Basic Research and National Goals: The Vietnam Academy of Science and Technology in an Emerging Innovation System

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Abstract

The mission of the National Center for Scientific Research set up in the 1970s included an ambition to address the core problem of responding to society's needs. With reforms in the early 1990s, there was an attempt to reorient the activities of the renamed National Center for Natural Science and Technology in response to the Đổi mới policies of economic liberalization. The optimism of the scientists regarding the opportunities for external sources of income from research contracts and commercialization of technology through entrepreneurial ventures only materialized to a limited extent. During the 21st Century, the leadership of the scientific organization – now called the Vietnam Academy of Science and Technology – and the Vietnamese Government have reiterated mission priorities for serving the society and establishing a key role in the innovation system. The recent five years have witnessed some improvement in this respect, however, with the consolidation of a legal framework and the establishment of new funding mechanisms for research and innovation. The lack of consistent orientation among scientists towards exploring and developing the utility of scientific research (i.e., Pasteur's quadrant), and the absence of psychological and material incentives for linkages with potential users and markets also hampered commercialization; those who ventured into the marketplace with their services for products had little experience about scaling up of production, marketing, or other aspects of business.

Keywords: Basic Research; Science and Technology; Innovation; Vietnam

1. Introduction

Vietnam has entered the ranks of middle-income countries and is widely considered an emerging economy with substantial potential for GDP growth (World Bank, 2017). However, the strategies of resource-based development that the Vietnamese economic reforms have encouraged since the 1990s will probably not be sustainable in the long run (Beresford, 2008). It is therefore essential to transition the national economy into high value industries, based on a stronger effort to integrate R&D and innovation in the Vietnamese economy. A recent analysis carried out under the auspices of the OECD and The World Bank noted that previous sources of growth are diminishing in power, and accordingly Vietnam will have to rely more on productivity gains driven by innovation, in order to avoid the "middle-income trap" (OECD/The World Bank, 2014: 15). Vietnam may avoid getting trapped in a "middle-income trap" by implementing the vision for reaching higher value-added production put forward by the Vietnamese Government for 2020 through the development of realistic industrial strategies and concrete action plans (Ohno, 2009). An important element of such strategies is the development of an effective innovation system in the country.

An ambitious science and technology development strategy for the period 2011-2020 was approved in 2012 by the Prime Minister Nguyễn Tấn Dũng, among other things aiming to boost the value of high-tech products or to 45% of total industrial production value by 2020 and to increase the amount of international scientific publications by 15-20% per year during the decade (Prime Minister, 2012). This strategy would require a major boost of the efficiency and effectiveness of the national innovation system in Vietnam. In many respects, the innovation

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system is weak, suffering from a very low level of output in terms of innovative products and services. One recent paper providing a diagnostic overview of Vietnam's national innovations system concludes that it is still very much at the early stage of development and faces many weaknesses the most significant being (Ahn et al, 2013):

- Isolation of research institutions including universities from the productive sectors of the economy;
- Within the productive sectors of the economy, the linkages between the more advanced (FDI) sectors with the laggard (domestic SMEs) are weak;
- There is a still favorable bias toward the state sectors;
- Higher education sector is not operating properly as the source of knowledge creation and transfer;
- Inadequate level of coordination between the policies, especially incentives for R&D for the business community; and
- Insufficient coordination between S&T policies at the national, regional, and community levels.

Moreover, the strategy identified the Vietnam Academy of Science and Technology and the Vietnam Academy of Social Sciences as targeted to become leading S&T organizations in Vietnam and ASEAN. VAST was established on the basis of an image of elite basic science and strategic applied research similar to the Soviet Academy of Sciences, and the organization still shares some features of that model. But it is also charged with a mission to support economic and social development in ways similar to public research institutes in both industrialized and developing countries.

The spread of advanced science has a long history, with the emergence of independent scientific and technological organizations in developing countries as a key element of modern economic growth (Basalla, 1967). In the optimism that followed the triumph of science in the Manhattan project and the development of powerful nuclear technologies during the Second World War, many countries established new scientific organizations that were designed to contribute to defense and economic development. This spirit permeated the United Nations and international organizations such UNESCO, which had been established in 1935 under the initial leadership of the British philosopher Julian Huxley with a special mission to promote science internationally. Similar ideas were also apparent in the remarkable consensus among scholars and policy makers, who shared the view that scientific and technological progress is an essential component of economic development, epitomized in the US by the influential report *Science: The Endless Frontier*, prepared by the presidential advisor Vannevar Bush (1945). The key message concerning the role of science in development, and the need for national policies promoting science, also became institutionalized in norms that were actively diffused to developing countries with rudimentary scientific activities by UNESCO in the 1950s and 1960s (Finnemore, 1993). On the basis of rather simplistic assumptions about the contribution of fundamental science to technological development – the so-called "linear model of innovation" – policy makers in the developing world were encouraged to adopt wholesale the organizations and frameworks for science that had been considered the driving forces of the military and economic strength of advanced countries.

This process can be characterized as mimetic institutional isomorphism for the development of science (DiMaggio and Powell, 1983; Frumkin and Galaskiewicz, 2004). Under the spell of modernization theory, the wholesale transfer of institutions of modern science to developing countries was assumed to provide these countries with economic growth, eli minating poverty and backwardness. However, a study of the experience of developing countries where science organizations following a mimetic institutional isomorphism model of modern science indicated that these organizations did not effectively contribute to economic development

(Shenhav and Kamens, 1991). For developing countries that were allied with the Soviet Union, such as China and Vietnam, a similar process of institutional imitation took place. The Soviet efforts to develop a science and technology system followed a linear model closely resembling the ideals proposed by Bush, but employing additional dogmatic principles of division of labor between scientific research, education and production (Graham, 1993).

The Chinese adopted the Soviet system of planning for scientific and technological development during industrialization in the 1950s, and created – with extensive assistance from Soviet experts – a network of sector research institutes under ministries of industries or agriculture. In addition, China created the Chinese Academy of Sciences that included the most prominent scientists in the country and a range of research institutes where basic and applied research for major projects in social and economic development were conducted (Suttmeier, 1974; Cao, 2004). This system survived severe onslaughts during the Cultural Revolution and reemerged during the 1970s, after which it underwent substantial reform in the 1980s (Baark, 1988). Following market-based reforms and the transformation of many research institutes to state-owned enterprises and the introduction of competitive research funding in major programs, the operation of a new system of innovation in China increasingly has come to resemble those of advanced industrialized countries (OECD, 2008). In the national innovation system, the Chinese Academy of Sciences has maintained its position as an organization which combines scientific excellence in major basic science disciplines with applied research and development related to areas of strategic importance for China (Suttmeier, Cao and Simon, 2006). In addition, the Chinese Academy of Sciences has implemented a "Knowledge Innovation Program" during the last decade, with the aim of catching up with leading scientific institutions internationally (Liu and Zhi, 2010). According to a recent analysis, the Chinese Academy of Science has been more successful in this endeavor than its former model, the Russian Academy of Sciences, as illustrated by a comparison of outputs in the new area of nanotechnology (Karaulova et al., 2017).

In Vietnam, the influence of the Soviet model became especially pronounced during the 1970s, when policy makers started to address issues of peaceful reconstruction of the unified country. Nevertheless, on account of the economic and political challenges faced by the Vietnamese government, it was not possible to achieve a full institutional isomorphism. The creation of S&T infrastructure had already been prepared during the 1960s, and were further enhanced by advanced training of large group of scientists and engineers in the Soviet Union and Eastern Europe. This paper examines how the Vietnam Academy of Science and Technology (VAST) – which was originally established as the National Center for Scientific Research (NCSR) in 1975, but changed its English name to the Vietnam Academy of Science and Technology[2] in 2003 – has evolved from a network of research institutes engaged primarily in basic research in natural sciences to a complex organization covering research and technological development across a wide range of scientific and technological fields.

The funding for activities at VAST still account for approximately 10% of the Vietnamese Government budget appropriations for S&T, and VAST scientists usually succeed in obtaining

[2] Somewhat confusingly, the organization has changed both its Vietnamese name and its official English name several times. In 1975, it was established as Viện Khoa học Việt Nam (literally: Vietnam Institute of Sciences) with the English designation Vietnam Center for Scientific Research. In 1993, the name was changed to Trung tâm Khoa học Tự nhiên và Công nghệ Quốc gia , with the English name National Center for Natural Sciences and Technology. In 2004, it became Viện Khoa học và Công nghệ Việt Nam (Literally Vietnam Institute of Sciences and Technology), with an English name Vietnam Academy of Science and Technology. Finally, the Vietnamese name was changed in 2012 to Viện Hàn lâm Khoa học và Công nghệ Việt Nam, keeping the English designation Vietnam Academy of Science and Technology. Interestingly, most of the time it has been known as "Viện" (literally: institute); but in this paper I shall generally refer to it as VAST, which is the current international designation for the organization.

almost half of the project funding for fundamental research granted by the Ministry of Science and Technology. Nevertheless, a persistent dilemma has been how the Academy should maintain a position as a champion of advanced research while, at the same time, becoming an important source of new technology for the economy – that is, balancing the role of conducting advanced science with the development and commercialization of technology. During the 1990s, the science and technology policy makers in the Vietnamese government and in the National Center for Science and Technology (VAST predecessor) attempted to complete a transition from the emphasis on basic research to use-inspired basic research and applications to solve social and economic problems. This transition was partly successful in making such a transition in a few fields of science and technology, but hardly solved the inherent issues of science for development. As a result, the rapid economic development and emerging transformation of the higher education sector in Vietnam has tended to marginalize VAST in the gradual expansion of the domestic innovation system in Vietnam during recent years (OECD/The World Bank, 2014).

The formulation and implementation of policies to support the role of science and technology and ultimately innovation in developing economies has been a major challenge for policy makers, and priorities have shifted considerably during recent decades. The traditional scientistic policy paradigm of the "linear model of innovation" encountered a challenge from neo-classical economic concepts that emphasized the role of market forces and the private sector in technological innovation, and thus the utility of applied research (Godin, 2006). This perspective has, in turn, been gradually replaced by concepts derived from evolutionary economics and inter-disciplinary perspectives that emphasize the extent to which the creation and application of knowledge is endogenous to the processes of economic development. The systemic nature of innovation is now seen as an essential conceptual reference point for science and technology policy and, indeed, it can be argued that the traditional approach of "science policy" was transformed to "technology policy" – and ultimate to "innovation policy" during the late 1990s (Lundvall and Borrás, 2005).

This development has been accompanied by the "institutional turn" in the economics of innovation, providing a new emphasis on the role of transaction costs, regulation and cultural values in incentivizing actors to pursue economic development and innovation (Carvalho et al., 2017; Evans, 2006). An institutional turn has proved very powerful in understanding essential development problems and policies in low-income countries, and can be considered the "third generation" of development economics (Altman, 2011). Institutional analysis has been very useful in a study exploring the difficulties that Russia has experienced in promoting innovation, coming to the conclusion that "Russia has faced historical barriers to innovation that we assert have stemmed primarily from a lack of institutional support, both formal and informal. In previous eras, the country has generally failed to move meaningfully beyond the innovation creation or invention stage. Without serious and coordinated institutional changes, current innovation initiatives would likely have the same unfortunate outcomes." (McCarthy et al., 2014, p. 254).

At the same time, the role of universities and public research organizations such as government laboratories as sources of new technological knowledge in national innovation systems have been increasingly highlighted in the academic literature (e.g., Crow and Bozeman 1998; Etzkowitz, 2008). Thus, public research organizations face increasing demands from society to realize the fruits of its efforts and contribute more concretely to a nation's economic growth and competitiveness (Laredo and Mustar 2004; Sharif and Baark, 2011). As observed by Ziman (1994), governments in many countries have concluded that they could no longer afford unconditional support for basic science due to the limits of available resources. In France, policies to encourage the commercialization - or valorization - of research output from universities and public research institutes were introduced in the 1980s and they have gradually

reoriented concepts of the relationship between publicly funded research and the private enterprise sector, affecting activities of organizations such as the *Centre National de la Recherche Scientifique* (Vavakova 2006). Even in Russia, where the research system had inherited Soviet concepts of a division of labour in research, and support for basic science in the Academy, governments initiated reforms to foster a commercial culture in the research organizations, trying to push them to respond to demand from business (Graham and Dezhina, 2008: 67-88).

With the increased reliance on R&D and innovation for competitiveness in most economies, institutional reforms are designed to provide strong incentives for public research organizations to commercialize research results (Walwyn and Scholes, 2006; Sharif and Baark, 2011). In Brazil, public research organizations were forced to compete for extra-budgetary funds and to (re)define their core competencies (Salles-Filho and Bonacelli, 2010, p. 202). On the other hand, quite a few countries have successfully mobilized public research institutes in national efforts to build scientific and technological capabilities for catching up with industrialized countries. The institutional context of the successful initiatives shows that the research programs did not operate within "ivory towers," but were oriented towards an actual or potential user-community (Mazzoleni and Nelson, 2007: p. 1525).

In other words, public research organizations such as the Vietnam Academy of Science and Technology are increasingly called upon to link closely with user communities in the economy in order to assist these in creating technological capabilities. In the case of the Vietnamese research organization, this implied institutional change from the pattern of the Soviet Academy of Sciences – which arguably was inappropriate in the context of the Vietnamese economy from the very beginning – to a model similar to the Korea Institute of Science and Technology, or the Industrial Technology Research Institute in Taiwan (Mazzoleni and Nelson, 2007: 1521-1522). Typically, such a process would be prompted by exogenous factors such as the challenges and potential opportunities presented by the structural economic reforms, but also by endogenous gradual institutional change within the organization (Mahoney and Thelen, 2009).

In Vietnam science management was significantly influenced by the exogenous shock introduced by the Đổi Mới [renovation] policy in the late 1980s that brought economic crisis and opening of market transactions in the economy in its wake, and the shift in science and technology policy towards a new emphasis on the applied research and technology development. At the same time, endogenous institutional changes in the scientific institutes sought to mobilize a shift towards use-inspired basic research. There was also an emergence of a new entrepreneurial culture among scientists which led some people to leave the institutes in order to pursue careers in spin-off enterprises. This phenomenon was partly related to excessive rates of inflation which made it impossible for scientists to live on a fixed salary provided by the state, forcing many to seek alternative employment to survive.

The key research questions addressed in this paper are therefore the following:

(1) What was the mission of the public research organization that became VAST when it was set up in the 1970s, and how has this mission evolved and been implemented during the following decades?
(2) Which factors influenced attempts to commercialize the results of VAST science and technology development through external contracts or entrepreneurial ventures?
(3) How does S&T policies affect the status of VAST in 21st Century Vietnam?

For the analysis of the process of institutional changes that Vietnam's premier research organization has experienced during the last four decades, this paper has adopted a qualitative research method examining the influence of policy in a historical development process. This

has focused on utilizing the information and data sources available in English and Vietnamese on important events and policy statements for science and technology since the 1970s. The academic literature on these topics is very limited, and therefore the most important documentary sources primarily originate from government reports or decisions. In addition, the paper is based on quantitative and qualitative data collected in interviews with two categories of respondents that could provide essential insights into the growth and status of VAST and its activities. One category was a select number of people who had been part of the core leadership of the organization at earlier periods, and who had been very influential in setting the goals and priorities during significant events. The other category consisted of people who had engaged in entrepreneurial activities related to VAST, including some that had set up spin-off companies. These interviews were conducted using a general question guide, but were very flexible in terms of discussing any issue or topic that the respondents believed were crucial to understanding the processes of change.

2. Science for Vietnam's Post-War Reconstruction

When it became evident that Vietnam would have to prepare for reconstruction after the Vietnam War, the role of scientific research became an even more vital element of development. The inspiration for developing a Vietnamese science policy came from the Soviet Union, where the concept of scientific-technological revolution (STR) had been developed by, among others, Bukharin (Cooper, 1977; Graham, 1993). As mentioned earlier, the Soviet approach epitomized a linear model of innovation, assigning a strict division of labor between basic research in the Academy, applied research in industrial research institutes, and application in production units. For example, in the Resolution on "Improvement of Scientific and Technical Activities in the New Situation," issued by the Central Committee of the Communist Party of Vietnam in 1967, two important tasks of science and technology were stressed: first, to serve actively the technical revolution in the war time; and secondly, to prepare the technical revolution in the whole country on a broader scale and higher level after the resistance war against the United States was completed successfully. Regarding the first task, some concrete issues were identified, for example enhancement of production means from handicraft to semi-mechanization or mechanization in industry, agriculture, transportation, irrigation; and improvement of mass movements to march into science and technology at the grass-roots level. The second task included the following tasks: (1) to develop strategies for carrying out the technical revolution and developing science and technology; (2) to build up scientific-technical manpower; (3) to investigate natural conditions and resources; (4) to be informed about world's scientific-technical results and to be able to understand the latest scientific-technical knowledge, which are related to the socialist construction in Vietnam; (5) to set up a national R&D system; and (6) to conduct basic scientific research in the fields which have to be tackled in the future (see "Resolution…," 1969).

After the war, the legendary General Võ Nguyên Giáp, who was appointed to take responsibility as Minister of Science in 1977 and who remained a leading proponent of science, summarized the Communist Party of Vietnam's views on the need for a scientific and technical revolution as follows:

> The socialist revolution in Vietnam consists of three revolutions which have to be carried out simultaneously and cohesively. That is the correct and new viewpoint, presenting the particular essence of Vietnam's transformation from backward to socialist production. The revolution in production relations leads to the creation and gradual improvement of socialist relations of production, hence opening the way for the development of STR and the revolution in ideology and culture. The STR has the task of enhancing, consolidating and improving the revolution in production and at the same time mobilizing the revolution in ideology and culture. The revolution in ideology and

> culture will create the prerequisites and conditions for STR and revolution in production relations. Therefore, all three revolutions possess crucial position without considering which one is the less important; nevertheless, the STR has a key position. (Giap, 1977)

In other words, scientific research and technological development were to be carried out for the purpose of socialist production, in conjunction with the transformation of society through socialist ideology and culture. This would happen under the guidance of the Communist Party of Vietnam in accordance with government plans. There was no concept of an autonomous scientific elite pursuing a fundamental quest for knowledge, or responding to market demand for new technology.

It was against this background that the Prime Minister sent a delegation to the Soviet Union and Eastern Europe in 1969 to investigate how an appropriate organization could be formed to develop science in Vietnam, and information and expert advice collected by this delegation also helped formulate the strategy for setting up a Commission for S&T under the Government. The recommendations of the delegation also included the creation of the National Center for Scientific Research (NCSR), set up in 1975. This organization was established to become a key performer of basic research – in particular mathematics and theoretical physics – in Vietnam. The concrete plans for the establishment of the National Center were developed during 1970-75, with the participation of the Prime Minister, and with the assistance of experts from the Soviet Union. Because of the high priority attached to the task by the government and the detailed preparations, the National Center could be set up quickly after reunification – the organizational framework completed in only 3 weeks (Interview no. 1). As indicated in the quote by Giáp above, the purpose was to support the cultural and material strength of Vietnam through inputs to socialist production. In addition, it was decided to achieve this by means of concentrating scientific resources on specific research programs and projects, including 11 high priority projects carried out experimentally during 1977-1980. Because the NCSR should play an important role in advancing S&T in Vietnam, the organization was placed directly under the Council of Ministers. This position gives the NCSR several advantages, compared with other research institutes. On the one hand, the NCSR enjoys special commitments including financial support from the government: the director of the NCSR had the status of a minister. On the other hand, the budgetary funds granted by the government offered the government the opportunity to impose certain priorities and major directions, thereby limiting the autonomy of the NCSR.

During the 1970s the National Center for Scientific Research thus entered its first stage of development, with the main center facilities established in Hanoi and affiliates set up in HCM City. During this period most scientists were recruited from Vietnam and socialist countries, and very few from Western countries. It was not difficult to recruit more than 1000 staff in 1975, because many scientist and engineers who had received their education in the countries of Eastern Europe or the Soviet Union were eager to join the most advanced scientific institution in Vietnam. The key tasks of the National Center were defined by Politburo Decision 97 of 1981 which envisaged that the organization would pursue its aims and operate on the basis of the model operating for the Soviet Academy of Sciences. For the people who became engaged in the early development of the academic units under NCSR, the context of post-war reconstruction under a Soviet-inspired system of planned economy naturally encouraged a bureaucratic interventionist model. In the Soviet Union and China, this approach became totally intermeshed with strategic priorities of nuclear and space technologies and the needs of the military-industrial complex. But interestingly, in Vietnam such military priorities became less influential in the portfolio of research conducted at the National Centre, despite the background of General Giáp as a famous military strategist.The participation of the scientific community in the policy-making process was by and large passive and limited. The nature of

the Vietnamese intellectual tradition and the relation between the literati and the state meant that Vietnamese intellectuals never achieved the status of an autonomous social group. The dominant Confucian philosophy created a sense of professionalism in the bureaucracy, instilling a perception of intellectuals as the key to efficient and honest government in an authoritarian society. Thus the Vietnamese literati were largely integrated into the hierarchy of state power through the institutionalization of dependency (Marr, 1988). There were few incentives for scientists to develop autonomous linkages with enterprises or other social organizations outside the scope of state planning. Similar to the Soviet Academy of Sciences, serving society consisted in fulfilling tasks set by the state and expecting society to utilize the results without further engagement by the scientists.

3. Reform and Markets

The economic reforms introduced with the Đổi Mới [renovation] policy in the late 1980s opened up entirely new opportunities for market forces to regulate the demand for new technologies, and thus significantly changed the conditions under which organizations engaged in scientific research could engage with business units (Dam, 1996; Ca, 1999, p. 45-51). Science and technology policy in Vietnam underwent major changes in the 1990s as a consequence of a general political change towards liberalization of the economy and opening to the international markets that had followed the introduction of *Đổi mới* in the late 1980s (Meske and Thinh, 2000). The planned socialist development which the Vietnamese Communist Party implemented during the first decade after unification in 1976 had not achieved the expected results, and did not appear to be an appropriate model for the conditions in Vietnam.

The process of reform was gradual, however, as the new policies of economic liberalization promulgated during the Sixth Party Congress in 1986 were implemented in the years that followed – sometimes encountering considerable opposition from ideologues or vested interest groups, or shaped in a symbiotic relation between the state and the people (Masina, 2006). Economic liberalization was successful in kick-starting an economy that had suffered severe stagnation and inadequate growth, but the overtures for political and intellectual liberalization that had emerged in the 1980s did not lead to further changes (Quinn-Judge, 2006). The integration of the two economies in the North and South also brought serious challenges for the government to stimulate technological upgrading in agriculture and industry, and a closer link between research and production was seen as necessary. This would have involved a move from Bohr's quadrant towards Pasteur's quadrant for scientific research, and closer interaction with firms or peasants who required solutions to their technological problems. However, at the time commercial research contracts between research institutes and production units were considered illegal, since all such relations should be "managed" and "controlled" by the State Planning Committee the State Commission of Science and Technology in accordance with the Plan of Scientific-Technological Progress. This can be seen in the important point stressed at the 6th National Party Congress in 1986, namely, that Vietnam's economy was now conceived as a planned commodity economy, in which R&D institutions together with enterprises constitute producers of knowledge commodities. As a result, according to Giáp (1989),

> … it is necessary to confirm that scientific results produced by R&D institutions (existing in forms of knowledge or material products) are by and large also commodities, a special type or often called commodities with high values. Naturally they have to participate in the process of economic circulation, distribution, exchange and consumption. Social demands in consumption are the starting point of scientific and technological activities. Meeting the social demands and accepting the market are the criteria to assess social relevance, effectiveness and economic values of scientific and technological activities.

For Giáp, the main principle in the new format of the organization and management of S&T was to integrate science with the economy. In an important sense, the leadership now acknowledged that scientific activities are not only linked with production; rather they have to be linked with consumption – i.e., in Pasteur's quadrant. Such linkages, which were so conspicuously absent in Vietnam's innovation system, were to be invigorated by social demand and mediated by market forces, demolishing the ivory tower that had characterized scientific institutions hitherto (Annerstedt and Ha, 1996). It is important to note that the economic conditions had deteriorated for scientists during the 1980s, as rampant inflation and stagnating salaries for state sector employees had made it virtually impossible to survive on the basis of one official job, and many scientists had been forced to take up one of several extra ways of earning an income. Since state funding for scientific equipment, materials, and prototype equipment had dried up, the opportunities for extra research funding, equipment and income offered by R&D contracts became essential for many institutes; a study conducted in 1989 found that the majority of research institutes received less than one quarter of their budget from the state (Annerstedt and Ha, 1996, p. 230).

Economic liberalization thus opened up new opportunities to contribute to industry and agriculture, while compensating for dwindling funding from the state, in particular for advanced technologies that were becoming the cornerstone of a new industrial revolution, such as information technology and biotechnology. During the 1980s, the President of NCSR Prof. Nguyễn Văn Hiệu had therefore encouraged the organization to carry out research in these fields and to develop indigenous technological capabilities. This led to potential opportunities for commercialization of technology transfer and for the establishment of new technology-based firms. The policies adopted the new paradigm that economic growth constitutes the ultimate goal of all development, and that the leverage of market forces and commercialization would provide the best incentives steering scientific research towards useful areas of technological development. New organizational changes and an expansion of research centers in addition to the 13 individual research institutes that existed at NCSR was designed to help scientists engage in applied research and technology development. As part of this process, the Institute of Cybernetics became the Institute for Information Technology, and the Institute for Experimental Biology became the Institute for Biotechnology.

In 1993, the government subsequently changed NCSR's name to the National Center for Natural Science and Technology (NCNST). More than a change in name, the new title indicated the extent of reforms in the organization and the function of the Center. Specifically, adding "technology" to the name of the Center implied that there would be more emphasis on contributions to economic and technological development. Before 1993, the activities of the scientists were formally 100% oriented towards scientific publications, but after 1993 the proportion of activities oriented towards publication remained 70%, while 30% of the activities at the new National Center for Natural Science and Technology became focused on invention (Interview no. 4). Moreover, it was assumed that the institutes and scientists under NCNST would become further engaged in supporting the transfer of technology from abroad. Many of the organizational and institutional changes were inspired by the model of the Korea Institute of Science and Technology (KIST), which had successfully assisted the creation of technological capacity in Korean industries. The inspiration from the KIST model also led to the attempt to introduce a new structure combining the core of research institutes undertaking fundamental research with a range of multidisciplinary research centers designed to carry out applied research and development.

The 1993 policy change was supported by the advice provided by several key scientists and powerful politicians, including the Minister of S&T and the Prime Minister. When the

proposals were to be implemented, however, it proved difficult to convince many scientists that this was the right way to go (interview no. 4). Therefore, the Prime Minister had to personally intervene in order to persuade the scientists to reorient their work. The significance of the new policy, and the fact that the National Center undertook a major organizational and strategic transformation was not widely understood in society, where the majority of people still believed that the Center should remain the same. The 1993 transformation was intended to create a National Center that operated in ways more appropriate for Vietnam. Nevertheless, the budget of the organization hardly increased, and the NCNST continued to receive nearly all its income from the government. The policy also assumed that the commercialization of technology by scientists, or the establishment of entrepreneurial high technology firms by researchers, would generate substantial income for the research organization. It was envisioned that the income would provide substantial new resources for research and better living conditions for the staff at NCNST. Income from external research and technical service contracts appear to have increased during the 1980s, and since the 1990s has constituted around twice as much as the funds provided from state agencies.

The prospects of generating income from surveys of natural resources in Vietnam (such as oil prospecting) encouraged the National Center to engage substantial research resources in carrying out fundamental surveys of Vietnam. Therefore, national surveys of natural conditions, natural resources, and natural environment became major tasks of newly established institutes for geography, geology, and environment respectively. Environmental services remain a very important avenue for contract research, constituting a large non-state income source for the Institute of Environmental Technology, amounting to 113 billion VND in 2016. When commercialization of research results and technical services became possible and was encouraged through institutional change in the 1980s and the 1990s, the National Center for Natural Science and Technology also started to promote entrepreneurship and helped establish more than 20 business groups. But commercialization of technology was typically very difficult at the stage of scaling up production or marketing of products.
In the late 1990s, several spin-off firms that had been set up by individual institutes turned out to be loss-making ventures. But even in the most successful cases of spin-off enterprises from NCNST, there was little benefit for the parent organization. One particularly interesting case is the FPT Group. This firm had been set up by scientists from the Institute of Mechanics, because they were able to buy some food processing equipment from a state-owned factory that had imported the equipment, but did not have the technological capability to operate it. They repaired the equipment and started to produce juice, etc. Therefore, the acronym FPT originally stood for “Food Processing Technology,” but it has been changed to designate “Financing and Promotion of Technology.” During its initial years, the firm had very good connections with the Government, and could utilize these connections for doing business, especially to import equipment (and even planes) from countries in Eastern Europe. After a number of years, the FPT Group became an importer of information technology systems to Vietnam, and it is now one of the leading IT service providers in the country, with revenues amounting to 1.8 billion US dollars and 28,397 employees in 2016. After privatization, the FPT Group does not have much relationship with VAST, and appears mostly to treat VAST like a “Grandfather”, visiting the VAST headquarters bringing some gifts on the occasion of New Year celebrations at Tết. One important aspect of the issue of the relationship between VAST and FPT is that, according to some observers, the technological level of VAST in IT systems is lower than the technologies available to FPT, so VAST has nothing to offer FPT (Interview no. 1).

4. The Academy in 21st Century

In 2004 the Government approved a change of the name to Vietnam Academy of Science and Technology (VAST). According to the Vietnamese Government Decree No. 62/2008/ND-CP, issued 12 May 2008, the functions, tasks, powers and organizational structures of the Vietnam Academy of Science and Technology is to conduct research into natural sciences and develop technologies in accordance with the state's key directions. It should also supply scientific results as a base for the mission of promoting management science, technology and building policy, strategy, project, schedule for socioeconomic development. In addition, it should train human resources in science and technology that can contribute highly skilled people for national development. The budget for the organization included 1,661.1 billion VND (almost 75 million USD) allocated by the Government budget for 2017. Around 55.5% of the budget should be spent on recurring costs for scientific activities, while 36.6% of the budget will finance new investments (VAST Annual Report., 2016). At the same time, the reliance on external sources of funding through research contracts has continued during recent years, as can be seen from Table 1.

Table 1: Research Contract Income for VAST, 2011-2016 (Billion VND)

	2011	2012	2013	2014	2015	2016
State Contracts	-	-	-	132	136	194
External contracts	-	-	-	218	266	287
Total Contract Revenue	118	151	230	350	402	481

Source: VAST *Annual Reports* 2011-2016

During 2016 institutes under VAST have signed 1076 contracts with a total budget of 300 billion VND. This includes 834 economic contracts with companies with a total budget of more than approximately 200 billion VND. The remaining contracts include 242 agreements, worth about 200 billion VND. The Institute of Environmental Technology has signed 467 contracts during 2016 with a total revenue from economic contracts of approximately 90 billion VND (Vietnam Academy of Science and Technology, 2016).

4.1 Scientific publications:

The output from the scientific research undertaken by VAST institutes has increased marginally during recent years. Table 2 below shows the figures provided in an official report from VAST. It is noteworthy that the leadership has succeeded in raising the figure for scientific publications in international journals, which obviously is a key criterion for achieving recognition in basic science. According to one source, the VAST publications represent 40-45% of the total international scientific articles in natural sciences by Vietnamese scientists.

Table 2: Scientific Publications by VAST, 2011-2016

	Category	2011	2012	2013	2014	2015	2016
A	Total number of scientific publications (1+2+3+4+5)	1.612	1.698	2.298	2.074	2.197	2.007
B	Publications in international journals (1+2+3+4)	550	601	660	803	802	996
C	Publications in SCI and SCI-E journals (1+2)	334	401	435	523	588	742
1	Publications in SCI journals	209	258	282	298	317	387
2	Publications in SCI-E journals	125	143	153	225	271	355
3	Publications in international journals with ISSN/ISBN codes (2016 only count the number of articles for journals ISSN)	216	200	225	246	176	248
4	Publications in VAST1 journals*				34	38	6
5	Publications in national journals	1.062	1.097	1.638	1.271	1.395	1.011

Source: VAST *Annual Report* 2016

Note: * In 2014-2015: 3 journals (Advances in Natural Sciences: Nanoscience and Nanotechnology, Vietnam Journal of Mathematics, Acta Mathematica Vietnamica); In 2016: 2 journals (Vietnam Journal of Mathematics, Acta Mathematica Vietnamica).

4.2 Intellectual property:

One of the indicators reflecting an increased emphasis on applied research and development in many public research institutes and universities is typically the amount of patented inventions or utility models. In the case of VAST, however, this figure has often been single digit numbers, as shown in Table 3.

Table 3: Patents and Utility Models Registered by VAST, 2011-2016

Category	2011	2012	2013	2014	2015	2016
Number of patents	7	7	7	3	11	11
Number of utility solutions	4	5	6	10	7	17

Source: VAST *Annual Reports* 2011-2016

The legal framework for intellectual property protection in Vietnam has been under development since the 1980s, and became formally approved as a Law on Intellectual Property (Law No. 50/2005/QH11) in 2005, with amendments adopted into Law No. 36/2009/QH12 in 2009. It should be noted that the annual number of patents granted to Vietnamese residents grew from 48 in 2011 to 76 in 2016, so getting 11 patents granted by VAST in 2016 would still constitute a considerable amount. Many researchers and inventors in Vietnam are still unfamiliar with the procedures and requirements of patent applications, however. A report on S&T results in Vietnam notes that patent application descriptions are often inadequate, illustrations missing, and no documentation from patent search is evident, so applications are often rejected (National Institute of Scientific and Technological Information, 2012).

4.3 Education and Post-Graduate Training:

Given the academic resources and research capabilities that exist at VAST, the opportunities for undertaking post-graduate education have been obvious, and therefore PhD and Masters programs have been set up by institutes to provide advanced education during the 1990s. Training of researchers during the early decades of the center was mostly undertaken as part of basic research projects, while opportunities for more formal doctoral research usually involved

overseas training in the Soviet Union and Eastern European countries. During the 1990s, more formal PG degree programs and PhD programs became popular in Vietnam, and the first type in particular provided opportunities for additional income for the institutes. At the early stage, PhD training was often done through the graduate level academic training of the Research Institution System of VAST, often in collaboration with major universities in Vietnam or abroad. In September 2014 VAST established The Graduate University of Science and Technology (GUST) under Decision number 1691/Q-TTg by the Prime Minister of the Socialist Republic of Vietnam. Currently, GUST is offering 50 Ph.D. programs and 14 M.Sc. programs in the fields of natural sciences and technology, belonging to 11 academic faculties, with 798 Ph.D. students.

Another flagship educational initiative was the University of Science and Technology Hanoi (USTH), which was established in 2009 under an international agreement between Vietnam and France, with cooperation of VAST, the Asian Development Bank and a consortium of 42 universities in France. In March 2016 the Prime Minister decided to transfer USTH to VAST management, to help VAST institutes to participate more actively in training and research at the university. A new campus is under construction at the Hoa Lac Hi Tech Park in the vicinity of Hanoi, and an agreement of cooperation with GUST has been signed to achieve better coordination between the two post graduate training institutions.

4.4 New Strategies*:*

In recent years, it was realized that interdisciplinary approaches would be necessary to address issues such as the consequences of climate change. This shows that there is a need to readjust research orientation all the time to take into account the new situation and environment, where fundamental research, applied research and development are inter-dependent in modern world. During the 1990s, concerns with environmental issues related to economic development also gained strength in Vietnam, and civil society activities often became important components in large projects (Sinh, 2002). In this way, the considerations of usefulness for society became influential in some areas of research, in particular those related to the environment. Nevertheless, such considerations remained relatively marginal in other fields of science and technological development, where pure economic priorities have continued to dominate. The tradition of top-down decision-making and emphasis on identification of high-priority plan targets also lingers on in the Vietnamese government. Research management and leadership in Vietnamese organizations remains weak, with large gaps in qualifications of leading administrators and a low level of effectiveness in the practical performance of research administration and projects; on top of this, the apparent lack of coordination between government agencies responsible for the management and funding of S&T projects leads to waste of time and resources (Olsson and Meek, 2013). The strategy approved by the Prime Minister for the development of S&T – and the strategy for VAST promulgated at about the same time – have long sections of general sector priorities, and often very specific priorities in terms of the quantity and nature of technologies desired, but with weak statements concerning the institutional or financial means to achieve such priorities.

An assessment of the strategy in 2014 noted that a qualitative chance had indeed taken place in international scientific publications, which had increased about 20% annually. Moreover, 4 Vietnamese scientific organizations had been recognized as highly ranked in ASEAN, with the VAST considered the strongest in Vietnam (Strategy Working Group, 2014: 102-03). Nevertheless, the same report acknowledges continuing challenges in achieving other targets of the strategy; for example, the value of high-tech and high technology applied products only increased slowly from 19.81% in 2010 to 20.47% in 2011.

Vietnamese policy makers expect VAST to play a central role in scientific research and economic development over the next decade, as demonstrated by the master development plan

for VAST approved by the Prime Minister on 1 December 2011 that states, inter alia: “Develop, with a sharp breakthrough, the Vietnam Academy of Science and Technology to become a powerful multi-disciplinary research and training centre of science and technology, a driving force for the national development of science and technology, to greatly contribute to speeding up socio-economic development, ensuring national defense and security, and meeting the demand of industrialization, modernization and international integration.” (Prime Minister, 2011).

There have been encouraging signs that the Vietnamese Government has increased its investments in research and development, raising the level of GERD/GDP from 0.19 in 2011 to 0.37 in 2013 according to official statistics (Ministry of Science and Technology, 2015: p. 86). In 2011, the business sector only provided 26% of the expenditure on R&D, but this proportion had grown to 52%, with a few companies providing the bulk of funding. Nevertheless, the assessment of the strategy noted: “The total annual investment from state budget for the whole system of S&T of Vietnam now is more or less US$1 billion, only 2 times higher the amount that Republic of Korea invests for a research institute of electronics and telecommunication (in 2010, ETRI Institute’s budget was over US$500 million to cover research expenses of 1,900 researchers)” (Strategy Working Group, 2014: 105). With thousands of research institutes and key research programs dependent on state funds, it is actually quite surprising that significant scientific and technological results have been achieved in recent years.

With the adoption of the important Resolution No. 20-NQ/TW at the 6th Plenum of the Central Committee of the Communist Party of Vietnam in its 11th session in 2012, entitled "On the S&T development to serve the cause of industrialization and modernization in conditions of socialist-oriented market economy and international integration," the introduction of a more complete legislative framework was initiated, spearheaded by an amendment of the Law on Science and Technology promulgated in 2013. Moreover, the National Foundation for S&T Development (NAFOSTED) had been created in 2003 for competitive, peer-reviewed funding of research projects; its activities were expanded in 2014, when 518 applications were received in natural sciences, and 25% of new international scientific articles published by Vietnamese scientist derived from NAFOSTED funded projects. The National Technology Innovation Fund with a statue capital of 1,000 Billion VND was set up in 2011 for support to innovation projects; and the Vietnamese S&T Enterprise Startup Fund, the first private fund for venture capital in Vietnam, was set up in 2014. These initiatives will probably help new entrepreneurial ventures using advanced R&D results to overcome the perennial problem of getting access to finance (OECD, 2014: 65-66) that killed many of the spin-off firms set up by VAST in the 1990s. Subsequently, there appears to a significant growth of S&T enterprises in Vietnam. An article published recently (Nguyen Van Anh et al, 2014) cited several official statements that indicated that there would be around 2000 S&T enterprises in Vietnam, but also pointed out that only 123 enterprises have received certificates as S&T enterprises by the authorities. On the other hand, the authors noted that at least 400 enterprises have been approved for establishment in Vietnamese High Tech Zones and Incubators, and therefore that at least 500 enterprises could be considered as based on research and development. Still, there is a long way to go to reach the 5000 S&T enterprises in 2020 that has been set out as the official goal for Vietnam in the Strategy for 2011-2020.

5. Conclusions

The analysis of the historical development and current challenges of VAST indicates that there are no simple and singular solutions to the dilemmas of public research organizations. The mission of the National Center for Scientific Research set up in the 1970s included an ambition to address the core problem of responding to society’s needs. However, the scientists were

operating a system of planning that replicated a strict division of labor between research, development and production. Moreover, the mentality of "Bohr's Quadrant" in Stokes (1997) terminology emphasized pure research without immediate orientation towards usefulness.

With reforms in the early 1990s, there was an attempt to reorient the activities of the renamed National Center for Natural Science and Technology in response to the *Đổi mới* policies of economic liberalization. The optimism of the scientists regarding the opportunities for external sources of income from research contracts and commercialization of technology through entrepreneurial ventures only materialized to a limited extent. This problem was further exacerbated by the unfavorable economic conditions and weak business opportunities that existed in Vietnam – a problem that the organization shared with academies of science in Russia (Graham and Dezhina, 2008) and former East European countries (Radosevic, 2003). It can be argued that the outlook of many scientists became closer to what Stokes (1997) calls "use-oriented pure research," and many initiatives were made to fulfill a mission to serve society and the economy.

During the 21st Century, the leadership of the scientific organization – now called the Vietnam Academy of Science and Technology – and the Vietnamese Government have reiterated mission priorities for serving the society and establishing a key role in the innovation system. However, weak funding of research and development in both public scientific organizations and in major business sectors has persisted, and continues to reduce the scope for VAST to link up with industry or create new high-tech firms. The recent five years have witnessed some improvement in this respect, however, with the consolidation of a legal framework and the establishment of new funding mechanisms for research and innovation. However, one could argue that the mission and role of VAST is "plus ça change, plus c'est la même chose," and a transformation to the models of ETRI in Korea or ITRI in Taiwan is still only on the far horizon.

The chief factor undermining the initiatives of the National Center for Natural Science and Technology to commercialize technology on the 1990s was the absence of financial means to fund the development, scaling up and production of technologies, and the weak demand for innovation from business in Vietnam. A successful spin off firm such as FPT survived on the basis of income from sale of imported technology, and gained financial and managerial independence from its parent organization. Gaps in funding continue to haunt initiatives by VAST and, in an important sense, the fate of this organization illustrates how extremely difficult it may be to reform a supply-oriented system of science and technology. This is especially arduous in a transitional economy that lacks appropriate institutional or market-based incentives for technological entrepreneurship and absorptive capacity for advanced technology among users. The lack of consistent orientation among scientists towards exploring and developing the utility of scientific research (i.e., Pasteur's quadrant), and the absence of psychological and material incentives for linkages with potential users and markets also hampered commercialization; those who ventured into the marketplace with their services for products had little experience about scaling up of production, marketing, or other aspects of business.

The S&T policy initiatives that the Vietnamese leadership have initiated since the early 2000s have certainly reformed key institutions that have opened up more opportunities for VAST to actively contribute to innovation and economic change in Vietnam. New sources of funding are becoming available, the legislation related to science, technology and research is favorable for public research organizations and universities, and the expansion of VAST's platform for postgraduate training has been supported both by the government and foreign donors. In a sense, VAST is still in a privileged position in Vietnam's emerging innovation system, even if that position may be challenged by the ongoing upgrading of research and development capabilities in universities and – gradually – major corporations or small high tech firms. It is

important for the leadership of VAST to exploit these new opportunities and fulfil its original mission of serving the Vietnamese society.

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