ethical individual. The three may act with distinctly different principles.

This chapter will not completely analyze the relationships and distinctions among micro frameworks in different disciplines such as economics, sociology, and ethics. More attention is given to the relationship between a micro framework and a macro framework.

From a Micro–Macro Split Toward Micro–Macro Integration

A heated debate on a micro theory and a macro theory arose not only in sociology but also in economics. Some scholars hold that the micro–macro split and the micro–macro debate in sociology lasted for more than a century and a half (Alexander

1988a, p. 260). In the fields of philosophy and economics, individualism and holism are two opposite kinds of fundamental theories. The former means a kind of a micro framework and the latter means a kind of a macro framework. Due to the limited space of this chapter, a subtle difference between micro/macro and individualism/holism in social science will be neglected, and for purposes here, individualism/holism is regarded as a synonym of micro/macro.

Now, I turn my attention to the topics of individualism and holism. It seems that some economists, to avoid discussing ontological issues, prudently employ the terms "methodological individualism" and "methodological holism" which are substitutes for ontological individualism and ontological holism. Of course, this is not to suggest that all economists want to avoid discussing ontological issues. In contrast to many economists who prefer the terms methodological individualism and methodological holism to the terms ontological individualism and ontological holism (Rutherford 1994, pp. 27–50), some philosophers prefer the terms ontological individualism and ontological holism to the methodological terms (Gilbert 1989, pp. 428–430). Although the term "methodological individualism" is literally different from the term "ontological individualism," the meaning of methodological individualism is almost identical with that of ontological individualism. The relationship between methodological holism and methodological individualism is almost identical as that between ontological holism and ontological individualism. As a matter of fact, methodological individualism cannot be separated from ontological individualism, and methodological holism also cannot be separated from ontological holism. It is impossible to advocate individualism or holism merely in the field of methodology. Scholars who advocate individualism or holism have to inevitably discuss ontological issues as well as methodological issues. In fact, the majority of scholars, including economists, sociologists, and philosophers, expound individualism or holism both from methodological and ontological perspective. Malcolm Rutherford writes,

> Methodological holism (MH) is an approach associated with sociology and anthropology more often than economics. The holist approach can be summarized as follows:
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> MH (i) The social whole is more than the sum of its parts,
>
> MH (ii) The social whole significantly influences and conditions the behaviour or functioning of its parts,
>
> MH (iii) The behaviour of individuals should be deduced from macro-scopic or social laws, purposes, or forces that are sui generis and that apply to the social system as a whole, and from the position (or function) of individuals within the whole.
>
> (Rutherford 1994, p. 28)

Similarly, methodological individualism (MI) can be summarized in three statements:

> MI (i) Only individuals have aims and interests,
>
> MI (ii) The social system, and changes to it, result from the action of individuals,
>
> MI (iii) All large scale sociological phenomena are ultimately to be explained in terms of theories that refer only to individuals, their dispositions, resources, and interrelations.
>
> (Rutherford 1994, pp. 31–32)

According to Rutherford's account, it is obvious that both individualism and holism concern not only epistemology but also ontology. Generally speaking, while economists who advocate mainstream economics stand for methodological individualism, economists who advocate heterodox economics stand against methodological individualism. It is said that Joseph Schumpeter invented the term "methodological individualism." However, from substantial perspective, methodological individualism has a longer history. Ludwig von Mises and Friedrich A. Hayek can be regarded as individualists, but some thinkers of the eighteenth and nineteenth centuries, for example, Jeremy Bentham and John Stuart Mill, can also be regarded as individualists (Hodgson 1988, pp. 55–56). Other scholars openly criticized individualism and supported holism. Therefore, a fierce debate on the subject of individualism and holism arose. In recent decades, new classical economists argue against holism, and some institutional economists argue against individualism (Hodgson 1988, p. 61).

The debate between individualism and holism has lasted for a long time in philosophy, economics, sociology, and ethics. The debate is sometimes heated and it is always difficult to understand the issues involved. The difficulties lie not only in the use of varied terms employed by scholars but also in the variety of contexts in which the debate is surrounded. The debate between individualism and holism illuminates the micro–macro split. While many sociologists, economists, and philosophers consider that individualism and holism are completely opposite, others consider that both of them can be integrated in some way. But, is it possible to integrate individualism with holism?

Admittedly, although individualism and holism are completely opposed to each other as kinds of fundamental theories, all individualists do not deny that there are collective events, while all holists do not deny that individuals are agents. Both scholars who advocate individualism and those who advocate holism try to a certain extent to establish a link between a micro theory and a macro theory. But that does not mean that they advocate an approach to integrate individualism and holism into one framework. Actually, the majority of individualists advocate a reductionist approach, and the majority of holists advocate a different one that can be named a holist or structural approach. As Rutherford says,

> Methodological individualism is usually associated with the reductionist claim that all theories of social science are reducible to theories of individual human action. Put another way, this means that the only allowable exogenous variables in a social science theory are natural and psychological givens. The emphasis is therefore on how individual action gives rise to institutions and institutional change. By contrast, holism is concerned with the social influences that bear on individual action. The individual is seen as socialized, as having internalized the norms and values of the society he inhabits. The holist focuses attention on how social 'forces' (institutions, social conventions, etc.) condition individual behaviour.
>
> (Rutherford 1994, pp. 27–28)

Although, inevitably, individualists talk about collective action and holists talk about individual action, the situation does not imply that individualists and holists involve in a common approach. It is obvious that an individualistic approach is quite

different from a holistic one. The former is a kind of micro-based approach, and the latter is a kind of macro-based approach. That is to say, the former means a micro framework and the latter means a macro framework. Neither of them can be really regarded as a kind of integration between individualism and holism (collectivism). Other scholars, such as Jeffrey C. Alexander and Joseph Agassi, try to find their way out of the split of individualism and holism and advocate a kind of integration between a micro theory and a macro theory or individualism and holism (collectivism) in the strict sense of the term "integration." Integration between a micro theory and a macro theory has attracted many scholars' attention. As a result, a variety of micro–macro theories have been raised. Joseph Agassi as a philosopher proposed institutional individualism (Agassi 1975). The institutional individualism is not a kind of pure individualism, but a combination of individualism and holism. Recently, more and more economists try to combine individualism with holism. In the history of sociology, it is said that Max Weber was the first sociologist who tried to synthesize the micro side and macro side and Talcott Parsons was the second sociologist who carried out similar work (Alexander 1988a, pp. 271–281). The trend of the micro–macro link increased in the 1980s. Sociological theory was said to be at a turning point at that time. On criticizing one-sidedness of schools of micro theorizing and one-sidedness of schools of macro theorizing, Jeffrey C. Alexander analyzes the situation at that time:

> I will demonstrate that one-sidedness has created debilitating contradictions within both the micro and macro traditions. It has been in order to escape these difficulties, I will suggest, that a younger generation of sociological theorists has set out an agenda of an entirely different kind. Among this new generation of theorists there remain fundamental disagreements. There is one foundational principle, however, about which they agree. Neither micro nor macro theory is satisfactory. Action and structure must now be intertwined. Where even 10 years ago the air was filled with demands for radical and one-sided theoretical programs, in the contemporary period one can only hear urgent calls for theorizing of an entirely different sort. Throughout the centers of Western sociology—in Britain and France, in Germany and the United States—synthetic rather than polemical theorizing now is the order of the day.
>
> (Alexander 1988b, p. 77)

Alexander and some sociologists tried to push "the new theoretical movement" forward in order to cut out their own way as a "third way" in the debate. The "third way" apparently means a new one that is not only different from a micro path but also different from a macro path. The aim of the third way is to integrate a micro theory with a macro theory. It seems to some theorists that such a way, which means an approach from the micro–macro split toward micro–macro integration, would be a hopeful one.

More than two decades have drifted by since Alexander talked about the new theoretical movement in sociology. Contrary to the Alexander's optimistic expectation, "the new theoretical movement" gradually vanished. Now, a great number of theorists find that they still stand at a turning point or crossroads. Many scholars think that the question about the relationship between micro and macro theories is still not resolved. Although a substantial advance has been made in the linkage,

conciliation, or integration of a micro framework and a macro framework, a great number of intricate and insoluble problems remain. There is a long way for sociologists to really go beyond the micro–macro split.

A Micro–Meso–Macro Framework: Beyond a Micro–Macro Framework

On hearing the call for the new theoretical movement, Göran Ahrne made a pointed remark on the movement:

> This seemingly unchallenged position of the movement may explain its rather bloodless and quiet appearance. There is a lack of vigour in the movement; it has a flavour of avant-garde and self-sufficiency at the same time. Although one has to agree with its general goal and aims one also has to fear the transformation of the movement into a mutual admiration society. There is a risk that the connection between micro- and macrotheory will have little to do with relations between the world and the everyday lives of ordinary people.
>
> (Ahrne 1990, pp. 4–5)

Ironically, just as Ahrne pointed out, Giddens who is said to be a representative of the new theoretical movement has criticized the idea of formulating theories in terms of micro and macro (Ahrne 1990, p. 7). To make a long story short, it seems to some scholars that the new theoretical movement approaches an end that not only the split between individualism and holism but also the integration between the two sides is unsatisfactory. This means that the effort to cut out a "third way" failed in some sense. Such being the case, is it possible for a "fourth way" to be discovered and cut out? In order to carve out a "fourth way," some scholars discerned "meso" being a new issue, a new level, or a new category in social sciences, including economics, sociology, ethics, and even philosophy.

In 1980s, few scholars distinguished a meso level from a micro level or a macro level. And for this reason, they could not establish a micro–meso–macro framework in academic fields. In 1990s, the situation was changing. A small number of scholars, such as K. E. Goodpaster, Georges Enderle (2002), and Ronald Jeurissen (1997), began to pay attention to the topic of a micro–meso–macro framework in the field of business ethics. However, the majority of ethicists, economists, sociologists, and philosophers neglected the micro–meso–macro framework for a long time.

A meso level is obviously essential in a micro–meso–macro theoretical system, and it has a deep and far-reaching influence on how the other two parts are considered. After specifying a meso level, a micro–meso–macro framework as a new framework was established, at least in principle. The number of scholars who advocated a micro–meso–macro framework could be counted on the fingers of one hand in 1980s and 1990s. In the first decade of the twenty-first century, the number of scholars who began to pay attention to the great vitality of a micro–meso–macro framework increased slightly in the academic fields. Particularly, some scholars who conduct research in the fields of business ethics and evolutionary economics

directed their attention toward a micro–meso–macro framework. However, the majority of scholars continued to neglect the micro–meso–macro framework.

In 2004, Kurt Dopfer, John Foster, and Jason Potts published their excellent article "Micro-meso-macro" (Dopfer et al. 2004) in which a micro–meso–macro framework is expounded. In 2009, Tan Weidong published *Economic Ethics: A Beyond-Modernism perspective* (Tan 2009). Li Bocong (author of this chapter) gave a lecture in which a micro–meso–macro framework was presented at a conference held in Kunming in 2009 and then published his article "On micro, meso, and macro issues in engineering ethics" in 2010 (Li 2010). In spite of the fact that authors mentioned above do not agree among themselves on the micro–meso–macro framework, it is very important that there is a new direction or a hopeful trend which has been pointed in the fields of social science. All in all, concerning the relationship between a micro framework and a macro framework, there are four kinds of views or approaches.

The first approach adopted by individualists is reductionism, which, to some extent, seems to be a mainstream in Western economics, ethics, and philosophy. The second approach is holism, which is discredited by many famous scholars. With a reductionist or a holist approach, the micro–macro split becomes even sharper.

Due to the disadvantages of reductionism and holism, some scholars divest themselves of pure individualism or pure holism and try to compromise a micro theory with a macro theory, which means a "third way." The third approach, which is different both from the first and the second ones, is an integration, which is mentioned above. The fourth approach is to try to establish a micro–meso–macro framework which claims to address problems associated with the other approaches. From my point of view, with specifying a meso level, a micro–meso–macro framework is actually beyond or more advanced than the micro–macro framework. It should be noted that fourth way involves both a methodological aspect and an ontological aspect.

Engineering: Multiple Constructions at Three Levels

In this section, the author mainly focuses on the nature and characteristics of engineering. The author's aim is to establish and employ a micro–meso–macro framework in philosophy of engineering or more universally, in the field of engineering studies. As for the meaning and reference of the terms micro/meso/macro, different scholars hold different opinions. For instance, economists regard micro as individuals and firms, meso as regional economy or industrial economy, and macro as a state economy. From Jeurissen's point of view, "The micro-level is the level of the individual in the organization. Meso is the level of the organization, its structure and culture. Macro is the level of institutions, the market, government, cultural traditions and the like" (Jeurissen 1997, p. 247). Different from them, Enderle regards micro as individuals, meso as organizations, and macro as institutions

(Enderle 2002, p. 10). Although authors mentioned above agree upon the importance of a micro–meso–macro framework, there is no satisfactory opinion upon the meaning of a micro–meso–macro framework among them. In the following section, the main topic will be turned to the explanation of the nature and characteristics of engineering.

Engineering phenomena can be analyzed at three levels, micro level, meso level, and macro level. In philosophy of engineering, it is better to follow the example of economics and to regard the micro level as individuals and enterprises, the meso level as a region or an industry, and the macro level as a nation even the world. Philosophers of engineering should investigate not only micro engineering phenomena, such as individual conduct and production of enterprises, but also meso engineering phenomena, such as a kind of engineering as an industry, development in a region, and industrial clusters, and macro engineering phenomena, such as a state development and world development.

Potts, Dopfer, and Foster call a rule system a meso. They neglect the fact that different rules are applied at those three levels. In other words, it should be noted that there are micro rules, meso rules, and macro rules. So their definition of meso is not a fitting one. While the aim of sociologists is to explain all social phenomena, scholars who conduct research in the field of philosophy of engineering limit their task to explaining engineering phenomena. In order to investigate engineering phenomena, scholars should pay attention to engineering facts, engineering acts, and engineering results, which occur at all three levels. For philosophy of engineering, both engineering "reality" and engineering "fact" should be contained in the keyword pool. In 1992, I briefly suggested an engineering realism at an international conference held in Beijing. In 1995, John R. Searle published *The Construction of Social Reality*, which is regarded as a classic in academic circles today.

Generally speaking, three terms, *social reality*, *institutional reality,* and *social fact*, are of great importance. However, in the field of philosophy of engineering, scholars should not be satisfied with an abstract theory. From my point of view, philosophers of engineering must focus on enterprises as a kind of social reality, individuals as members of an enterprise, and engineering projects as a subclass of social fact. Only in this way can scholars develop a tenable theory based on engineering practice rather than a speculative theory of visionaries. On the basis of thinking in this way, it should be proposed that the main topic of philosophy of engineering is engineering construction.

It is obvious that engineering construction is a subclass of social construction. In 1966, Peter Berger and Thomas Luckmann published *The Social Construction of Reality*. The relation and difference between the title of Peter Berger and Thomas Luckmann's book and the title of Searle's book *The Construction of Social Reality* afford much food for reflection. The core is two transformations: the transformation from "social construction" into "construction" and the transformation from "reality" into "social reality." If the two transformations would be integrated into one, then "social construction of social reality" would reveal itself. I would argue that the nature

of engineering consists in the social construction of engineering reality. The term "social" can be interpreted in a narrow sense or in a broad sense. The term "social" in its narrow sense means a social aspect which is parallel to an economic aspect, a technological aspect, a psychological aspect, and so on. The term "social" in its broad sense means integration among all aspects mentioned above. In order to distinguish its narrow senses from its broad sense, the term "social" and "societal" are respectively interpreted in a broad sense and in a narrow sense in the section below.

Briefly, social construction of engineering reality consists of a great number of aspects, technological construction of engineering reality, economic construction of engineering reality, societal construction of engineering reality, institutional construction of engineering reality, and so on. On the basis of the fact mentioned above, engineering or engineering reality means a multiple construction. Human beings construct engineering not only at a micro level but also at a meso level and a macro level. A "level" has not only a time dimension but also a space dimension. Therefore, the three levels, including a micro level, a meso level, and a macro level, have respectively three different time–space scales or measurements. At the last part of this section, a linguistic question concerning personal pronouns will be briefly discussed.

John R. Searle and Raimo Tuomela accentuate the importance of personal pronouns. Searle investigates the relationship between "I intentions" and "we intentions," and Tuomela investigates the relationship between "I-mode" and "we-mode." Searle points out that all genuinely social behavior contains collective intentionality on the part of the participants. He writes,

> [T]he problem I am discussing has a traditional name. It's called 'the problem of methodological individualism'. And the assumption has always been either you reduce collective intentionality to the first person singular, to 'I intend', or else you have to postulate a collective world spirit and all sorts of other perfectly dreadful metaphysical excrescences. But I reject the assumption that in order to have all my intentionality in my head, it must be expressible in the first person singular form. I have a great deal of intentionality, which is in the first person plural.
>
> (Searle 2001, p. 26)

Searle has acute theoretical eyesight. He considers that collective intentionality cannot be reduced to individual intentionality. He regards collective intentionality as a biologically primitive phenomenon that cannot be reduced to or eliminated in favor of something else (Searle 1995, p. 24).

Tuomela's view is parallel to Searle's view. Tuomela presents detailed analyses of I-mode and we-mode and shows that the we-mode is not reducible to the I-mode (Tuomela 2003, p. 93). Who am I? While in the span of a person's life "I" am constant, the denotation of "we" of which "I" am a member is continually changing. Thus, the relationship between "I" and "we" is a key topic in the field of social science.

In philosophy of engineering, the main range of investigation is narrowed to the relationship between "I" as a member of an engineering community and "we" as an engineering community such as an enterprise or a department of an engineering project.

Conclusion

It is natural that the keywords of philosophy of engineering consists of engineering phenomena, engineering facts, engineering reality, engineering design, engineering construction, engineering realism, and so on. In spite of a wide extension of the topic, I devote great attention to the topic of a micro–meso–macro framework and multiple constructions of engineering reality. In the history of philosophy, economics, ethics, and sociology, scholars debated whether to advocate a micro framework which is associated with individualism or a macro framework which is associated with holism. The debate concerns not only methodological issues but also ontological issues.

To investigate social phenomena, scholars developed four approaches, namely, micro-theory-based approach, macro-theory-based approach, micro–macro approach, and micro–meso–macro approach as a new kind of beyond micro–macro approach.

In 1990s, a few scholars who conducted research in the field of business ethics began to propose a micro–meso–macro framework in which the meso level becomes a key level. Recently, economists on evolutionary economics developed a micro–meso–macro framework that attracts our attention and inspires us to further efforts. Since the micro–meso–macro framework of engineering is thought of as a starting point, we can propound some new philosophical viewpoints. We regard micro–meso–macro framework as beyond the old-fashioned micro–macro split. The relationships among a micro level, a meso level, and a macro level is complicated and changeable. In contrast with a micro–macro framework, a meso level becomes a connecting or interpretive level in a micro–meso–macro framework. The presentation of the micro–meso–macro framework and multiple construction of engineering reality is of great importance and far-reaching.

From the linguistic point of view, it is not "I," "you," "he," or "she" as in the singular but "we," "you," and "they" as in the plural become subjects carrying out engineering practice. In an engineering community, individuals should be considered as its members. From the methodological and ontological point of view, an independent individual or a person as a member of the community is both identical and differential (Li et al. 2010, p. 292–304).

From the view of newly developed epistemology, it is not justification but creating, sharing, learning, organizing, and managing of knowledge that comes into the limelight which the author will expound in another article.

Because of the importance of engineering phenomena, engineering activity, engineering facts, and engineering reality, investigation of these aspects is of critical importance to the philosophy of engineering. We should stress importance on investigation of engineering facts and engineering reality in the context of a micro–meso–macro framework.

We should consider engineering in all its aspects, including a philosophical aspect, a technological aspect, a societal aspect, and a practical aspect. Engineering as a kind of social construction of social reality should be explained as a kind of multiple construction which is undertaken at micro, meso, and macro levels. The traditional micro–macro framework is obsolete. We should try to establish a new kind of micro–meso–macro framework.

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