THE TRANSFORMATION OF KNOWLEDGE PRODUCTION IN INDUSTRIAL TECHNOLOGY R&D INSTITUTES IN VIETNAM

Dr. Bach Tan Sinh[1]
National Institute for Science and Technology Policy and Strategies Studies

Abstract:

In the process of economic transition from a centrally planned economy to a market oriented one, science and technology (S&T) institutions in general and industrial technology R&D institutes in particular in Vietnam have also undergone their institutional transformation to response to the changing conditions created by the market. It was believed that a technology market can play a mediating role between the R&D institutions and enterprises and commercialization of technology is a solution to the poor exploitation of knowledge in Vietnam's S&T system.

The paper attempts to question the underlying assumption of the role of the technology market and policy initiatives supporting the commercialization of technology from institutionalize approach. It examines the interconnection between the transition of S&T policy (from policy for science to science in policy, policy for technological innovation, and recently to policy for distributed knowledge production) and the transformation of knowledge production in Vietnam. Using the two case studies on industrial technology R&D institute, the paper aims at illustrating the changing way of producing and exploring scientific and technological knowledge in R&D institutions and identifying institutional changes that facilitate the transformation of knowledge production towards socially distributed knowledge production.

Keywords: *knowledge production, knowledge management, innovation, S&T institutions, S&T policy, institutional change.*

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1. The shift of S&T policy and its interconnection with transformation of knowledge production

1.1. The shifting focuses of S&T policy

The analysis of the transformation of scientific and technological knowledge entails major changes in the S&T policy. This section will

[1] The author's contact is at sinhbt@gmail.com

explore the significance of the shift in the way of producing S&T knowledge against background of the development of S&T policy over the four decades in Vietnam.

Using the conceptual framework of cultural dimensions of S&T policy developed by *(Jamison and Baark, 1990; Elzinga and Jamison, 1995)*, once can think of four main "policy cultures" that coexist within each society, competing for resources and influence, and seeking to steer S&T in different directions (Table 1). While in practice these policy cultures often become intertwined in the process of policy-making, for analytical purposes it is useful to separate them as "ideal types". They exist primarily as interest lobbies or institutional networks, and as such exercise significant influence over practical policy-making. For *Elzinga and Jamison (1995)*, "these cultures represent different interest and draw on different institutional bases and traditions for their position. Each policy culture has its own perception of policy, including doctrinal assumptions, ideological preferences, and ideals of S&T. Each policy culture has also a different set of relationships with the holders of political and economic power". The national styles of S&T policy can be different depending on the relative strengths and modes of interactions among the policy cultures mentioned above. The national S&T policy will affect the formalized country-specific institutional arrangements for production of knowledge.

First, there is an academic culture, based in the universities and research institutes, a culture in which science is pursued as a vocation and where the growth and development of scientific knowledge is seen as an important element of human and social enlightenment. S&T policy in this culture is primarily concerned with the advancement of science and expansion of academic institutions. The S&T policy in this academic culture concerns with policy for science. In Vietnam during the 1960s and 1970s, S&T policy was considered Policy for Science (Table 2). In this academic policy domain prominent scientists, politicians played a key role in directing the development of S&T. During this period, Vietnam established a number of independent research institutes outside the production sector and universities following the model of Soviet Union, based on the initiatives of leading scientists most of whom were trained in Soviet Union.

Second, the bureaucratic culture, which in many countries is largely dominated by military, based in the state administration with its agencies, committees, councils, and advisory bodies, concerned with the effective administration, coordination, planning and organization. Here science is of interest for what might be termed its social uses. The S&T policy concerns with Science for Policy or Science in Policy. During the 1980s, Vietnam's

Policy for Science shifted to policy in which science was seen to support the objectives of other policies - the Science for Policy. The intention was that science is mean to achieve objectives of other policies, e.g. socio-economic development, national security, etc. rather than simply aiming at the development of science itself. Senior bureaucrats, ministerial decision-makers were the main actors shaping the S&T policy.

Third, the economic culture is based in corporations and enterprises, a culture in which S&T are instrumental means to productive and financial ends, contributors to wealth and economic growth. The concerns of this culture thus revolve around the utilization of knowledge, both its application, its transformation into products and processes and its diffusion into the commercial marketplace. The emphasis is on Policy for Technological Development and Diffusion. This economic policy domain shaped by entrepreneurial scientists and engineers, top and middle managers in industry during the 1990s in Vietnam narrowed its perspective on the role of science in achieving national goals to the single question of how to hitch the scientific enterprise to industrial innovation and competitiveness. Incentive measures to link R&D with industrial innovation were applied, such as R&D and technology service contracts, commercialization of technology, technology market.

Finally, there is a civic culture, which is based in popular, social movements such as environmentalism and feminism, and whose concerns are more with the social consequences and implications of science than its production and application. The civic culture articulates its position through public interest organizations as well as through campaign and movements, and its influences is determined by the relative strength of the civil society of this country. In Vietnam, the civic policy domain is in the beginning of the establishment.

Table 1. Cultural tensions in S&T policy

Policy domain	**Bureaucratic**	**Economic**	**Academic**	**Civic**
	"science for policy"	"policy for innovation"	"policy for science"	
Doctrine (Macro level)	national development and security	economic growth	enlightenment	democracy
Steering mechanism (Meso level)	planning	commercial/ profitability	peer review	assessment
Ethos (Micro	formalistic/	entrepreneurial	scientific	participatory

level)	authoritarian			

Sources: Jamison and Baark (1990), Elzinga and Jamison (1995)

Table 2. S&T Policy Shift during the period of 1960s-2000s[2]

Phase 1: Policy for science in 1960s and 1970s

Policy objectives	Growth of the scientific enterprise per se (establishment of a number of R&D institutes)
Instrument of implementation	Order
Key actors or policy players	Prominent scientists, politicians
R&D institutions involved	Highly specialized and independent R&D institutes, universities.

Phase 2: Science in policy or science for policy in 1980s

Policy objectives	Science is a means to achieve objectives of other policies. e.g. socio- economic development, national security, etc. rather than simply aiming at the development of science itself
Instrument of implementation	Top-down S&T plan
Key actors or policy players	Senior bureaucrats, ministerial decision-makers
R&D institutions involved	Highly specialized R&D institutes, pilot plants, experimental workshops, and "science-production association"

S&T-push approach during 1960s-1980s

Phase 3: Policy for technological innovation or innovation policy in 1990s and 2000s

Policy objectives	Contribution of S&T to industrial innovation (narrowing the role of S&T)
Instrument of implementation	Incentive measures to link R&D with industrial innovation, e.g. R&D and technology service contracts, commercialization of technology, technology market
Key actors or policy players	Entrepreneurial scientists and engineers; top and middle managers in industry
R&D institutions involved	R&D centers; consultancy firms; engineering units in industry; technology service centers, science parks

[2] It is not a description of a historical break of S&T Policy in Vietnam but rather a significant shift of emphasis. In each period, there exist all types of S&T policy but with different focus depending on the influence of one type of S&T policy.

Science/Technology-Push or Supply-Push is complemented by Demand-Pull Approach during 1990s and 2000s.

1.2. Transformation of scientific and technological knowledge production in R&D institutes

S&T policy as *Jamison and Baark (1990)* argued "can be seen as the resolution - sometimes successful, often not - of the conflicts and tensions that unfold between these main policy cultures at the various levels or layers of the S&T policy system". There is the macro level in which overall decisions of emphasis and orientation are made. It is at this level that the dominant policy doctrines or guidelines are formulated. In Vietnam, during the 1960s and 1970s the concept of Scientific and Technical Revolution was expressed at the doctrine level reflecting a strong faith in S&T's leading role for the growth of the economy and societal transformation. Counterpoised to this, on a micro or practitioner level, are the various institutional and organizational networks within which S&T are actually conducted in a particular country or social unit. In other words, ***it is the level where S&T knowledge is actually produced.*** Between the macro and micro levels there is a meso level where the macro level political discourse and the micro level reality are transformed in the committees and meeting rooms into really existing policy. In the remaining part of the paper, the author would argue that the ongoing mode of knowledge production in R&D institutions in Vietnam has been the result of the specific institutional arrangements that are influenced by the policy doctrine at the macro level and steering mechanism at meso level.

Structure of industrial technology R&D institutes in Vietnam

The industrial technology R&D institutes in Vietnam currently undergoing market-oriented reform are basically characterized with the extensive externalization (outside firms/enterprises) of elements relating to industrial technological change such as R&D, design, standardization, etc. As a part of the whole S&T system that has been established according the administrative levels, the industrial technology R&D institutes have been subordinated to the line ministries. These institutes have been set up separately from the production enterprises in their sectors. Their R&D activities have been independently from other activities related to technological innovation in industry, such as design, engineering, manufacturing and operation of production process. The industry R&D capabilities have been developed not in enterprises but in the industrial technology R&D institutes with the assumption that the enterprises do not have the demand to invest on their in-house R&D activities.

Numerous attempts are reported to have been made from the 1970s, most of which were focused on intensifying links between separate organizations and functions necessary for technological change (Figure 1). During the 1980, there was an S&T planning mechanism with the so-called "plan of application of S&T results". The line ministries had played a central role in planning S&T. Annually the enterprises had to submit their plan to apply S&T results in their production based on the problems facing to their line ministries. Based on this plan, the ministry will look for competent R&D institutes under their supervision to assign them conducting R&D, which deals with the problems of the enterprises. In this centrally planning mechanism there were three actors representing different interests and cultures of dealing with the issues concerning application of S&T results - scientists/technologist, bureaucrats and industry managers. There was no direct links between the R&D institutes and enterprises. In line with this belief of S&T planning, other effort was the push for the establishment of "science-production association".

Since the end of 1980s central economic plans have been gradually abandoned and the funds granted from government budgets to both enterprises and R&D institutes have been dramatically reduced. As a result, R&D institutes were forced to sell themselves on the market. With the Decision 175/CP issued in 1981 which allowed R&D institutes to sign R&D and technological services contract directly with the enterprises, a transaction between the producers/suppliers and the users of scientific and technological knowledge did take place in the market.

Technology was not longer considered as "public goods" to receive for free. It became a commodity to be sold in the market. It was believed that the market could play a mediating role between them. However, in the reality not many R&D institutes could sell their scientific and technological products to enterprises due to a number of reasons, such as their limited capacity to meet the technical problems posed by enterprises *(Meske and Dang Duy Thinh, 2000)* and the inefficiency of the technology market[3].

[3] Factors influencing the failing of technology market are: (i) Uncertainty of technological innovation: market mechanism is not well adapted to dealing with the uncertainty of technological innovation; (ii) Inexperience of users; and (iii) Underdevelopment of market institutions. Concerning the factor of uncertainty of technological innovation, in industrial-developed market economies, industrial firms are the institutional basis for industrial technology *(Freeman 1992)*. A large part of industrial R&D and design is internalised within firm organizations. The uncertainty of technological innovation, and the tacitness of technological knowledge, has favoured institutional rather than pure market mechanism. It is argued that the commercial success of industrial technology depends on continually seeking to match uncertain technological opportunities to changing market possibilities, the match can be realized more easily within firms, with better information feedback between the various activities. This internalization has developed spontaneously in market economies, underlying the imperfections of the market mechanism in dealing with technology transaction.

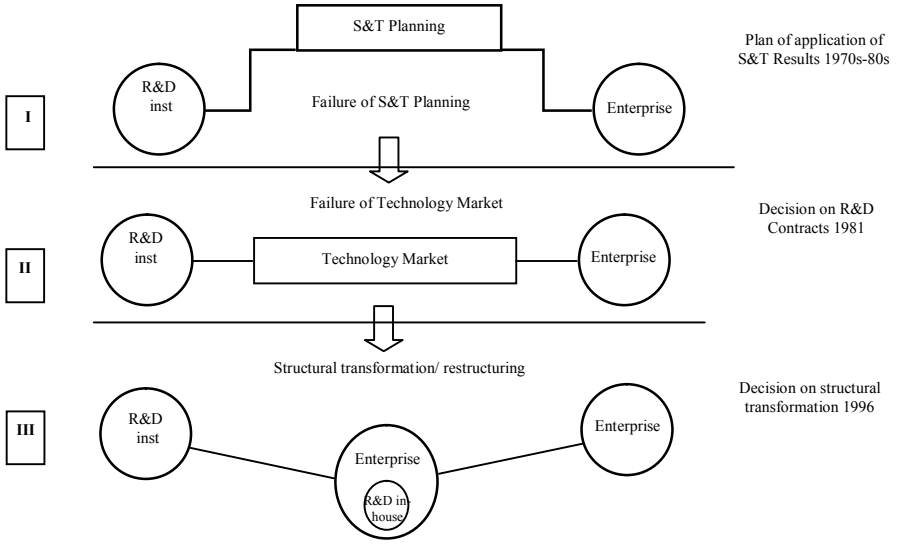

Figure 1. S&T policy change concerning transformation of industrial technology R&D institutes

Institutional dimensions of technological exploitation

The theoretical framework proposed by Douglass C. North *(North, 1990)* provides the explanation on the incentives and constraints for the production and utilization of technological knowledge. His approach features a model of institutions, which specifies the structural characteristics of informal constraints, formal rules and enforcement of a particular political or economic order. This view of institutions that culture defines the way individuals process and utilize information and hence may affect the way that informal constraints operate in a society. Informal institutional constraints shape the activities of researchers, innovators and entrepreneurs, and thus constitute a culture-specific framework for generation and exploitation of knowledge. Informal institutional constraints include such attitudes as the long-standing perceptions of a negligible value of technological knowledge, or the various attitudes of both producers and users of such knowledge towards the conditions for its transfer *(Baark, 1999).*

In Vietnam, all policy initiatives and efforts so far aim at linking the two separate systems without addressing the structural inherit problem, which is the independent existence of two system. The way scientific and

technological knowledge has been created and exploited, to a large extent follows the linear science/technology push innovation model. (Figure 2).

The S&T policy changes over the periods of 1980s-1990s in Vietnam reflected the shift of the locus of decision-making control over R&D activities from the administrative bureaucracy to the performers themselves. The planning system which Vietnam has practiced for S&T has situated most decision-making at the highest level of the administrative hierarchy in Vietnam; now, the market forces would be mobilised to shift the locus to the agents that were directly involved in the process of creating and exploiting new scientific and technological knowledge.

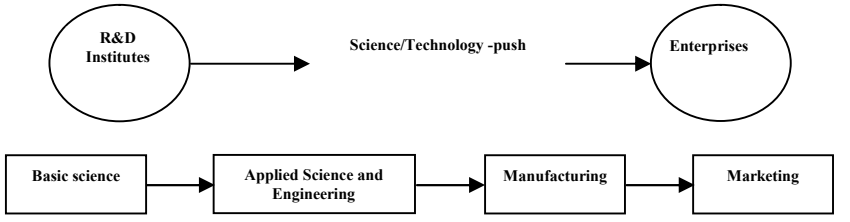

Figure 2. Linear science/technology push innovation process

Some dynamic move of active industrial technology R&D institutes toward structural transformation were driven by the experience that with the outputs in the transactions shifting from 'software' know-how to 'hardware' outputs or integrated engineering services. It means due to the failure of the technology market, R&D institutes prefer to commercialize their scientific and technological knowledge by setting up their own enterprises within the institutes or their spin-off companies. In other words, the R&D institutes want to integrate R&D function with other functions of enterprises such as design, engineering, marketing, procurement, etc. to reduce the transaction costs[4]. In this effort, there exist so far three types of structural transformation of industrial technology R&D institutes in Vietnam:

- Transformation through merging the entire R&D institute into the existing enterprises or corporation, either voluntarily or by force. For example the administrative merge of the Institute of Industrial Chemistry (now transformed as Vietnam Institute of Industrial Chemistry) into the

[4] The approach of transaction costs developed by Williamson *(Williamson, 1975)* has been further elaborated by Lundvall *(Lundvall, 1992)* for user-producer relationship in dealing with technological innovation. For Lundall, innovation is a collision between needs and opportunities. The basic function of user-producer relationships is to communicate about both technological opportunities and user needs and a well-established user-producer relationship in terms of trust is costly.

Vietnam Corporation of Chemicals (now transformed as Vietnam National Chemical Group) (see the case 1);

- Voluntary transformation of entire R&D institute into special types of companies (S&T based companies including engineering, designing, consultancy companies). For example, the transformation of the Design Institute of Industrial Chemicals into the Chemical Industry Engineering Joint Stock Company (CECO) (see the case 2);
- Spinning-off transformation through setting up spin-off companies. The Instate of Industrial Chemistry provides an excellent case where once can find two forms of spinning-off. The first form regarded as an organized part of the institute is channeled into an independent enterprise. The Additives and Petroleum Products Company (APP) was established in 1996 as a spin-off company from a group of researchers working in the Centre of R&D of Additives and Petroleum Products under the Institute of Industrial Chemistry. The second form is an organized part of the institute licensed as an enterprise but remain an integrated part of the R&D institute. The Cau Dien Enterprise for Experiment and Pilot Production was established as an enterprise within the Institute of Industrial Chemistry (see the case 1).

Through the organizational and functional change, the R&D institute also transforms its mode of knowledge production, which will be presented in detail in the two case studies below.

2. Case studies on Institute of Chemical Industry and Chemical Engineering Corporation

In the chemical industry, there are two research institutions - the Institute for Industrial Chemistry (IIC) and Institute for Design in Industrial Chemistry (now transformed as Chemical Industry Engineering Joint Stock Company CECO). The Institute for Industrial Chemistry has been assigned to conduct research and development, and to apply technological results in the chemical industry. Unlike the Institute for Industrial Chemistry, Chemical Engineering Corporation is engaged in design activities and construction of equipment in chemical industry. The Vietnam National Chemical Group directly controls both of them.

2.1. Case 1: The Institute of Chemical Industry (IIC)

The IIC was established in 1955 with the function of conducting basic research in industrial chemistry including 10 sub-fields, operated in a similar way of the Soviet style Academy of Sciences. But in the reality, in

the course of its development for more than 35 years the institute has ever been considered a basic research institute.

Organisational and functional transformation under the impact of economic reform and market

The transformation process of IIC can be considered through two major phases. The first phase (1955-1996) characterised by the effort of the government in developing a strong independent branch research institute. The second phase (1996-2016) is regarded as the attempt to link the IIC more closely with production by putting the institute under direct control of the Vietnam National Chemical Group.

The phase 1 (1955-1996)

The linear science-push S&T policy has affected to a large extent the way in which IIC operated. However, in the course of implementation of this policy, those necessary conditions such as financial resource and equipment to develop such a competent branch research institute have never been materialised. As a result, instead of meeting the initial designed expected goal of the institute - to generate basic scientific knowledge to be applied in the industrial chemistry sector, IIC was forced to conducting mainly applied research and technological development.

In 1992, the IIC was reorganised consisting of 8 centres with the goal of giving attention to some strategic areas in industrial chemistry such as new material, products from oil and to strengthen its linkage to industry. At the beginning, thanks to this organisational change, some centres have utilised their autonomy in improving their cooperation with industry through signing R&D and technology service contracts. But after a while this organisation change was no longer the important factor in helping its centres in selling its technological knowledge to industry. The market did not really help the knowledge producers and user to overcome the risks and transaction costs associated with technological innovation.

Instead of transferring the scientific research results produced by IIC or providing technological services to production enterprises in chemical industry sector, IIC has linked their activities with industry by setting up "spinning-off" enterprises based on the scientific and technological knowledge generated by the institutes. The setting up of such new production enterprises based on the Centre of Additives and Petroleum and Centre of Fertilisers are the examples of the organisational and functional transformation of the IIC. These two enterprises - The Company of Additives and Petroleum Products (APP) and the Company of Fertilisers

have been now under the Vietnam National Chemical Corporation (Figure 3). The production enterprise is established based on a core group of scientists of the institute. The setting up of the enterprise does not only link to technological transfer but also the transfer of the organisation created through the technological transfer process which include human resources, its relationship and understanding among the members of this organisation, the way of exchanging information and knowledge, and its operation procedures, etc. All associated factors for the establishment of a new organisation are transferred from an academic research environment to a new environment, which requires new knowledge such as marketing, management of product and quality, etc. In the context of newly created organisation, the technological change continues to take place and being complemented by new skills which ensure the responsiveness of the enterprise to the needs of the market.

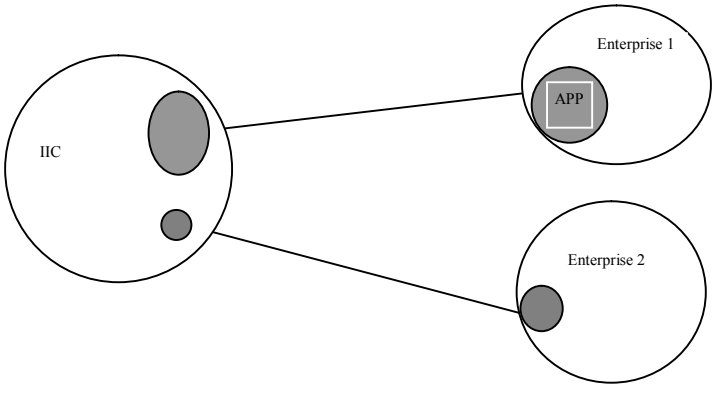

Figure 3. "Spinning off" enterprises established based on the in-house research departments of the IIC

There is a need to change the traditional attitude towards the tasks of research institutes, which are no longer suitable to the new context of scientific and technological production. Apart from the concern how to create technologies by the institutes, way of thinking towards the functions of a research institute needs to be changed. For example, the transfer of human resource from research institute to production enterprise can be considered positive in the relation to the links between R&D and Production; it should not be regarded as "brain drain"[5]. One of the recent

[5] Around this issue, there are two kinds of opinions within the IIC regarding the move-out of the Centre of Additives and Petroleum, and become the Company of Additives and Petroleum Products under the Vietnam National Chemical Corporation. The first group was against the transfer of the Centre, considering this as "brain drain" with the explanation that when the Centre moves out it brings along its staff and equipment thereby weakening the research capability of the institute. The other group argued that the transfer of the Centre from institute to Corporation provides favourable conditions for the development of the Centre since its operation and

ways of producing knowledge during 1990s is that knowledge is usually produced by a group of scientists rather than a single individual one, and the transfer of this knowledge is carried out by this group of scientists. It implies the acknowledgement of one important factor associated with this transfer process which is the human in developing an institutional capacity of an organisation in general and technological capability of the enterprise in particular. The knowledge is transferred along with the transfer of scientists who produce this knowledge and it often exists in the tacit form - tacit knowledge *(Gibbons, M. at al, 1994)*. With this trend, the way in which technology is transferred will change towards receiving technologies through receiving human resources generating these technologies or transfer of know-how rather than receiving technologies through design and equipment *(Turpin and Spence, 1998)*.

Phase 2 (1996-2016)

In 1996 to implement the government Decision 783 on transferring some research institutes to national corporations, IIC was forced to be under direct control of the Vietnam National Chemical Corporation (Figure 4)

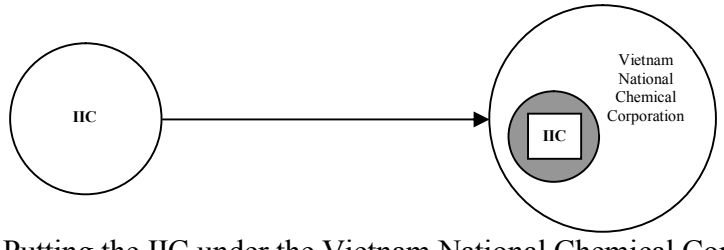

Figure 4. Putting the IIC under the Vietnam National Chemical Corporation

In reality, the transfer of IIC to Vietnam National Chemical Corporation was not justified to meet the demand of the corporation as well as the willingness of researchers but rather to satisfy the administrational and organisational purposes *(Tran Tri Duc, 1998)*, and to reduce the financial budget allocated by government to research institutes. The implementation of the Decision 782 revealed the fact that the plan to put a research institute under the corporation without understanding their mutual benefits seems to fail. Among six research institutes planed to transfer to corporations four requested not to follow the Decision, one research institute was merged with other university *(Nguyen Van Hoc, 1998)*. The lesson learned in this case did not only valid in Vietnam but also in China *(Conroy, 1992)*. In contrast, this approach seems to work well in South Korea. For example,

products are more suitable to be located outside of the institute, avoiding to complying with regulations directed to research institutes that become barriers.

during 1970s the Korean Institute of Electronic Technology developed its strong research capacity with modern equipment in the semi-conductor industry. The institute was then bought by a corporation and become the in-house R&D unit of the corporation. In this case, the corporation has a real demand to develop their products based on scientific and technological results, thereby strengthening its competitiveness in the global market.

It is important to differentiate two ways of organisational transformation of the IIC. The establishments of two spin-off enterprises based on two research centres of IIC took place because of the needs of the products in the market and the willingness of scientists themselves. But the transfer of the whole institute - IIC to the Vietnam National Chemical Corporation was "forced" with administrative measures.

2.2. Case 2: Chemical Engineering Corporation (CECO)

In the course of its development, although changing its name many times the functions of CECO remain unchanged which are designing and conducting research and development to serve the sectors such as fertilisers, oil-chemistry, pharmacy chemistry, food processing, plastic, rubber, etc. After the corporation operated according to the Decree 388-HDBT issued by the Government on the operational procedures of state-owned enterprises, its profiles have been expanded to include various activities such as investment consultancy, design of industrial and civil projects and complex, treatment of industrial pollution and environmental impact assessment, anti-corrosion, ensuring project quality, appraisal of projects, turn key project from design to implementation, market research.

The organisational and functional transformation under the impacts of economic reform and market

Before 1993, CECO operated as governmental research institute economically self-reliant. After issuance of the Decision 35 by the Government on the Regulation regarding Procedure to Registration and Operation of the R&D institutes, CECO has registered as a government R&D institute. But for a short period CECO has been facing many disadvantages during its daily operation, therefore decided to change its legal state from being a research institute to a state-owned enterprise operated in designing activities subject to be regulated by the Decision 388 on Operation and Function of a Business Enterprise issued by the Government. One of the difficulties CECO has had when operating as a research institute according to the Decision 35 was the entitlement for not being able to borrow money from the banks. Besides, CECO was not allowed to expand its pilot production in a large scale, to sign economic

contracts with other business enterprises in providing equipment and consultancy services.

The way of transforming can be described as bellow:

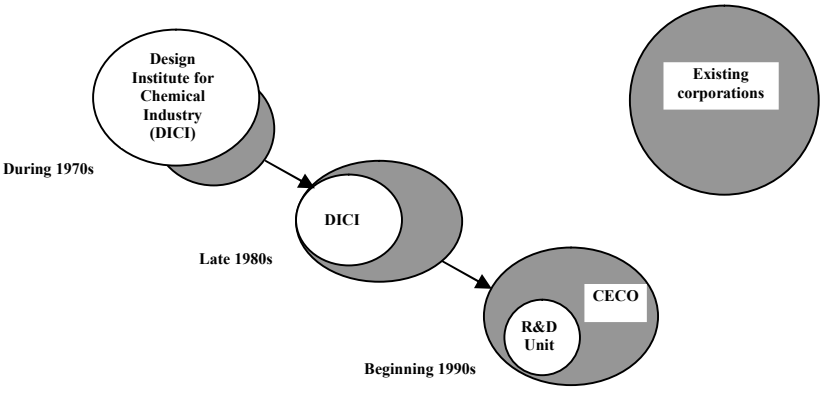

Figure 7. Organisational transformation from institute-based to corporation-based model.

From the monopolistic position as the only one institute providing technological equipment in the chemical industry under the centrally planning economy, CECO has been losing this position when entering the market economy in the beginning 1990s because the corporation has to compete with some domestic companies and foreign design companies *(Assessment Report of the Project DP/VIE87/016, November 1992: 23)*.

Facing with this new challenge, CECO has expanded its profiles to include not only designing technological equipment in the chemical industry but also other activities that comprise of: (1) research on investment options; (2) pre-feasibility and feasibility studies; (3) defence of investment plans on the behalf of the investors at the governmental responsible agencies; (4) design including basic design using its in-house know-how or buying foreign technologies, detailed design; (5) set up the total estimated costs for the projects; (6) advice to investors going through different steps and procedures concerning bidding for investment, from preparing bidding documents, open bidding, appraisal of bidding; (7) monitor the construction works, producing equipment; (8) participate in pilot operation of equipment; (9) assist foreign investors in matters related to administrative procedures such as looking for investment location, meeting responsible governmental agencies to apply for licenses for land-use, electricity and water; (10) jointly prepare with foreign consultancy companies investment documents. The main former activity on generating technologies has been gradually replaced by consultancy activities to select and adapt imported

technologies accompanied with foreign direct investment projects. These activities do not address only the technical aspect but also new aspects such as marketing and project management.

However, some traditional activities of CECO conducted before such as pre-feasibility and feasibility studies, defence on the behalf of investors remain unchanged but are required to meet higher quality, especially in the area of appraisal of investment. Those factors such as market needs and prices, which have been given not enough attention in the past, become now decisive factors to the success or failure of the investment projects. The quality of pre-feasibility and feasibility will affect the design process later. If research on market and prices has not been conducted properly, it is CECO that has to suffer in the fist place since CECO will be the designer using those data and information from the research. Therefore, CECO paid more attention to develop its company management capability at company and project levels which comprise of reporting, preparing project documents, developing business plans, conducting feasibility studies including analysis of various expenses such as technical, financial, operational ones, and negotiation.

In order to meet the function of a designing company, apart from expanding its profiles, CECO has also changed its organisation accordingly. For example, the Department of Research and Development was merged with the Centre of Environmental Engineering, setting up some new centres such as Centre for Investment Consultancy, Centre of Anti-corrosion, Department of Project Management which helps CECO in managing and co-ordinating its projects.

CECO not only expands its technological development process and diversifies its products but also develops its profiles to include activities in other industrial sectors. Apart from activities in the chemical industry, which accounts for 40% of the total turnover of the corporation, CECO operates in agriculture, rural development and oil industry.

During the 1990s after having transformed its activities, CECO has become a special enterprise with its science-based products, which are not replicable. CECO focused mainly on design and consultancy, followed by construction. The production activities accounted the major part in the beginning but were gradually degreased and become the minor part in 1998. This represents a fact that the corporation has proved its position in the market providing specific science-based design products, which are different from normal products of ordinary enterprises.

Instead one unit within the institute moving out of the institute and becoming a “spin-off” enterprise or company as the case of the Centre of

Additives and Petroleum and Centre of Fertilisers within the Institute of Industrial Chemistry, the whole former Design Institute for Industrial Chemistry transformed itself and become a corporation. Since it is a corporation, a number of new capacities as mentioned above, such as market research, project management, monitor construction and investment consultancy have been developed within the corporation. While new capacities have been in place, one of the two former important activities which is research and development becomes a modest one in the form of a R&D Unit merged with the Centre of Environmental Engineering. The transformational experience taken place in CECO is similar to the model assessed in a research by Martin Bell concerning approach to strengthening links and structural change between R&D and production sectors *(Bell, 1993)*. According to Bell, the way in which research institutes in China have transformed themselves has been similar. This transformation is to respond to reforms that aim improving effective utilisation of scientific and technological bases available in industrial R&D institutes.

Conclusion

The two case studies reveal a reality that the exploitation of knowledge requires participation in its generation. In socially distributed knowledge production the organization of that participation becomes the crucial factor. Many significant changes taking place in the production of knowledge, in industry as well as in the traditional sites where science is practised need to be taken into account when a policy for socially distributed knowledge production is implemented. This policy needs a new management style of distributed knowledge production, which can be summarized in two notions - increasing permeability of boundaries and brokering.

In distributed knowledge production the dynamics of scientific research and technological innovation are the principal driving forces leading to the emerge of new forms of organizations. The process of increasing permeability of boundaries weakens the centralising tendency of bureaucracy. Policies of decentralisation should incorporate incentives to encourage openness and reward individuals who can generate new forms of specialised knowledge through configuration of existing human resources. The cases of CECO and APP showed the crucial role of the leaders in transforming the previous organization with existing human resources into a new form of organization with new way of producing the knowledge.

The notion of brokering should be for government, alone or in cooperation with others, or some of their agencies, to function as honest brokers. Brokering is necessary because in distributed knowledge production more actors, not all scientists and technical experts, are involved. Brokering will

demand exceptional skills because the individuals involved in the innovation process will come from many different institutions and organizations. This implies that policy arena itself will undergo a drastic change in composition (Table 2). During the phase characterised as policy for science, pprominent scientists, politicians were the key policy players. This has become less as government has shifted from support of science for its own sake towards innovation policy. During the 1990s, not only pprominent scientists, politicians, senior bureaucrats, ministerial decision-makers but also entrepreneurial scientists and engineers, top and middle managers in industry, and marketing experts have become involved in S&T policy. The shift of the locus of authority in the knowledge production reflects the distributed nature of knowledge production.

The new policy is the one that is people and competence centered. It will need different institutions, and promotes interchange among scientists and technologists and the general connectivity of innovation system, possibly using information technology to exploit its knowledge base. People, as the carriers of competence will constitute the main resource for innovation and entrepreneurship./.

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