Chapter Two

Science, Technology, and Society

Introduction

In the previous chapter, we argued that the discourse of the meanings and relations of S&T is of great importance to a study of science policy. In that, the discussion focused mainly on the epistemological background of S&T with brief overviews of the philosophical and historical discourse of S&T. The latter was meant to provide us with the different forms and interpretations accorded to S&T through out the centuries which helps explain the relations of S&T and the different attitudes adopted by the scientists and engineers towards S&T. In addition, we also adopted the view that the relations of S&T and the attitudes adopted by the scientists and engineers towards it immensely influence the outcome of a policy.

How S&T is understood, not only epistemologically but sociologically, influences our understanding of the interactions between S&T and society. This is our subject of discussion in the present chapter. In any discussion of the interactions between S&T and society, it is important to keep in mind the different meanings of S&T discussed in the last chapter. How we come to define S&T and to understand their relationships effects our description of the interactions between S&T and society.

S&T and Society

Given the long history of the relation between S&T and society and the difficulty on determining the precise time of the origin of the interaction, it becomes almost impossible to give a definite historical background of this interaction. Nevertheless, in the context of this discussion, which explores the influence of S&T and society and the impact of the social demand on the development of S&T, it suffices to say that, this interaction began when human being invented tools to extend their capacity in order to survive. The origin of this interaction then obviously starts with the Stone Age when human being invented tools from the stones for hunting and for protection against wild animals. This social phenomenon influenced that society in many different ways.

The tools made of stones were a beginning that changed the material aspect of life in that society. It enabled the people to hunt without much difficulty and increased the possibility of better life and survival. People were now enabled to hunt large number of animals. In addition, the stone tools give man a weapon to defend themselves in a newer way against the external enemies, humans as well as wild animals.

The interaction between S&T and society, however, evolved and developed steadily through out the centuries together with the development of S&T. Charles and Boyle have explained this interaction in three models, the *linear model*, the *interaction model* and the *embedded model.*[83] The *linear model*, as the name indicates, starts with the discoveries in science leading to technological applications that produce certain effects on society.[84]

This model largely reflects the assembly line model in production. In the assembly line model, in production, research in pure science leads to new discoveries and the later leads to production. This type of interaction between S&T and society is believed to have existed in the nineteenth century. At that time, the pure research in electricity and magnetism led to the study of electrons, which eventually led to the invention of television. The resulting effects of this development on society were the dissemination of information and news, entertainment, propaganda, advertising and so on.[85]

However, this model presents a simplistic and deterministic picture of the interaction between S&T and society. In this, S&T have been understood simply as a process and technique which are discovered and produced as cause and effect and which then influences the society in direct and fixed way.

The second model outlined by Boyle is called the *interaction model.* This model explains the changes in society in terms of demands by the society leading to scientific and technological innovation. This model can be found in the interaction of S&T and society in the eighteenth century when the economic need - a demand by

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[83] Charles Boyle, p.4.
[84] Ibid.
[85] Ibid.

society - for a new source of power led to the invention and the gradual improvement of the steam engine.[86]

This model seems to be the reverse of the first model, the linear model. In the linear model, as discussed above, the scientific discovery leads to technological innovation and the later exerts its influence on the society. In the *interaction model*, the demands from society lead to technological innovation and the later in turn add to the stock of scientific knowledge.

Moreover, this model operate based on the law of supply and demand, in economics. Whereby the customers demand leads as well as decides the supply and the quality of the goods in the market. Also the demand for a different product, including an improved one, depends on the demands of the customers which consequently leads to improvement of the processes and techniques of production.

Such an understanding of the interaction between S&T and society perhaps have tremendous implication for science policy including R&D. In this context, R&D related decisions including funding for particular fields of technology development would be guided largely according to the national demands. If there exist a demand for R&D in specific areas, like computer and telecommunication technology than that would be translated into policy and the funds for R&D will be channelled towards developing that fields. If, on the other hand, there is demand for developing nuclear weapons technology than nuclear related R&D gets considerable attention.

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[86] Ibid.

Furthermore, an important point that relate to the epistemology of S&T and seems to have influenced the description of this model of interaction pertains to the relationship between S&T, explained in the last chapter. In this model, the S&T is understood as two isolated things and interacts only with the presence of an external factor, mostly the demand by society. However, this was true in the past. And it was due to the scarcity of the resources and the scarcity of knowledge of science and technology. However, the interaction between S&T and society have taken a different form and shape in which science and technology are considered as embedded to each other and tends to overlap in their development.

The *embedded model*, the third model, is based on the view of S&T as immersed in society and gradually soaks through them as through a sponge.[87] In this, S&T is not anymore autonomous and isolated from each other. The scientists use the insights of social studies to provide perspectives on science and technology. In addition, the direction and development of S&T is largely conditioned by the socio-cultural, political and economic factors. Where socio-political and economic factors influence the scientific and technological development, and shape, to some extent, the epistemological and philosophical views of S&T.

Thus, in this type of interaction, S&T being embedded in society exert great influence on society including the social intuitions, culture and worldview. McGinn studies this influence at two levels of society, the *societal* sectors as well as the

[87] Ibid, p.6

ideational realm.[88] The societal sector includes the social institutions, like workforce (workers' patterns of social interactions) and social groups, (the women, the elderly, and the children). And the ideational sector represents the mental realm of the society including worldviews, ideas, norms, beliefs, attitudes, feelings, and expectations. to name just a few, of the society.

At the societal sector, S&T has brought about significant changes and improvements. Empirical studies show that in the last century and a half, a series of far-reaching techno-economic changes has transformed the institution of work in both its economic and non-economic roles. The impact of S&T on the institution, further, of work involves one or more of the three general components. They include power by which the activity in question is carried out; the *control* exercised over the work process; and *intellectual analysis and decision making* pertaining to work goals, means, and processes.[89]

The *power* component of work has changed from one based on human and animal physical power with inanimate sources of energy to energy-generating technologies. Moreover, the processes of control have gone mechanisation, to the extent that to a significant degree, control over work processes is now exercised via technological means. In addition the integrated-flow assembly lines, computer-assisted manufacturing systems, and remote-sensing devices are a notable example of this.

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[88] Robert McGinn, p.130.
[89] Ibid,p.106.

Furthermore, in recent years even the conceptual-intellectual component of work activity has begun to undergo mechanisation. Computer-based programs and procedures have been developed to assist in product and system design, as have computer-based "expert systems" for medical diagnosis and financial, industrial, and military decision making.[90]

The ideational influence of modern scientific and technological change includes several mental elements including the worldviews, beliefs and attitudes. The first great influence of S&T on worldviews in modern Western culture was one brought about by the scientific revolution of the seventeenth century. The changes in man's understanding of the universe and of his place and purpose in it that have occurred in antiquity through the Renaissance to the Enlightenment and the modern times, have largely been brought about by development in science.[91]

This was emphasised more by Kuhn where he contends that, "after a revolution scientists are responding to a different world", and, "after the revolution scientists work in a different world."[92] Kuhn explains this change in worldview as a result of change in scientific paradigm, when paradigm changes, the world itself changes with them...and paradigm changes do cause the scientists to see the world of their research engagement differently.[93]

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[90] Ibid.
[91] J.D. Bernal, 1967, p.3.
[92] Thomas Kuhn, *The Structure of Scientific Revolution*, (Chicago: University of Chicago Press, 1970), p.111 &135.
[93] Ibid, p.111.

Hugh Kearney sees this change as result of improvement in techniques. According to him, the change results largely from the advances in techniques and scientific instruments, with a different and improved technique the scientists look at the world in a different way. "In fact, the improved technique enables them to go deep in their exploration of the universe. As the new sophisticated instruments enabled man to land on the moon and go for sea quest."[94]

Take for example the character of the modern science which was based on the mechanical conception of the universe, and explained the world in mechanical terms. This conception of universe had a great impact on man's life and thought, it changed the worldview, the social institutions, and man's place in it.

By around 1700, educated man conceived the universe as a mechanical structure like a clock, the earth was regarded as a planet revolving around the sun, and the mysteries of nature were supposed to be open to investigation by means of experimentation and mathematical analysis. These new attitudes to the natural world contrast strikingly with the traditional conception of nature. In the traditional sense the earth was immobile and the centre of the cosmos. The cosmos itself was envisaged as a structure of crystalline spheres enveloping the central earth like the layers of an onion; nature was conceived as a living organism, a connected structure link by a web of hidden active power.[95]

It is now clear from the above overview of the interactions of the S&T and society that each influences the development of the other in certain ways. However,

[94] Hugh Kearney, 1981, 64.

the conclusion that can be drawn from the interaction between S&T and society at the present time would be that although society influences the direction in the development of S&T, it is S&T that have an upper hand in this relationship. To rephrase the sentence, S&T being the engine of economic growth today determines the direction in which a society should go rather than the other way round. And this becomes a cause for concern given the tremendous power S&T can yield that can lead to catastrophe if it is not managed appropriately.

This indicates the importance of S&T Policy today, which has become part of socio-economic planning in almost all countries, including Malaysia. However, the reason for the management of S&T by the governments and private corporations is not that, if not managed appropriately S&T will yield destructive results but rather it is the economic concerns by the governments that necessitates the management of S&T.

The Politics of Science

Politics of science investigates the impact of politics and political ideologies on the management of S&T. It would prove a difficult task to determine the exact period and time of the development of the interaction between politics and S&T. However, as Condorcent, the French philosopher, expressed in the 1700s "In every century Princes have been found to love sciences even to cultivate them, to attract Savants to their places and to reward by their favours and their amity men who

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[95] P.M. Harman, *The Scientific Revolution*, (London: Methuen, 1983), pp. 8-9.

afforded them a sure and constant refuge from world-weariness a sort of disease to which supreme power seems particularly prone."[96]

The reasons for the attitude of the Princes towards S&T were different than the intention of the politicians are now. The Princes would do that for love of knowledge and wisdom and for religious practices and metaphysical reasons. Governments now support S&T for purely political and ideological reasons. In this discussion, we choose two case studies which illustrates the impact of political ideologies and pure politics on policy for S&T. The first case looks at the role of Marxism as a political ideology on the development of S&T, in the former Soviet Union. While the second case would look at the broader issue of politics and sciences as represented in the Manhattan project.

The ideology of the former Soviet Union was based on Marxism and drew its conduct of science and technology from the tenets of the Marxist ideology. Marxism perceives the material world to be conditioned by the society we live in. In which there takes place a process of continuous creation, satisfaction, and recreation of human needs. Human beings struggle with their environment in an attempt to satisfy their needs, however their efforts are limited by the conditions of the societies in which they work: technology, ideology, division of labour, and so forth. Therefore, human history is determined by the relationships of labour to ownership.[97] And S&T is a determinant factor in the development of these societies. As Marx puts it, "the

[96] Jean Jacques Salomon, *Science and Politics*, (Cambridge: MIT Press, 1973), p.3.
[97] Ian P. McGreal, ed., *Great Thinkers of the Western World*, (New York: Harper Collins Publishers, 1992), p.379.

hand-mill will give you society with the feudal lord, the steam-mill society with industrial capitalism."[98] That is why Marx blames the capitalist societies for using S&T for dominating people.[99]

This conception of S&T resulted into the Marxists believe that the development and application of S&T is basic for the creation of a Marxist society. Therefore, in the former Soviet Union where Marxism was the official ideology of the country, the communist party allotted S&T an exceptional place in the struggle to construct a socialist state. As V.I. Lenin asserted that "The proletarian revolution was the first in history to place all achievements of science and culture at the service of the people."[100]

This conception of S&T led to the Marxist believe that, S&T is basic to the creation of a socialist society. This attitude dominated the practice of S&T in the former Empire. The natural sciences became the primary target in this campaign. To this end, in the 20's and later a strong ideological campaign was launched by the communist party to redirect the attention of the Russian scientist from the Western science towards the creation of a natural science based on Marxist ideology.

Two principal themes have run through party policy towards the Soviet scientific community since the late 1960:[101] First, the enhancement of the role of the

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[98] Neil Postman, *The Surrender of Culture to Technology*, (New York: Vintage Books, 1993), p.21. quoted by Ibid, p.75.
[99] John Stachel, "Science, Politics and Social Practice", Kostas Gavroglu, Marx W. Wartofsky, *Science, Politics and Social Practice*, eds., (London: Kluwer Academic Publishers, 1995), p.75.
[100] UNESCO, *Science Policy and the Organisation of Research in the U.S.S.R.*, (France: UNESCO, 1967), p.10.
[101] Peter Keen, *Soviet Scientist and the State: Studies in Soviet History and Society*, R.W. Davies, (Ed.), (The Macmillan Press Ltd, 1984), p.82.

party in the scientific institutions. Second the pursuit of the effective science.[102] This was to infuse the influence of the party policy into the scientific community so the party could be confident about the outcome of the community and avoid the involvement of the scientist in the activities that are not in the interest of the socialist state.

Led by the Communist party, the campaign towards the creation of a Marxist science initiated several programmes. One was aimed at providing forums for scientists to discuss the broader implications of their work and, in the process, to acquire an appropriately Communist interpretation of their role in Soviet society.[103] In the meantime, the communist party started also publishing papers and books combating idealism in all sciences, including physics, chemistry, biology and even mathematics.[104] Instead, dialectical materialism was proclaimed as the general method of all sciences, including the applied sciences. [105] In addition, as extra measures the communist party took control of appointment of the scientists to administrative positions within the scientific community. This includes the appointment of the directors of research establishments, their deputies and the heads of the divisions and laboratories.[106]

To communists this measure was necessary. Only few of the most leading Russian scientists who had been educated before the Revolution were members of the

[102] Ibid, p.82.
[103] Ibid,p.69.
[104] Ibid, p.44.
[105] Ibid, p.50.
[106] P.R. Hiskes,p.70.

Communist Party.[107] Moreover, the scientists were mainly active in the field of pure research, which was not good enough for the Socialist State. The Academy and other scientific organisations were often chastised for being devoted to pure science without sufficient regard for political and economic goal.[108]

Through the control of the administrative practices, members of Communist Party were empowered in the scientific community. By the 1970s the majority of the Academy's administrators including the top officers, the members of the Academy Presidium, the scientific secretaries, the administrators of the division, even the laboratory directors were all members of the Communist Party. A small number included also those scientists who avoided conflict of interest between science and politics."[109]

Moreover, the political campaign to create a Marxist science was not confined only to the realm of natural sciences, it was extended to the social sciences too. Beginning in the 1920s, it was communist party's to train Marxist scholars to replace the historians, philosophers, jurists of the pre-Revolutionary period, who were considered to be unsympathetic to the Soviet government.[110]

This practice, gradually changed the role of scientists and technologist in the scientific community. It significantly weakened the structure of the scientific community and put the management of scientific research to the hands of politicians.

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[107] Harvey Brooks & Chester L. Cooper, eds., *Science for Public Policy* , (England: Pergamon Press, 1987), p.133.
[108] Ibid, p.133.
[109] Ibid, p.134.
[110] Ibid, p.76.

As a result the Soviet academy of sciences was subject to systematic pressure to undertake technical projects which did not allow an objective and positive practice of scientific and technological knowledge.[111]

The Manhattan project represents another picture of the influence of political practice on S&T. The project which took place during World War II resulted in the invention of the nuclear bomb. The success of this project brought to the fore the weight politics can have on S&T. Although, the practice of military research was common, in different countries of Western Europe, United States, Japan and China, even before the war, however, it did not involve such a radical innovation either in science or politics. For example during the World War I in Britain, government-funded research councils were created to form the basis of scientific organisation and to ensure that adequate resources were made available for scientists to pursue their researches in military, medical, agricultural and industrial fields.[112]

The production of the atomic bomb and its impact on world politics brought a paradigm shift in the interaction of politics with S&T. It opened the way for the political domination of the practice of S&T, which throughout this century fostered the creation of new technologies for military and political domination.[113] In addition, this new relationship between politics and S&T gives the governments a major role in defining the objectives of scientific research and technological development. Now

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[111] Ibid, p.98.
[112] Charles Boyle, p.51.
[113] Ibid, p.48.

the governments orders the scientific community to provide ways and means of achieving goals that scientist do not set.[114]

Science Policy

Science policy is defined as the intention to influence the development of S&T in a coherent way by authoritative and informed decisions.[115] Its task is to identify problem areas within the progress of society, to express these social problems as the goals of scientific research and development. Its objective also is to find means and ways of achieving these goals, to allocate resources for various branches of research, and to advance the utilisation of the results of research.[116]

The precise dates for the origin of S&T Policy differ from country to country. It started to grow much earlier in some countries than in another. For example, in France there was a tradition of interaction between science and government predating the Napoleon Period. Russia, on the other hand, did not have a science policy until a few years after 1917 revolution.

It is important to point out that, in the study of science policy of a particular country it is important to distinguish, on the one hand between general efforts and practices in the areas of science and technology, and continuing national efforts, on the other hand. Almost all societies have shown commitment to the use and development of S&T. What it means by the origin of science policy is, the moment

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[114] P.R. Hiskes, *Science, Technology, and Policy Decisions*, (Cambridge: Cambridge University Press 1991), pp.40-41.
[115] Andrew Webster, *Science, Technology and Society: New Directions*, (New Yirk: Macmillan:1991),p.34.
[116] Ilkka Niniluoto, p.226.

when a nation first attempted to formulate a policy towards S&T and as a whole and to sustain and revise that policy overtime.

For example, Russia has a long scientific tradition that dates back to the Tsarist government. It even had organised scientific community involved in scientific activities. The Russian Academy of Sciences founded in 1725, and its universities, such as those of Moscow and St. Petersburg, dating to the mid-eighteenth and early nineteenth centuries, were the foci of significant scientific research long before the 1917 revolution.[117]

Despite this strong tradition of science in the pre-Revolutionary period, Russia did not have a science policy. Science policy only started after the Revolution of 1917. When the government made organised attempts to direct the efforts of scientific and technological communities towards industrialisation and military weapons.

It is also believed that the development of science policy started immediately after World War II. Britain in the 1920s, for example, described the need for new machinery and for additional state assistance in fostering and to organise scientific research. The need was created as a result of the need for heavy machinery and

[117] The strongest tradition in the history of Russia in science before the 1917 revolution was probably mathematics, a tradition created and sustained by a series of brilliant scholars of whom N.I. Lobachevsky, M.V. Ostragradsky, V.I. Buniakovsky, and P.L. Chebyshev are examples. Another tradition in pre-Revolutionary Russian science was that of chemistry. The greatest figure in this field was Mendeleyev whose principle achievement came to the formulation of periodic tables of the elements. Peter Kenn, *Soviet Scientist and the State: Studies in Soviet History and Society*, R.W. Davies, (Ed.) New York: Macmillan Press Ltd, 19984), p.79.

equipment for trade and industry.[118] In Russia, on the other hand, the practice of science policy began immediately after the revolution of 1917.

In the United States science policy originated during World War II. It was when the United States began to seek ways to enhance its military potential by organising its resources.[119] At that time, the main objective was the massive mobilisation of science and technology for the war effort.[120]

However, the efforts to use S&T for military purposes continued even after WW2. The arms race between the former Soviet Union and the United States was motive behind the massive R&D in the in different fields for military purposes.[121]

The utilisation S&T for military purposes was, of course, one aspect of S&T in the US, with the other aspects being the socio-economic objectives. As in the words of Nelkin, over the next 20 years science policy studies were concerned with the application of S&T for socio-economic development; where the main concern was to find strategies and institutions for effective support of scientific research and technological development.[122]

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[118] Andrew Webster, "Scheme for the Organisation and Development of Scientific and Industrial Research", *HMSO*, (1914-16)Cd 8005, 1., 1991, p.351., 1991.

[119] UNESCO, "National Science Policy of the USA: Origins, Development, and Present Status", No.10., (Paris: UNESCO, 1968), p.21. An eight-member National Defence Research Committee (NDRC) was established in the 1940 was to conduct research on the matters relating directly to the processes and instruments of warfare. Ibid.

[120] Jurgen Schmandt, "Science Policy: One Step forward, Two Steps back", Joseph Haberes, ed., *Science and Technology Policy & Problems*, (Lexington: 1977), p.9.

[121] Ibid, p.9.

[122] Dorothy Nelkin, "Trends in Science Policy: The search for Controls", Joseph Haberes, ed., *Science and Technology Policy & Problems*, (Lexington Books, 1977), p.69.

If we look deeply into the treatment of S&T by the governments at the present time and also in the past, there appears to be yet another dimension to the utilisation of S&T for national development, that of politics of S&T. The politics of science that is correlated to the socio-cultural and economic aspects of S&T is in fact draws attention from the governments throughout history. Given the arm race and strives for dominance and also struggle for survival and self defence, by other nations, the political factor has become an overriding factor in the government decisions towards the formulation and execution of S&T policy in our time.

Conclusion

This chapter focused on; (i) the interactions between science, technology and society, (ii) politics of science and (iii)science policy. In discussing the first, three models of interactions between S&T and society was discussed; (a) linear, (b) interacting, and (c) embedded. An alternative view that incorporates all the models is considered here. This view takes into account the epistemological influence of S&T as well as dynamics of the interaction between social factors in the development of S&T.

Science in the early stages of its development was mainly speculative, it was part of human activity in the society. However, science was a marginal activity without much influence on the society. In this science and technology exist independent of each other, although both are organised activities in the domain of society.

The next stage of development in this interaction, which pictures the existing situation today, dates back to the time when science and technology became more developed and started to shape society. In this model, S&T became autonomous disciplines and independent forces which did not really stood outside the society but rather became a major agent of change in the society.

The politics of science is about the interaction of S&T with politics in society. As soon as the impact of S&T on the society is felt, the interaction between S&T and government becomes intimate and this relation becomes a matter of national concern. Governments start to encourage the development of science by awarding the practitioners, funding building institutions for scientific and technological activities and granting funds for R&D in particular fields. However, the interaction between the two changes with the changes in the role of government conditioned by the political ideology of the government.

And the brief overview on the meaning, origin and development of science policy in this chapter is meant to set the background discussion on Malaysia's science policy discussed in the next part.