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Beyond the Triple Helix: Framing STS in the Developmental Context

Sulfikar Amir[1] and Yanuar Nugroho[2,3]

Abstract

For the past three decades or so, the field of Science and Technology Studies (STS) has shed light on the interrelationship between modern science and technology, on one side, and contemporary society, on the other. A majority of this knowledge and insights are situated in the context of Western societies, or more precisely, in economically and technologically advanced societies in Western Europe and North America. However, STS has much to offer to the discourse of science and technology in the Global South, a territory characterized by developmental processes. Insights from different schools of thoughts in STS are arguably not only relevant but also applicable to unveil the root cause of problems that many developing societies are facing today. To make this possible, an STS-informed framework is developed to replace the Triple Helix model, which is currently a dominant perspective that prompts how science, technology, and innovation are structurally organized in the developing world. Two steps are taken in this agenda. First, limitations of the Triple Helix are exposed, and second, a new approach drawing on STS concepts is offered as an alternative model that takes into account structural, cultural, and epistemological features of technoscience.

Keywords

development, Triple Helix, science and technology studies, epistemology

Introduction

It was a beautiful morning in Bandung when a large group of academics, businessmen, and government officials were attending a special event lavishly held at a five star hotel located at the heart of the city. The event was the Triple Helix 10th International Conference, which is an annual meeting of the Torino-based Triple Helix Association. Jointly organized by Indonesia's Ministry of Research and Technology, Ministry of Education and Culture, and Institut Teknologi Bandung (ITB) with support from the government of West Java Province and the Indonesian Chamber of Commerce and Industry (KADIN), the conference brought up the theme on "Emerging Triple Helix Models for Developing Countries: From Conceptualization to Implementation." In fact, this was the first time the conference was held in a developing country in Asia in which innovation and development issues became the foci of conversations among 200 participants in the meeting, consisting of people not only from universities and research institutions but also from presenters and audiences from governmental agencies and corporations. The meeting revolved around a conceptual framework called the Triple Helix, which defines innovation as a process that involves three entities, each of which has a specific role: "The industrial sector operates as the locus of production; government as the source of contractual relations that guarantee stable interactions and exchange; the university as a source of new knowledge and technology, the generative principle of knowledge-based economies."[1] Revolving around this concept, the conference suggested developing countries to foster interrelations and collaborations of the Triple Helix institutions in order to advance economic progress.

For the past two decades, the Triple Helix has been strongly influential in directing how science and technology ought to be organized and materialized. The success of this framework in analyzing the extensive production of science and technology in developed economies prompted many researchers to employ this approach in studying how science and technology can be developed and used through similar mechanisms found in the Western system. However, the Triple Helix is by no means flawless. Despite its claimed advantages in deciphering institutional structures underpinning science and technology production, the Triple Helix framework bears some limitations. In this light, the STS

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scholarship has potentials to offer a broader perspective that goes beyond the triple-helix structure.

There is a good reason to bring STS into the discourse of science and technology in the developmental context. For the past three decades or so, the field of Science and Technology Studies,[2] hereafter STS, has shed light on the interrelationship between modern science and technology, on one side, and contemporary society, on the other. As an interdisciplinary field, STS takes advantage from multiple methods, multiple approaches, and multiple intellectual tools, to critically examine not only how technoscientific products have affected modern societies but also how a myriad of social, economic, political, and ideological factors come to intervene and direct the production of scientific knowledge and technical systems (Hacket, Amsterdamska, Lynch, & Wajcman, 2008). Thus, a wide range of technoscientific objects, from simple artifact such as bicycle and bridges to more advanced products including the Internet, medical science, nuclear energy, nanotechnology, and so forth, have been probed and analyzed by STS scholars in such distinctive ways that give us a clearer picture of the role and consequences of science and technology as a product of modernity.

Despite what STS scholars have considerably produced to unpack social, political, and cultural relations that underlie the construction of technoscience, a majority of this knowledge and insights are situated in the context of Western societies, or more precisely, in economically and technologically advanced societies mostly in Western Europe and North America. Only a tiny portion of attention has been given to issues of science, technology, and society outside these geographical domains. This is due to the fact that science and technology are genealogically modern products that have grown rapidly more in the Western world. There are a number of works that sought to compare scientific knowledge in Western tradition and in Eastern tradition, but this type of work does not pay full attention on the whole structure of relations between modern science and technology, on one side, and developing societies, on the other. As a result, STS seems to be irrelevant, if not disconnected at all, when it comes to the question of how science and technology should be examined and developed in the context of the developing world.

Although STS has been predominantly focused on revealing the coproduction of technoscience and modern, Western society, it is reasonable to believe that STS has much to offer to the discourse of science and technology in the Global South, a territory characterized by developmental processes. Insights from different schools of thoughts in STS are arguably not only relevant but also applicable to unveil the root cause of problems that many developing societies are facing today with regard to the implementation of scientific and technological programs. When development was first introduced as a modern project to the postcolonial world from 1950s through 1970s, one of the most important elements in the development program was technology[3] (Escobar, 1995). Thus, development not only entailed industrialization and the establishment of modern social and political institutions but also primarily encouraged the utilization of modern technology to remedy a wide range of problems such as lack of infrastructure, lack of clean water supply, electricity, housing, and so on. In this article, we would like to bring the STS discourse into the discussion of development and to offer a new perspective that allows us to place technoscience in a proper position within the developing world.

The article is divided into three sections. In the first section, a brief historical account is presented on the development of STS as an interdisciplinary field that seeks to unravel processes, mechanisms, and practices through which science and technology are produced. Highlighted are some of the prominent concepts that make up the STS scholarship. Furthermore, how these concepts are relevant in examining science and technology in the developmental context is discussed. In the second section, the discussion shifts to the Triple Helix, which shows how this framework has been widely used in science and technology policy in the developed and developing world. In this section, limitations of this framework in understanding science and technology in the developmental context are pointed out. The last section offers a new perspective for looking at science, technology, and development. In this section, STS is framed within the developmental context, which leads to the formulation of an STS-informed framework that enables researchers to reframe science, technology, and society in the developing world.

STS and Developmental Issues

It was during the heyday of 20th century modernization that STS started as a project to locate scientific institutions in modern society. It was pioneered by Robert Merton's (1973) study of the norms that underpinned the institution of science. Historian Thomas Kuhn (1962) also influenced the growth of STS through his seminal work, *The Structure of Scientific Revolutions*. In addition to Merton and Kuhn, there are other figures who contributed to the birth of social studies of science. Imre Lakatos, Karl Popper, Karl Mannheim, and a group of German thinkers affiliated with the Frankfurt School are among those whose works set the ground for the emergence of STS as a critical study of science and technology in the modern culture. STS began to take shape as we see it today when a group of young sociologists sought to challenge Mertonian sociology of science in defining and describing the scientific practice. The Sociology of Scientific Knowledge (SSK), as it is known, emerged out of a conviction that social scientific tools were applicable not only to explain the formation and development of scientific institutions but also to look further into the very production of scientific knowledge (Knorr-Cetina & Mulkay, 1983), a domain considered cognitive by Merton and his contemporaries, thus beyond sociological inquiry. Resorting to social constructivism, the chief agenda of SSK lies in the attempt to open the black box of science and to analyze the social construction of scientific knowledge (Barnes, 1974; Fleck, 1979). Informed by ethnomethodology, STS scholars developed a new approach to disclose the intricate process of knowledge production right from its very place, namely, the laboratory (Knorr-Cetina, 1981; Latour & Woolgar, 1979/1986). This is a site where scientists are directly engaged in the world seemingly isolated from the social sphere. STS scholars thus delved into this world driven by curiosity to comprehend social and cultural interactions established among individual scientists and their constructed environments. This approach was able to shed light on cultural features as the embodiment of science practices (Knorr-Cetina, 1999; Pickering, 1995; Traweek, 1992). It resulted in the notion of science as a system of manufactured reality, a term that refers to the assemblage of instruments, human individuals, and materials making up the networks of technoscientific production (Callon, 1986; Latour, 1987). The assemblage of these entities is certainly unique and varies across places and contexts; it is replete with symbolic elements that allow scientists to produce meanings out of scientific investigation and impose them on circulated knowledge (Hess, 1995). What empirical studies on the laboratory showed is not only that scientific knowledge is always social. More important, it is culturally situated and locally produced (Haraway, 1988; Harding, 1998). This means that scientific formulae, concepts, and theories are constructed out of specific and peculiar conditions that may not be universal. This is not, however, to say that the universality claim has no grounds to stand up. Neither is it to claim relativism in science. The underlying argument is that local realities play a role in allowing scientists to accomplish their scientific goals and that it is these realities that have been largely ignored in the sociological explanation of science (Haraway, 1997).

STS became a well-rounded field after technology was formally included in its inquiry. This is marked by the work of sociologists who studied how technology evolution is shaped by different forces in society (Bijker, Hughes, & Pinch, 1987; Bijker & Law, 1992; MacKenzie & Wajcman, 1999; Woolgar, 1991; Smith and Marx, 1994). Challenging technological determinism, STS scholars provide a myriad of empirical materials that demonstrate social, cultural, and political components imbued in the construction of technology (Winner, 1986). This signifies STS's complete foray into science and technology and solidified the framework of STS as an interdisciplinary field that enables us to critically examine what lies inside the black box of science and technology and the consequences outside the black box.

One question arises here: How are the insights STS scholars have provided through empirically grounded studies rendered relevant to problems of the developing world in relation to science and technology? Science and technology have been prevalent in development since this modern project was first introduced to the Third World over six decades ago. A large number of developmental projects carried out by transnational institutions and governmental agencies in developing countries are essentially aimed to apply scientific and technological knowledge and systems to make substantial improvements in the livelihood of the Third World people. Thus, what we see is large-scale mobilization of scientific and technological resources from developed to developing areas. Transfer of technology is the main theme of this measure. However, when science and technology travel from one location to another, there are many cases that vividly demonstrate that discrepancy between the transferred system of science and technology and local conditions of the destination country strikingly emerged (Anderson, 2002; Fortun, 2001). Such a discrepancy, which could lead to failure and even catastrophic outcomes, is due to social, cultural, and political features embodied in science and technology (Jasanoff, 2002).

The STS scholarship as briefly discussed above, however, appeared to draw scanty attention to the growth of science, technology, and innovation in relation to developmental problems. Most sociologists of science and technology whose works had dominantly shaped the STS discourse concentrated on the production and utilization of science and technology in the context of industrially advanced societies. As a result, the STS concepts such as Social Construction of Technology, Actor-Network Theory, Technological Politics, and so forth seemed to be less relevant, or perhaps disconnected to the ways in which science and technology directed development in the Third World. In their volume on *Science, Technology in a Developing World*, Shinn, Spaapen, and Krishna (1997) explicitly note this disconnection.

> STSS counterpart in the North (sociology of science, studies of technical change and innovation) offered little that appeared contextually pertinent. Neither Mertonian, Kuhnian, and social constructivist perspectives in the sociology of science nor the sophisticated perspective of economics of technical change and innovation studies evoked considerable perspective in the South (p. 16).

The lacunae between the sociology of science and technology that constitute the core of STS discourse and the problem of science, technology, and development is perhaps due to the proclivity of sociology as a scientific study of modern society. It comes as no surprise that sociologists of science and technology in the 1970s and 1980s placed their focus on science and technology as the main feature characterizing Western modernity. This is by no means that the STS perspective is completely irrelevant to understanding how science and technology interact with developmental change. In the 1990s, the STS scholarship began to engage in the developmental discourse after a number of anthropologists travelled to the Third World to examine the consequences of scientific and technological transformation in this part of the world. Arturo Escobar's *Encountering Development* (1995) is one of the most influential works in this domain. Using Foucauldian analysis of power and knowledge, Escobar dismantled the discourse of development deeply embedded in scientific rationality. In a similar vein, Kim Fortun (2001) exposes the brutality of modern technology of the chemical plant in India in causing long-term harmful impacts to the developing society whereas David Hess

(2010) provides detailed notes on the social, historical, and cultural differences in Brazilian science. Perhaps the first effort to directly link the STS scholarship to development studies is taken by those whose works bring postcolonial studies into the STS scholarship, which "seek to understand the ways in which technoscience is implicated in the postcolonial provincializing of 'universal' reason, the description of 'alternative modernities', and the recognition of hybridities, borderlands and in- between conditions" (Anderson, 2002, p. 643). Furthermore, Michael Fischer's (2009) extensive studies of science and technology particularly in Southeast Asia enlarge the spectrum of STS perspective on how culture, nature, and bodies are constructed and reconstructed in rapid developmental processes.

STS's expansion into the development discourse is further strengthened by the presence of a new generation of STS researchers who are no longer constrained by geographical boundaries. Gradually, the developmental issues were incorporated into sociological, anthropological, historical, and political studies of science and technology, a new trend marked by the notions of post and new modernities. Itty Abraham (1998) exemplifies this genre in which his historical and political examination of India's atomic bomb project results in a critical analysis of the imagination and obsession of the postcolonial state for technological superiority. Although taking a colonial period in the Dutch East Indies (now Indonesia), Suzanne Moon (2007) also contributes a new perspective to trace the genealogy of technology development in the colonial world. In a more globalized perspective, Kaushik Sunder Rajan (2006) demonstrates the global networks of technoscientific production, linking the developed society with the developing one in a large-scale biocapital production, whereas Sulfikar Amir (2012) explores into the politics of technology in Indonesia, highlighting the formation of what he refers to as the technological state as an extension of developmental state.

The growth of STS discourses beyond the Western context renders the field to have adequate tools to encounter development. As Sheila Jasanoff (2002) points out, the humanistic, interpretive, and constructivist analysis of STS can serve as a reminder of "the historical acts, or failures, of imagination that underpin development trajectories, which seem inevitable only *after* societies have definitely embarked upon them" (p. 262). Furthermore, Jasanoff believes that STS works provide ways to imagine alternative modernities for developing societies, ones that embrace science and technology and cultural harmony. This is a powerful message that we think STS scholars should follow up. However, most of STS research in the developing world ends at best in analyzing the social, cultural, historical, and political construction of technoscience in postcolonial societies without explicitly offering an alternative framework of how science and technology are socially and culturally integrated into development. STS research on development is strikingly marked by reluctance and hesitation to draw useful insights, practical implications, and instrumental models for organizing and reorganizing technoscience for betterment of billions of people living in the developing world. This is the direction that this article is primarily intended to pursue. Before we proceed to that point, the following section will examine the Triple Helix concept, which has served as the dominant model for many developing states in implementing science and technology for development. Our criticism of the model will be an entry point to our proposal of an STS-informed framework for science, technology, and development.

The Triple Helix: Limits of the Current Paradigm

In 1994, *The New Production of Knowledge* (Gibbons et al., 1994) was published. This book, judged from the citations and references, arguably became one of the most influential works dominating the discourse in innovation studies (Shinn, 2002). It argued that a new mode of the production of knowledge (referred to as "Mode 2") was emerging, distinctly different from the current traditional one ("Mode 1"). Such change transformed the way knowledge was produced and used in terms of (a) purpose and the context of application, (b) disciplinarity, (c) organizational diversity, (d) social accountability, and (e) quality assessment. The new mode believes that new knowledge is produced to solve the real problem in the context of application rather than being "disinterested." As such it can occur anywhere not only in the university and relies on the collaboration and team in broader context rather than on individual researchers in research institutes or universities. Consequently, the new production of knowledge is multidisciplinary in nature and calls for open evaluation with high level of accountability and reflexivity rather than the old model, which was disciplinary and relied too much on the academic peer reviewing with low level of social accountability. Imperatively at the policy dimension, the new mode suggests that innovation policy, rather than science policy, is a new norm for institutionalizing knowledge production processes. The table below summarizes the difference between the two modes.

Feature	Mode 1	Mode 2
Purpose and context of application	"Disinterested" generation and validation of new knowledge	Solving problems in "context of application"
Disciplinarity	Disciplinary	Multidisciplinary
Organizational diversity	Specialized knowledge production, based on individual researcher, particular research institution, or university	Knowledge production anywhere, based on collaboration and teams, in broader context and network
Social accountability	Low level	High level of accountability and reflexivity
Quality assessment	Academic peer reviewing	Open evaluation
Policy	Science policy	Innovation policy

This "mode-ist" concept of the production of knowledge quickly became one of the leading developments not only in the area of science and technology studies but also science and technology policy, reflected from the extent to which the work was cited (Shinn, 2002) and the number of conference presentations in the policy context that refer to it. However, despite the influence, the concept seemed to remain just vocabulary—at the most metaphor and catch phrase—rather than methodological foundation for at least two reasons: It had not been tested robustly (Boden, Cox, Nedeva, & Barker, 2004), and it was developed in a very specific developed context in which the evolution of science and technology and the relations to the societal problems escaped from the analysis.

The consequence of it is that it is not straightforward to look at the links between the concept of knowledge production and social practice, particularly policy making, although it undoubtedly attracted so many policy makers in the West. Perhaps obsessed by progress, the concept had been rather uncritically let to enter political and policy domain as discourse (that is to justify policy developments) as well as an ideological driver for policy changes. In Europe and the United States, the impacts were clearly observable, for example, the increasing share of public funding for research distributed through research networks rather than individual institutions grounded on the ideological belief that networks were the better way for the new production of knowledge. Although there was probably a self-fulfilling prophecy explaining the relations between new production of knowledge and policy making that was taken as the right "way to go" for policy makers (Boden et al., 2004), the concept actually did not provide much ground to learn about institutional change governing science and technology, let alone in the contexts other than the West.

Reacting to the problem of the empirical validity of The New Production of Knowledge, a new concept was born: the Triple Helix (Etzkowitz & Leydesdorff, 1995, 2000; Leydesdorff & Etzkowitz, 1996, 1998). Arguing that "Mode 2" is not new, the Triple Helix aims to model the complex system of innovation, unpacking the relations between the most important three actors in science and technology development, that is, university, government, and industry. From the outset the Triple Helix initially seemed to tackle the differences of contexts as it admitted that the developmental stages of nation states differ to great extent. However, the Triple Helix believed that the interest of these countries remain the same, that is, to foster knowledge-based economic and social development and hence offered a generic perspective to understand the mechanism through which the complexities of innovation can be untangled. The proponents of the model argue that without the helix, innovation would go on arbitrarily with many valuable aspects ignored. Central to this model is the dynamic relationship between government, industry, and universities. The argument is that three dynamics should be accounted for in order to put science and technology at work for innovation, namely, the economic dynamics of the market (industry), the dynamics of knowledge production (university), and the governance at different levels (government).

> The Triple Helix model takes the traditional forms of institutional differentiation among universities, industries and government as its starting point. The evolutionary perspective adds to this historical configuration the notion that human carriers reflexively reshape these institutions. The model thus takes account of the expanding role of the knowledge sector in relation to the political and economic infrastructure of the larger society. (Leydesdorff & Etzkowitz, 1996, p. 280)

Unlike the New Production of Knowledge, the Triple Helix has methodological ambitions, that is, to provide a conceptual model and framework in studying the complex institutionalization process involved in the process of innovation (Leydesdorff & Etzkowitz, 1998). It not only takes the "traditional forms of institutional differentiation among universities, industries and government" but also takes into account "the expanding role of the knowledge sector in relation to the political and economic infrastructure of the larger society" (Leydesdorff & Etzkowitz, 1996, p. 280).

As such the Triple Helix may have been a useful tool to enlarge research field particularly in innovation and science and technology studies, that is, to organize researchers studying issues arising at the boundaries or intersection between research, industry, and government through so many conferences, workshops, and research events and publication under this umbrella. As a result, the Triple Helix has reached beyond research communities as traditionally defined: Besides that, the framework fosters the concept of knowledge clusters and the "entrepreneurial" university; it also affected the major players in policy making, particularly politics of science as well as industrial development. The U.S. National Science Foundation, U.K. Research Councils, and other EU research councils were among those who quickly actively promoted the framework so that research, science, and technology became core in the workings of the knowledge economy.

Quickly the Triple Helix was adapted, particularly in developed economies, and became a policy norm to advancing science and technology for knowledge-based economic development. In many contexts, the framework was then translated in practice into entrepreneurial environment with business-friendly regulatory framework, profit-oriented investments, and so-called "world-class" universities. Perhaps it is no coincidence that the Triple Helix favors private property right regime since it keeps innovation going through providing incentives to researchers and innovators. In practice, however, the operationalization of the Triple Helix works rather mechanistic: The government's role is often perceived and even made to be limited only to be the facilitator of the business environment and capital; the

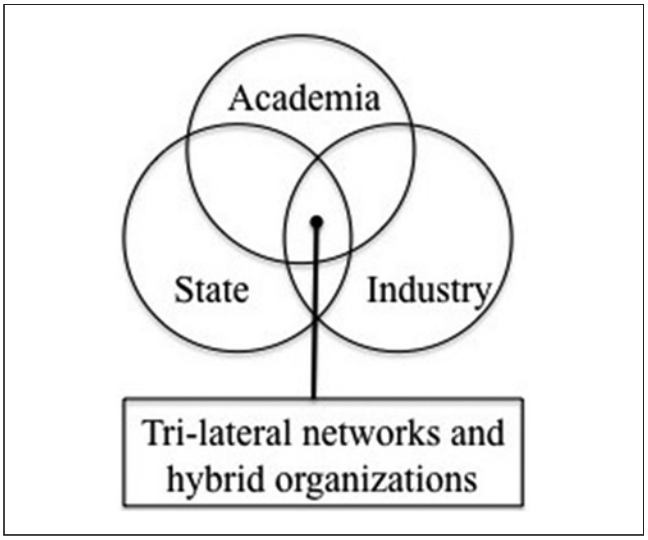

Figure 1. The Triple Helix model of university-industry-government relations.
Source. Etzkowitz and Leydesdorff (2000, p. 111).

industry functions mainly as a funnel to the marketplace; and the university generates knowledge products mostly relevant only for the market to cash in on (see Figure 1).

In a textbook case, this theoretically works out to be perfect, but the real story turns out to be very different. Reaping the benefit of the knowledge economy seems to be the only obsession of the framework that economic gain is so central. Much so that it leads many to believe that the advancement of society can only be achieved through economic growth, which is primarily underpinned by the progress of science and technology. Furthermore, technoscientific progress should be governed neatly as suggested by the Triple Helix model. This, at least, is the science and technology-led policy that seems to have been widely applied in the developed world in the West and over the past decade have been exported to many developing countries in the Global South. Since a decade ago, in emerging economies in Latin America, Asia, and Africa, the Triple Helix has become a new dominant framework informing development policies and seen as an all-encompassing-problem-solving formula to foster technoscientific progress (Shinn, 2002).

However, we witness amply documented evidences that might not reflect what the framework claims it will lead the progress to. First, the government often becomes the principal player in the development such as in the case of Singapore and China and for the sake of economic progress dictates through rules and regulations, rather than facilitates through engagements, the interaction between universities and industry (e.g., Bello & Rosenfeld, 1992; Démurger et al., 2002; Naughton, 2007; Wong, 2001, among others). Second, despite growth and progress, technological and other socioeconomic divides, which are unintended but inevitable consequences of globalization, are already leading us to crisis, both in the developed and developing nations. At the moment three quarter of the earth's seven billion population still live on less than US$2 per day; the inequality gap keeps widening (World Bank, 2011), whereas social exclusion keeps growing (e.g., Betts & Gaynor, 2010) and the environment degrades at an unprecedented speed and scale (United Nations Environment Programme, 2012). While unequal distribution and access to technology hamper development agenda through intellectual property regime in low-income or emerging economies often creating "development divide" (e.g., Chon, 2006), cases like "London Riots" show how widening societal divide can also fuel conflicts and violence in an advanced economy (Leight, Chan, & Krasnodebska, 2011); some inevitably see this as an unintended consequence of progress that science-technology–based norms like the Triple Helix cannot really address.

From the outset, the Triple Helix framework has followed a neoliberal narrative as its very purpose is all about accumulation and concentration of capital through science and technology-based innovation. It is inclined to neglect and constrain other aspects and objectives in development that are not—directly or indirectly—related to capital interests. The structure of Triple Helix seems to only encourage research toward ends that yield financial profits instead of pursuing important objectives for the people at the bottom-of-the-pyramid who cannot afford technology. For example, it is often the case where research in the so-called "entrepreneurial" universities is mostly focused toward commercialized patented products or outputs that meet the needs of those who can afford (e.g., ageing issues in developed economies; see Walker & Maltby, 2012) rather than addressing problems common to the poor (e.g., tropical diseases in the North; see Pokhrel, Reidpath, & Allotey, 2011). It is also common in developing countries that most universities are teaching-based rather than research-focused institutions for the money comes mostly from the tuition fee rather than from research income. This has, as a consequence, not only made R&D a luxury for development purpose but also created a gap in the access to scientific knowledge, which actually can be beneficial to address problems in the developing world.

It is clear that science and technology cannot be a panacea for developmental problems. It needs to be embedded within the societal contexts in which it exists—a limitation that the Triple Helix model at the moment suffers from. For those closely paying attention to the innovation dynamics, the Triple Helix model has probably become more a political rhetoric rather than a conceptual framework (e.g., Shinn, 2002). Etzkowitz and Leydesdorff (2000) seem to be confident that the Triple Helix would provide a methodological foundation to analyze the dynamics of innovations occurring among industry, government, and research. However, it fails to explain adequately the links among the three actors, except the imperative that the links have to be made in order for the collaboration to happen, no matter what (see also Boden et al., 2004). What happens is perhaps that the societal (social, economic, environmental, political, cultural) problems emerging from research and research collaboration, including commercialization, escape the attention of the model.

As such not only it fails to provide methodological foundation for analyzing change in the area of innovation, it is also defunct to be guidance for practice. The Triple Helix model appears to be more of a "political directive" suggesting an imperative that success is likely achieved through linking universities, business organizations, and government bodies rather than a conceptual framework of *how* to effectively create the links, let alone *why* these all matter. The *process* of how the helix works remains a black box as the model is uncritically adopted. As results, many unintended consequences of these links are not properly addressed. For example, the urgent drive for capitalizing the result of university research (or the lack of it) often leads to how the universities prioritize certain fields of study, risking the strategic, long-term research agenda being undermined. The collaboration itself, being only prescribed for government, university, and industry, seems to either neglect that there are many other societal actors being capable of undertaking innovative activities or over-simplifying the working of the society, the diversity of innovation undertakings, and the impacts of the dynamics interactions of the two.

In emerging or growing economies, like in Asia, the Triple Helix model is often used as a policy tool for science and technology development. Yet careful evaluation shows that research policies sometimes, if not oftentimes, fail to positively contribute to the research cooperation itself as prescribed by the model. In Korea, for example, interinstitutional collaboration is not influenced by the national science and technology policies, which focus on the numbers of academic publication rather than on the level of collaboration among academic, private, and public domains (Park & Leydesdorff, 2010). Other emerging countries that still develop their democracy, like Malaysia, for instance, have universities that are often seen as part of "statist and laissez-faire" economic regime in which the government is the dominant actor (Razak & Saad, 2007).

In our reflection, it is in fact not so surprising that in the developing countries, and in the development perspective more broadly, particularly one that embraces neoliberal thinking, science and technology have been perceived as a sine qua non for development. The result being, universities remain to be positioned as knowledge producer to enact relationships among other actors in the Triple Helix model. This is despite the very fact that today knowledge is also produced outside academic institution. Business firms, government bodies, public institutions, citizens, and consumer groups, among many others, are all knowledge producers, users, and innovators at the same time. This forces us to rethink the nature of innovative collaboration and to address the consequences and challenges emerging from it, like commercialization of research outputs and societal impacts often unaccounted for in the model.

Many attempts have hence been made to remedy this situation. Some authors have tried to remodel, or at least modify, the Triple Helix paradigm by including civil society as the fourth helix (e.g., Rigby, Nugroho, Morrison, & Miles, 2012) arguing the importance of embeddedness of the framework in the society itself. The gap in this approach as well, we understand, is the lack of acknowledgement that society itself has many subdivisions based on the wealth divide as the ones in the developing countries. While those critics are valid, we have two perspectives. First, the Triple Helix model does not pay enough attention to the problems of locality in which the model is applied, especially when research results are scaled up and commercialized. At this point, unforeseen are social problems that often occur, ranging from the changing environments for the production to consumers' concerns toward their impacts. The debate of genetically modified crops, nuclear energy, and nanotechnology are examples of this. Second, taking into account the classical sociological perspective of societal forces in society, it is rather disheartening that the Triple Helix model does not include the role of citizen or third sector as they also play an important role in the system of innovation, more than just being intermediaries (Howells, 2006).

Transcending the Triple Helix

As noted in our discussion above on the limitations of the Triple Helix framework, the challenge undertaken in this article is to bring STS concepts into the arena of development in which science and technology are regarded as the prominent medium to advance socioeconomic conditions of Third World societies. But how should development be understood? What vision should direct the public policy in, and for, development?

"Development" is in no way a value-neutral concept as it is closely associated with the discourses of "betterment," particularly of human's livelihood. As such, development cannot be separated from science and technology as its core "instrument." What is needed here is to situate, or embed, science and technology into the fabric of development, that is, societal relationships. Therefore, we are in full agreement with Sheila Jasanoff.

> It is time to invent other, more discursively open-ended concepts around which to crystallize our dreams and projects of human betterment. Not one modernity, but as many new *modernities* as the citizens of the earth can responsibly imagine should be the goal. We can only be led there through an energetic and unabashedly humanistic contemplation of *alternative democratic futures* (Jasanoff, 2002, p. 271).

This is a valid point that we want to extend forward. We suggest reframing the role of science and technology from purely an engine of economic growth, a conviction that has predominantly preoccupied development planners and governmental officials of developing states, to an institutionalized mechanism that facilitates and enhances social equality and cultural diversity. This requires relocating science and technology within the developmental discourse.

Drawing on our critics of the dominating Triple Helix framework in the discourse of science, technology, and development, we offer a new approach that seeks to overcome the shortcomings of the Triple Helix at three fronts: structural, cultural, and epistemological. The most immediate insight that we can draw from the STS scholarship to transform and reshape the framework for science and technology in the developmental context deals with the structural problem. By "structural" we mean the social and political relations that are established between technoscientific institutions and class structures in society (Kleinman, 2000). STS scholars have cogently explained that technoscience production is embedded in the social processes that are incredibly penetrated by an array of political and economic forces (Kleinman, 1995; Sarewitz, 1996). This implies the nonneutrality of science and technology in terms of direction and orientation of their development as well as their consequences. Rather, they are tightly attached to the social structures marked by a struggle of power as studied by Pierre Bourdieu (1975) and Michel Foucault (1980). Hence, the underlying logic of rapid developments in science and technology is continuously aligned with class interests (Barnes, 1977). The profit-oriented tendency that strongly characterizes the mainstream paradigm of science, technology, and innovation policy to which the Triple Helix deeply subscribes attests to this structural thesis. The bottom line is that structural factors dictate the larger proportion of the production of science and technology in which capital accumulation strikingly appears as the ultimate end. It comes as no surprise that the production and utilization of science and technology often results in the concentration of wealth and power in society. In other words, the conventional practice of science and technology merely reflects social structures that exist in society.

Efforts have been undertaken by scientists and engineers in developed countries to produce technologies devoted for the unfortunate in developing ones, such as the inexpensive laptop, the Internet for remote villages, solar-powered utensils for low-income households, and so forth. However, this technical approach does not hit the nail on the head. We are skeptical that those initiatives will bring about sustainable effects to improve the livelihood of developing societies because the core problem lies in the social and institutional structures that govern rapid progress (or lack thereof) of science and technology. Consequently, any endeavors to change the production of science and technology that benefit the majority of population in the developing and emerging economies must take into account structural transformations that allow not only the triumvirate of the state, university, and business but also a myriad of other social groups and individuals to partake in science, technology, and innovation for development. This entails a shift of power relations in technoscience. But this is not simply a cliché suggestion of "empowerment," an NGO-driven movement in the mid-1990s aiming to encourage powerful actors to share their power with grassroots communities. Such an initiative has been proven impotent and was even susceptible to manipulation (e.g., Rowlands, 1997). We recommend a radical transformation in the way science and technology is structurally reorganized, which gives opportunities for any groups and individuals in society to get involved, participate, and influence science and technology development that directly or indirectly benefit these actors. In this approach, the Triple Helix structure is no longer valid; it is replaced by a structure of multiple helices. What lies at the center is a common-pool resource of knowledge and innovation widely accessible for any interested group to harness for a variety of purposes. The CPR governance developed by Elinor Ostrom (1990) may provide an adoptable model for such structural transformations. This fluid structure will eradicate barriers and hindrance for non–triple helix agents to access science and technology resources. The materialization of this new framework will vary across societies in the developing world. Hence, it is designed as an adjustable system to suit social, cultural, economic, and political environments where science and technology grow and develop in a contextualized fashion.

Inextricably intertwined with the structural arrangement is the cultural setting. STS was able to unpack the ways in which science and technology are formed through cultural systems (Downey & Dumitt, 1997; Pickering, 1992; Reid & Traweek, 2000). The basic elements of scientific knowledge and technological systems are imbued by cultural meanings manifested in a set of practices and symbolic values. In the Triple Helix framework, scientific knowledge and technological systems are produced in the cultural environment characterized by a narrow definition of knowledge. The implication is that it is inclined to rule out, or marginalize at best, other ways of knowing originating from non-Western cultural systems (Harding, 1998). The effect of cultural contradictions in the adoption and introduction of science and technology in the developing world is enormous. A typical case creates a discrepancy between the operation of science and technology and the everyday experience of the local people. This is attributed to the universalist assumption in the mainstream technology transfer policy. Although social, cultural, and economic conditions are often acknowledged as factors to be taken into consideration in exporting science and technology through the Triple Helix scenario, it often fails to truly address the root cause of disappointing outcomes. STS emphasizes that science and technology are cultural forms anchored in a particular context of its origin. When they travel to a different social world, it is likely to undergo reformative and deformative processes that oftentimes results in an unexpected ending (Anderson & Adams, 2008). During the "transfer" process, especially through the Triple Helix arrangement, science and technology are set in particular parameters that are not fully compatible to cultural realities in the developing society, for reduction and oversimplification are likely to occur along this process. The heavy material-oriented paradigm of the Triple Helix is unable to capture nonmaterial aspects, for example, beliefs, norms, values, meanings, and so on. It renders the Triple Helix to be far from adequate and effective in turning science and technology into a panacea for misfortunes in the developing world.

The STS's understanding of the cultural dimension of science and technology offers a better framework (Hess, 1995). It suggests that the working model of science, technology, and development must recognize the cultural facts surrounding technoscience. The adoption of the cultural recipe thus consists of two parts. First, it is equipped with adequate tools to identify cultural barriers that hinder science and technology from touching on local realities. Once these cultural barriers are exposed, we need to rearrange technoscientific practices in such a way that it becomes permeable to local influences. This implies a decentering of the rationality-irrationality binary logic that preoccupies the culture of modern science and technology as promoted in the Triple Helix. Another part of the cultural strategy involves redefinition of meanings. Specifically, this refers to how science and technology are conceptualized and institutionalized that determine their relationship with society. In the alternative framework, the culture of science and technology becomes more fluid and accommodative. This does not necessarily reduce rigorousness in scientific practice. It is about how local knowledge and experience is acknowledged and accepted in the ways in which science and technology are carried out for developmental change.

One of the acute weaknesses in the Triple Helix framework is its limited ability to address social, economic, and environmental problems plaguing the majority of the Third World populations. Despite rapid growth in some developing economies, a range of dire problems, from poverty, health, infrastructures, and inequalities to violence and crime, remain prevalent throughout the Third World. Science, technology, and innovation policies seem to ignore the proliferation of these problems on the ground. To change this situation cannot be achieved simply by offering what modern science and technology have done for industrially advanced societies. This is because the problem lies less in what science and technology can offer than how to make the production of science and technology responsive to those situations. Accordingly, any efforts to adjust the production system of science and technology to accomplish developmental goals must take into account not only the increase of knowledge production but also changes in the content of knowledge. This adds another element, namely, epistemology, to the whole package of the alternative framework offered in this article. For the structural and cultural dimensions require epistemological reconstruction in order to have a complete transformation following the STS prescription.

Changes in epistemological features that allow science and technology to get connected to, and anchored in, the developmental reality is justified, and supported, by ample works in STS, in particular the philosophy of science stream, that look into the epistemological ingredient of scientific knowledge. Not only institutions, networks, and practices of technoscience are socially constructed but also the very content of knowledge are also socially, culturally, and politically shaped and conditioned. From this vantage point, it explains why modern science and technology encounter difficulties in achieving satisfactory outputs for the developing societies due to the epistemological foundation, which is formed and shaped in different social, cultural, and political conditions alien to the developing world. Therefore, we should go into the heart of the problem by modifying the epistemological ingredients that inform and direct how science and technology yield productive outputs for the local people (Harding, 2000; Sardar, 1998). This is not a simple task because it involves dismantling the ideology of modernity embodied in the scientific epistemology. If the structure and culture of scientific knowledge and technological systems change, it will open up the possibility for an epistemological transformation to take place (Woodhouse, Hess, Breyman, & Martin, 2002). In practice, epistemological transformation refers to changes in two main areas that prompt how science and technology are entangled with local realities. First, it switches the research agendas in which problems are chosen and defined; problems to be researched are chosen and defined not exclusively by scientists, engineers, and high-leveled technocrats but set in a more democratic arrangement that allow different social groups to influence (Fischer, 2000; Harding, 2000). Second, it deals with methodologies suitable for indigenously produced knowledge. This is the area that defines how scientific and technological researches are conducted and directed. An open-ended approach in the methodology allows pluralistic knowledge systems from multiple perspectives to be included and advanced for the progress of the Third World society.

Conclusion

This article rests on the argument that the STS scholarship is highly relevant to the developmental context. Although since its inception STS scholars have been focusing more on a variety of issues, problems, and dynamics of science and technology in the context of industrially advanced countries, we believe that the insights from the STS scholarship have merits in examining how science and technology should have worked in developing societies. In doing so, we have briefly reviewed the historical development of the STS scholarship by highlighting some prominent concepts and ideas that have contributed to the establishment of STS as an interdisciplinary field.

To frame STS in the developmental context, we have critically examined one particular framework, namely, the Triple Helix. This framework is currently dominating the discourse of science, technology, and innovation in developing economies. It has wide influences in public agencies as well as private sectors especially for the past 10 years. As a matter of fact, the Triple Helix has established itself as a technoscientific regime that aims to regulate how science and technology is organized through the balanced roles between the government, university, and industry. As we have argued, the Triple Helix framework is plagued by shortcomings due to its narrowed goal on capital accumulation. It also tends to rule out social groups that are considered incompetent and incapable for handling technoscientific matters. As a result, the outputs of the Triple-Helix–oriented policies are often times very limited in scope and ineffective in remedying socioeconomic ills of the society in developing countries.

This all happens, in our hindsight, because the mainstream view may have a convenient way of explaining the working of science and technology in society: The people (adopters, users) cannot but yield to the advancement of the inventors and innovators—as evident in the assumption of Triple Helix. This is why the diffusion of science and technology in Triple Helix model is often seen as patron-client relationship: the scientific and technological innovation as patron, and user or adopter as client. This has been characterizing the discourse in the model. However, there is a drawback in this logic: The explanation for successful implementation of the Triple Helix lies mostly in the assumption of technological determinism. Not only is such perspective weak in its logic, it also lags behind the empirical process it aims to explain.

As an alternative to the Triple Helix framework, we resort to three most valuable insights from STS, which we believe constitute a better lens to critically examine the rapid proliferation of technoscience in the Global South and to reveal the implications of such a development. The first one deals with the structures through which the production of science and technology is organized. We highlight the empirical facts from STS researches that demonstrate how science and technology are socially, culturally, and politically constructed. Thus, what we suggest is reconstruction of these structures that enables multiple groups to engage in technoscientific development. The second insight concerns about the cultural strategy in which we propose redefinition of meanings in science and technology. This redefinition will open up new possibilities for local knowledge systems to be incorporated in tackling real problems in the developing world. The last one discusses the epistemological foundation in science and technology. In this light, we stress the importance of epistemological transformation to alter how scientific and technological research is performed. It refers to a more democratic arrangement in problem definition and the use of multiple methodologies in which local knowledge, values, and wisdoms are seen as potential resources for technoscientific progress.

On the last note, we are aware that to achieve the objective in transforming the framework for science and technology production in the developing world will take massive efforts and firm commitment. We also realize that this proposal bears some limitations. For it needs further work to transform the alternative framework into a doable policy recommendation and institutionalized governance. Notwithstanding these limitations, we hope to have initiated an intellectual discourse that aims to bring STS outside its comfort zone. Nevertheless, framing STS in the developmental context should be a new challenge for the field to extend its relevance in the globalized society today.

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Notes

1. STS is also referred to as Science, Technology, and Society.
2. In this program, scientific knowledge was included as one package of technological development.

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