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DEVELOPMENT OF SCIENTIFIC AND TECHNOLOGY HUMAN RESOURCES IN THE NEW STAGE: CASE STUDY VIETNAM

Tran Van Trang
Customs General Department of Viet Nam.
Doan Hong Le
Research Institute for Socio-Economic, Duy Tan University, Vietnam.
Corresponding Author : dlehong@yahoo.com
Nguyen Thanh Truc
Rector, Tay Nguyen University, Dak Lak, Vietnam.
Ho Bach Thu Nguyen
Honors Program, Duy Tan University, Da Nang, Viet Nam

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ABSTRACT
For the first time, this study outlines the concepts of science and technology human resources, analyzes and evaluates the strengths, weaknesses and causes of limitations of Vietnam's science and technology human resources over 20 years. At the same time, propose solutions to comprehensively develop this team in the coming international integration period. These include: strengthening the system of organizations and apparatus, attracting talented people, developing the scale and quality of human resources in science and technology, and cooperating to commercialize research results and publish them internationally. With the desk research method, using secondary data, the authors have deeply analyzed the mechanisms and policies of management, use and development of science and technology human resources in Vietnam. The article uses a dialectical, positivist approach, compares experiences and contrasts the policies of modern scientific and technological human resource development to assess reality and upcoming requirements.

Keywords: Scientific and technology organization; Science and technology human resources; Mechanisms and policies; Attraction and development

1. INTRODUCTION
Theories and practices have proven that human resources in science and technology (S&T) are one of the core issues in social - economic development in each country. For Vietnam, the guidelines and policies on social - economic development by the State are always associated with policies enhancing S&T and S&T human resources. In addition to that, S&T management mechanism and potentials have been gradually innovated

and developed. Especially, new science has been contributed positively in S&T development process. (Toan et al., 2020)

According to OECD, S&T human resources consists of people who graduated from universities, colleges working or not working in any S&T aspects; who have not yet graduated from universities, colleges but working in a S&T field which requires a relevant qualification (OECD, 1995), From the above characteristics, S&T human resources are a collection of groups of people participating in S&T activities with the functions of research, creativity, teaching, management…, which have contributed in the development of S&T, economic and social progress and speeding up the industrialization and modernization of the country.

In order to develop S&T human resources Vietnam needs achievement for the targets in terms of quantity and quality, the structure is rationalized in regions, fields of science, socio-economics, security, and national security. Over the years, the State has promptly issued many practical and appropriate mechanisms and policies. including policies of training, attracting and deploying the S&T human resources, encouraging S&T research and creativity, applying financial incentives mechanisms and policies, protecting the intellectual property rights, creating an autonomous mechanism among S&T organizations in technology transfer, investment, international cooperation as well as policies on management, usage and development of human resources in priority fields and areas. The document of the XIII Congress of the Communist Party of Vietnam of the Communist Party of Vietnam has determined: "Rapidly develop human resources, especially high-quality human resources; prioritize the development of human resources for leadership, management and key fields on the basis of improving and creating a strong, comprehensive and fundamental change in the quality of education and training associated with the institution. recruitment, use and treatment of talents. (Communist Party of Vietnam, 2017).

However, in the process of implementing the mechanisms and policies, there are some limitations and weaknesses that need to be adjusted and overcome in order to develop S&T human resources which meet the demand of national development in the new settings.

2. RESEARCH METHODOLOGY

The paper uses exploratory research and desk research methods, collecting information from the government, central and state agencies, ministries, functional agencies and from provinces and cities in 3 Central, South and North of Vietnam; research institutions, universities. In particular, studying data of 2 Academy of Science - Technology and Vietnam Academy of Social Sciences - 2 leading research agencies in science and formulating policies, strategies, and development planning. socio-economic development of the country. These are also addresses with diverse and rich Science & Technology human resources. The article also investigates the output of data

on quantity, quality and contribution of Science & Technology human resources to the development of the country. In order to have a comprehensive picture of the current state of Science & Technology human resources, the authors also collect information about the majors and fields of operation of this team. Covering basic sciences, social sciences and humanities, agriculture, industry, construction, transportation, health, public health, national defense and security... Besides, the article synthesized and analyzed data on the application of research and other contributions of Science & Technology such as total factor productivity (TFP), average labor productivity growth in different periods, the added value of scientific and technological products and the contributions of new biomedical technologies to social life.

On the basis of shaping the core factors of the current state of the country's S&T human resources such as size, quality, and structure, from 2010 to 2021 is the period when Vietnam focuses on implementing its economic development strategy - 10 years 2011 - 2020, and the period before the Covid-19 pandemic to design the necessary target content of the article. The authors also discussed with experts and experienced scientists to confirm the contents that need to be researched for the article such as criteria for quality assessment, structure, and particularities in the fields of Science & Technology, technology, territories, development policies, training Science & Technology human resources to obtain appropriate practical data. However, all informational data has been scientifically processed, including cross-checked through other independent sources to ensure accuracy, consistent with the content and structure of the article.

3. RESULTS

3.1. Evaluation the results achieved in all aspects of S & T human resources

+ On S&T organization

By 2016, Vietnam had 2,500 S&T organizations, increased 11.15 times compared to 1996. In which, there are 1,432 public S&T organizations, 1,389 non-public ones (665 central and 724 local organizations), accounted for 46% in total. Especially 100% of non-public organizations made up 52% in total 665 central and 724 local organizations ([Dân trí News,2016a). It is worth noting that the number of S&T business is increasing. As of 2019, there were approximately 3.000 enterprises eligible enough to be considered as S&T enterprises (Ministry of Science and Technology, 2019). However, since 2017the number of public S&T organizations managed by Government and local authorities fell remarkably, only 1,513 in total (Ministry of Science and Technology, 2019).

+ On S&T human resources

Together with S&T organizations, S&T human resources have experienced a fairly rapid development. According to statistics, the capacity of S&T human resources was 60,543, reached the rate of seven out of one thousand citizens by 2020. In which, the number of professors and associate professors is about 2,000 people, one with doctoral

degree is 5,293 people (8.74%), one with master's degree is 11,081 people (18.30%), one with university degree is 28,689 people (47.39%) and 15,480 people with a college degree or below (25.57%). S&T human resources are distributed in 5 sectors: social sciences and humanities; natural sciences; agricultural sciences; pharmacy and medical sciences; science & technology and technology. Out of a total of 60,543 people, 6,420 people are working in social sciences and humanities sector, accounting for 10.6%; 4,460 people are working in natural sciences sector, accounting for 7.4%; 15,302 people are working in agricultural science sector, accounting for 25.3%; 6,548 people are working in pharmacy and medical sciences sector, accounting for 10.8%; and 27,813 people are working in science & technology and technology sector, accounting for 45.9% (Vietnam Academy of Science and Technology, 2021) . However, the S&T staff at research institutes still has some limitations. It is due to that highly qualified staff shifted to other jobs to obtain higher income while the number of newly recruited staff were mainly fresh graduates with no research experience. Currently, the majority of them are old-aged scientific researchers. According to an investigation by the Ministry of Science and Technology, most of professors and associate professor are 60 and over, the number of those under 50 years old accounts for only 12%. Even though more than 10,000 people have doctorate degrees, only 25% is proficient in English, especially lack of experts and project managers fluent in English. In fact, there is a shortage in both quantity and quality of scientist team (more than 90% of S&T organizations has less than 30 employees, some have less than 10). The majority of scientists are working in Hanoi and Ho Chi Minh City. (Vietnam Academy of Science and Technology, 2021)

+ On attracting S&T human resources

In recent years, departments and ministries as well as localities have established and implemented various programs and projects on the basis of the Government and the Prime Minister's regulations in order to attract S&T human resources and high-quality human resources from diverse sources such as: attracting qualified scientists with a specific distinction level, foreign scientists, especially overseas Vietnamese scientists coming back our country to work; funding abroad training for talented students by the government or local budget then requiring them back to work domestically as committed. (Government's Decree No. 40/2014/ND-CP), (Government's Decree No. 87 /2014/ND-CP)

In general, the attracted human resources are all preeminent, effective and contribute to the regional development. Although the quantity is small, these policies are premises to promote staff's quality enhancement in order to meet the requirements of market economy development, international integration, national defense and political system in the new era. These incentives have been detailed and accommodated with salary, allowance, benefit policies, creating a better working and researching conditions for human resources of distinction. The highest allowance for Doctor of Philosophy, Associate Professors, Professors is up to a half billion dong in Ha Noi, Ca Mau…. The

talents in Da Nang are supported with an amount of 15 million dong, salary allowance of 1.5 million dong and low rent apartment. Valedictorians working in Ha Noi receive an allowance which is 5 times higher than the minimum monthly salary. When thesis is successfully defended, the allowance is 30 times higher than the minimum monthly salary, this number can reach to 80 if doctoral thesis defense is conducted. Other attractive incentives have been implemented in other provinces. (Giang, Dinh Ngọc 2015)

On the other hand, a large number of employees have been planned, promoted and appointed to managerial positions in accordance with their capacity, strengths and demand in each period. Open recruitments for managerial positions are carried out in some cities, which enables qualified applicants to compete equally and contribute to the local progress such as Quang Ninh City, Thai Binh City, Quang Nam Province, Da Nang City (National Data Portal, 2017)

The implementation of policies attracting, rewarding and creating a working environment for S&T human resources is efficient; a plenty of policies are introduced to encourage S&T labor force to work in rural and poor areas as well as rewarding strategies are given to organization and individual who have outstanding contribution to S&T aspect. These strategies and policies are proven to have positive effects in reality. As a result, the rejuvenation and quality enhancement in S&T human resources are clearly seen. This S&T labor force has participated effectively in consulting, researching and tackling major concerns in S&T and S&E development in many fields, especially in socio-economic development strategy, education and training enhancement. (Phuong, Dinh Viet, 2022),

However, there are some drawbacks in attracting and employing high quality S&T human resources such as: inconsistency in criteria for review, evaluation and utilization of S&T labor force. Some regions pay attention to qualifications, sometimes put as much emphasis on structures or ages while other cities are in favor of graduates with distinction bachelor's degree from public universities. The employee attraction is aimed mostly to political system, not much to business, still lack of evaluation, classification of worker skills and competencies in order to plan training strategies and cultivate the talents. In general, working in public area system is not attractive enough for excellent graduates and young talents to pursue a career. In some cities, the implementation of subsidized employment programs for excellent graduates and young scientists is neither supportive nor well-equipped with proper infrastructure to facilitate employees at work as well as inappropriate policies on wage and housing subsidies …

+ On the quality of S&T human resources

In general, there is a significant improvement in technical skills, education and qualifications. For example, researches and applications are done in manufacturing building materials, craft souvenirs, after-harvest crop protection methods, which helps

to diversify the product lines, improve productivity and lower the cost of production. In the medical field, researches and technological advances are increasingly applied in medical diagnosis, disease detection, prevention and treatment. In agricultural sector, a number of high-quality and productive plant varieties and livestock breeds and some advanced techniques have been transferred to some regions. Those contributions of continuous S&T researches and applications are vital for the development of key economic regions and other provinces. In addition, Vietnam has made progress in the basic research, which is considered to set up a foundation for brand new fields of S&T such as cosmology, bioengineering, Nano and nuclear industry. In the aspect of natural science, high ranking achievements have been awarded to Vietnam among ASEAN countries. The social sciences and humanities have promptly provided arguments for the policies planning which is aimed to develop our country, accomplish legislation, contribute to economic thinking changes, maintain the history of the formation and development of our nation, preserve the value systems and cultural identity of Vietnam. (Phuong, Dinh Viet, 2022).

Not only the educational level has been improved, the professional and technical level of Vietnamese human resources has also been continuously improved. The percentage of population with technical expertise has increased significantly since 2007, increasing by 6.3 percentage points, from 17.7% (in 2007) to 24% (second quarter of 2020). The proportion of the population with a university degree or higher increased the most, from 4.9% (in 2007) to 11.1% (in the second quarter of 2020). (Quynh, Nguyen Thuy, 2021)

Although there are a wide range of criteria for human resources' quality evaluation, the level of development as well as the competitiveness of a country is evaluated base on the number of ISI Journal Publications and world-recognized researches and inventions. So, investment into S&T and international publications and inventions are the top priority in many countries including Vietnam. According to statistics of the Institute of Scientific Information (ISI), only 200 patents and inventions were granted by Intellectual Property Office of Vietnam, 5 patents were registered in the US from 2006 to 2010.

(https://www.vass.gov.vn, 2020) In 2011, there weren't any Viet Nam patents registered in the US meanwhile the figure in Singapore, Malaysia, Thailand and the Philippines were 647, 161, 53 and 27 registered patents respectively. Although the number of patents and utility solutions is not compatible with the S&T human resources, government policies have created the motivations and incentives encouraging the copyright protection, which witnesses a significant increase in the number of patent applications from individuals and organizations in Viet Nam. (Như Bao, 2021)

During the period 2013-2022, the average growth rate of patent and utility solution applications in Vietnam is 9.11%/year. Meanwhile, foreign entities have a total number of patent applications of 55,774, higher than Vietnamese entities (7,012 applications).

However, the average annual growth rate of the number of patent applications filed by Vietnamese entities is increasing faster than those filed by foreign entities. (Nhi Anh, 2023).This fact shows that Vietnamese organizations and individuals are increasingly paying more attention to intellectual property. In particular, the total number of applications for utility solution registration in the past decade by Vietnamese entities is 2.27 times larger than that of foreign entities. The growth rate of utility solution registration applications of Vietnamese entities is 8.82%/year, higher than the growth rate of foreign entities (4.74%).(See table 1)

Table 1: Applications for registration of inventions and utility solutions from 2013 to 2022 of Vietnamese and foreign subjects

Year	Number of patent applications filed				
	Vietnamese applicants		Foreign applicants		Total
	Invent	Useful solution	Invent	Useful solution	
2013	443	227	3.726	104	4.500
2014	487	246	3.960	127	4.820
2015	583	310	4.450	140	5.483
2016	560	326	4.668	152	5.706
2017	592	273	4.790	161	5.816
2018	646	370	5.425	187	6.628
2019	720	395	6.800	204	8.119
2020	1020	485	6.674	189	8.368
2021	1066	449	7.469	146	9.130
2022	895	454	7.812	147	9.308
Total	7012	3535	55.774	1.557	67.878
Average annual growth rate (%)	9,12%	9,11%	8,82%	4,74%	8,60%

Source: https://vneconomy.vn/don-dang-ky-sang-che-cua-chu-the-viet-nam-chi-bang-1-8-so-voi-chu-the-nuoc-ngoai.htm

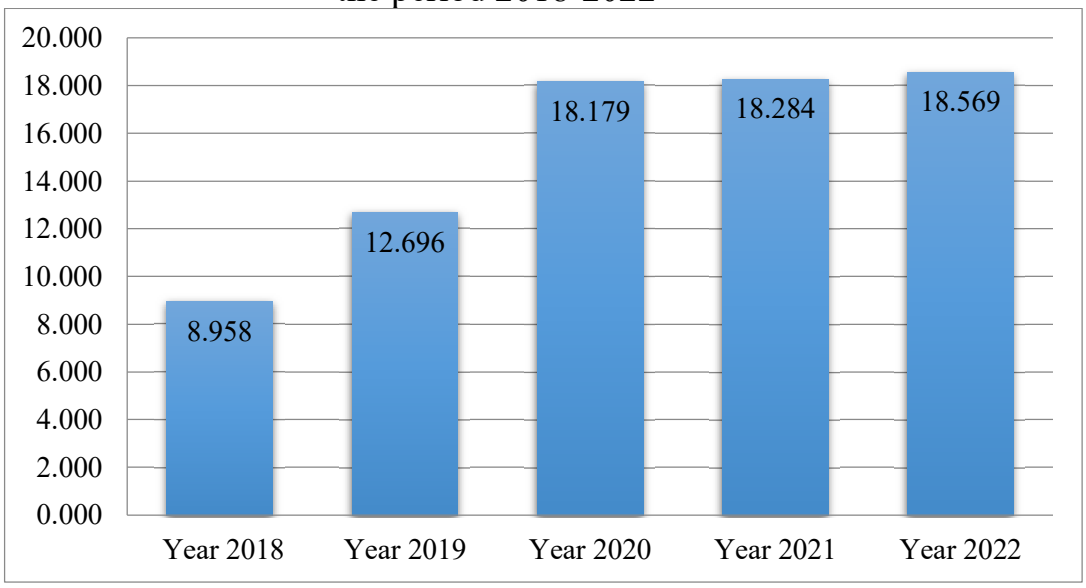
According to Strategies for Science and Technology Development in the period 2011-2020, the number of scientific and technological researchers would reach from 9 to 10 people per ten thousand people, 5,000 qualified engineers to participate in management, 30 fundamental research institutions by 2015. Currently, Viet Nam is in the shortage of science and technology researchers to achieve the ratio of 10-12 scientific staff per 10,000 people by 2020. (Vietnam Academy of Science and Technology, 2021)

+ Vietnamese scientific publications in international journals

During the period 2018-2022, the total number of Vietnamese scientific articles published in prestigious international journals is 76,686 articles.(

http://thongke.cesti.gov.vn/phan-tich-thong-ke/ket -qua-thong-ke/1082-cong-bo-khoa-hoc-viet-nam) . In particular, from 2020 until now, the number of annual publications has reached over 18,000 articles (see figure 1). Vietnamese articles published in international journals are classified into 27 specialized fields from 4 major fields according to Scopus classification: Physical Sciences, Health Sciences, Social Sciences and Science. learn life. Of these, 10 specialized fields account for the majority of research: Engineering, Computer Science, Mathematics, Physics and Astronomy, Environmental Science, Medicine, Materials Science, Chemistry, Science Agriculture and Biology. Besides, in 2022, there will be 15,075 scientific articles published in domestic science and technology journals. Notably, up to now, Vietnam has had more than 20 domestic scientific journals joining the ACI, Scopus...

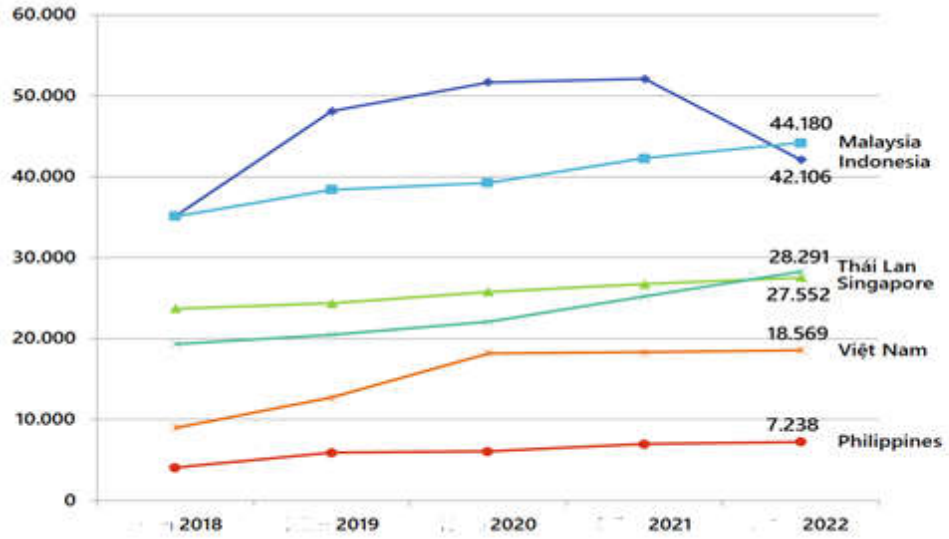
Figure 1. Number of Vietnamese scientific publications in international journals in the period 2018-2022



Source: Scopus database of Elsevier Publishing, data retrieval date: February 27, 2023

Notably, in the ASEAN region, Vietnam has risen to the 5th position in international publications (see figure 2).

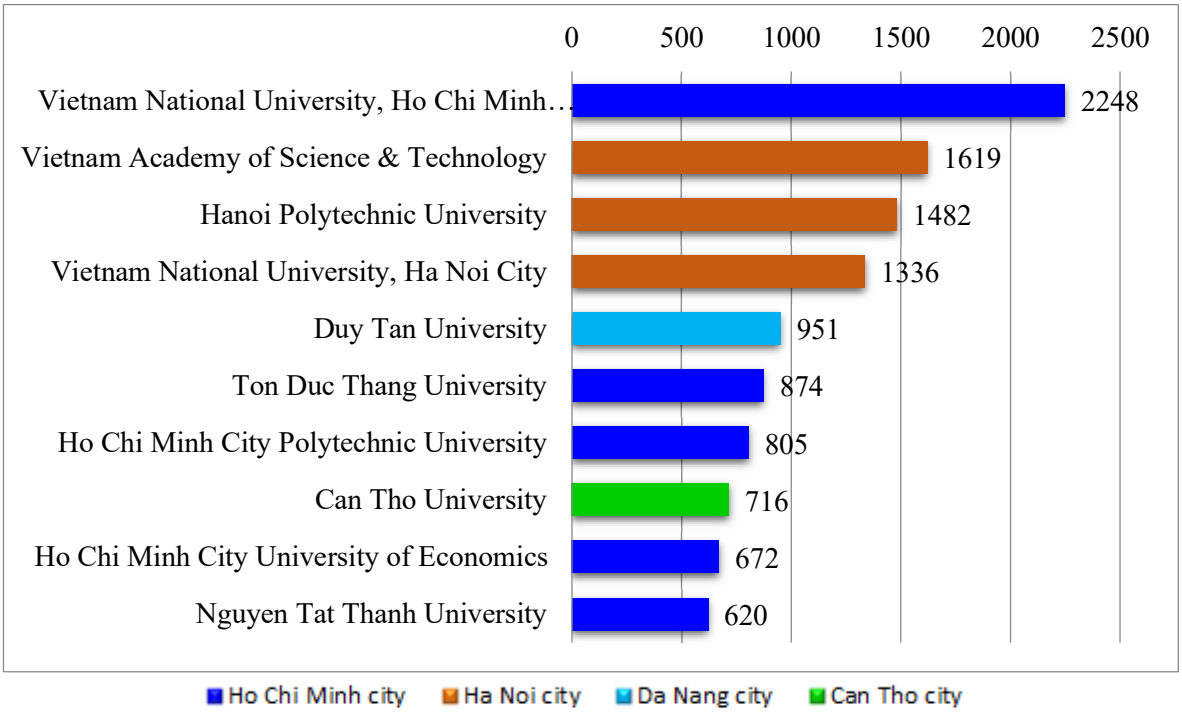
Figure 2. Comparison of Vietnam's international published papers with the ASEAN region in the period of 2018 – 2022



Source: Scopus database of Elsevier Publishing, data retrieval date: February 27, 2023

However, international publications are mainly concentrated in 10 universities. (See figure 3)

Figure 3 : 10 Vietnamese organizations with the highest international publications in 2022



Source: Scopus database of Elsevier Publishing

+ On the structure of S&T human resources

S&T human resources' role in S&T development in Vietnam is becoming more and more important. However, there are still imbalance in human resources structures; the

ratio of direct labor to total S&T labor force is too high; there are still so many obstacles in incentives and supportive policies in credit capital; a competitive environment is not successfully set up; the quality of staff, officials in S&T duties are low. On the other hand, S&T labor structure in administrative departments is distributed unequally, which is considered to be lack of both quantity and quality. The association between public S&T organizations and business and training organizations are so detached that capital for S&T investment is deployed uselessly (research findings have not yet been put into practice). In some public S&T organizations, there are not enough direct and indirect labor forces (who are called civil servants). The structure of those human resources has not been divided properly, which cannot be literally a powerful tool to promote the S&T development largely. **(**Phuong Dinh Viet, 2021)

Not a significant change in the structure of employees in public sectors was recorded in 2016 in comparison with 2011. In 2011, 25,971 people working in ministries and departments out of 30,327 S&T staffs, which accounted for 85.63%; while the percentage in local structure was 14.36% (4,356/30,327 employees). In 2016, the ratio of S&T human resources in public sectors was 85.81% (34,305/39,976 employees) and fell to 14.18% in local authority (5,671/39,976 employees) (https://www.vass.gov.vn/tap-chi-vien-han-lam**,** 2020)
Moreover, improvement the quality of S&T human resources in remote and border areas, islands, extremely difficult economic zones, ethnic minority areas and mountainous areas is always a matter of concern to the Government. A wide range of policies have been issued to attract and persuade high quality S&T labor force to work and delicate to these areas. However, according to some reports from Committee for Ethnic Affairs, there are still some limitations in implementation strategies enhancing the S&T staffs in mountainous and ethnic minority areas. The number of workers without professional qualifications made up to 86.21% in total labor force. The proportion of unskilled labor in the population of working age is still high (98.7% in the Hmong ethnic group, 97.7% in Khmer ethnic group 94.6 % in the Thai ethnic group and 93.3% Muong ethnic group). (https://www.vass.gov.vn/tap-chi-vien-han-lam, 2020)

Although the proportion of human resources (working directly and related to S&T sector) having a university degree or higher accounted for 77.26% in the total population, their actual skill and capacity are much lower than those who are working in other provinces and cities in the plains. The distribution among regions and localities is quite unreasonable and unbalanced in terms of the proportion between industries and occupations. For instance, Haiphong City experiences an imbalance in some outstanding industries (such as mechanics, new material technology, processing industry, information technology), in which there is a low rate of high professional skill labor (only 7% in science and industry; 6.8% in information technology; 2.24% in environment, and lowest at 0.79 % in building sector) (Dân tri-News, 2016b)

Statistics on the qualifications of the S&T workforce show that the proportion of trained workers with degrees and certificates has gradually increased over the years, by the second quarter of 2022 it was 26.2%. However, there is a difference in the trained rate of workers between urban and rural areas, this rate in urban areas reaches 40.7%, 2.3 times higher than in rural areas (17.8%). Notably, the supply and demand of labor is still imbalanced, demonstrating the situation where workers do not work in accordance with their trained occupations, and there is a mismatch between technical and professional levels and trained occupations with the needs. of the market. Accordingly, up to 84.61% of workers have college degrees, 65.99% of workers have intermediate degrees, 22.81% of workers have university degrees or higher working in jobs that require lower levels of technical expertise/skills than the trained technical qualifications. On the other hand, about 44.48% of workers work in jobs that require technical expertise/skills higher than a degree. (Nhật Dương, 2022)

+ On training situation to develop science and technology human resources

To supplement and develop human resources, including scientific and technological human resources, training activities from institutes, schools, and training facilities are needed. In particular, training at the undergraduate and postgraduate levels is Vietnam's strategic task during the digital technology revolution, with the goal of turning Vietnam into an economy with high growth speed and quality and high competitiveness in the world.

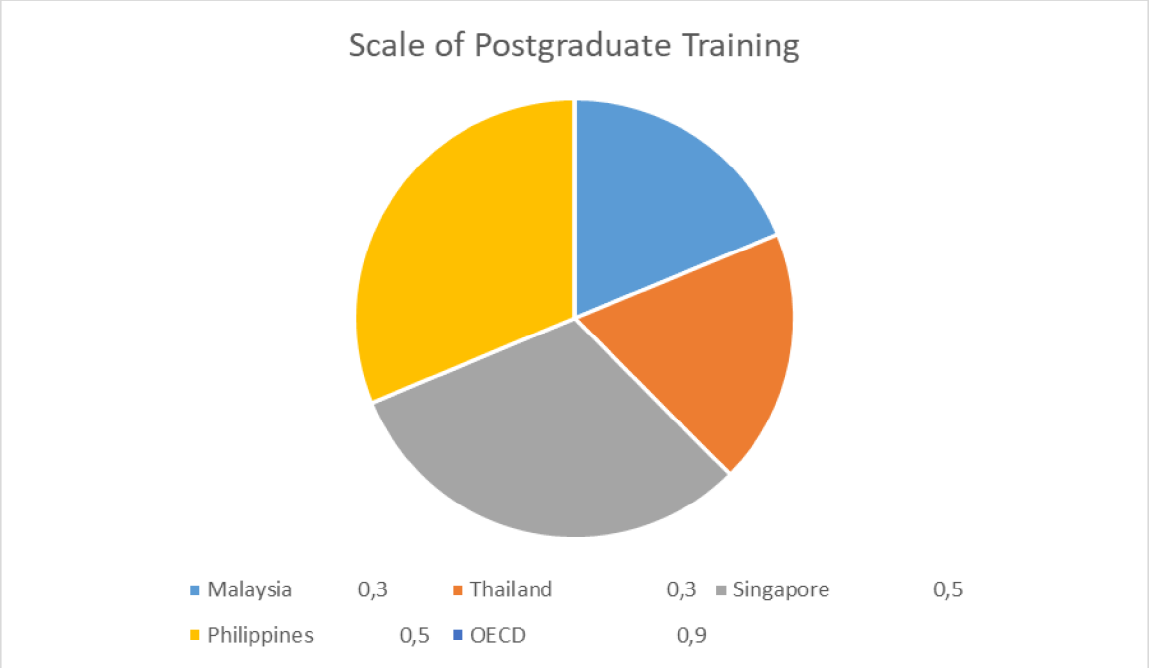
In recent years, Vietnam has implemented human resource training programs: high quality, advanced programs, and talent programs that meet regional standards in the fields of basic science, high technology, and economics; key socio-economic and foreign language... These programs are designed from 140 to 155 credits, on the basis of improving and supplementing a number of subjects compared to the world's standard program... Program of training is designed to be accessible and comparable to the training programs of a number of highly prestigious international universities.

Talented and high-quality programs meet 80% of the subjects in the training programs of advanced foreign universities and are designed taking into account the suitability of Vietnam's conditions. In particular, in the context of globalization and deep integration, economics and finance between countries interact and influence each other. Along with the strong changes of the 4th revolution, Vietnam focuses on programs, training, and education for growth. Vietnam also aims to develop a skilled workforce to transform into an upper middle-income economy by 2035.

However, the results of training and developing human resources in general and scientific and technological human resources are still limited, such as: the quality of education and training does not meet the development requirements of society ; the structure of education and training among professions and fields is not reasonable; curriculum, content, teaching and learning methods are outdated and slow to innovate.

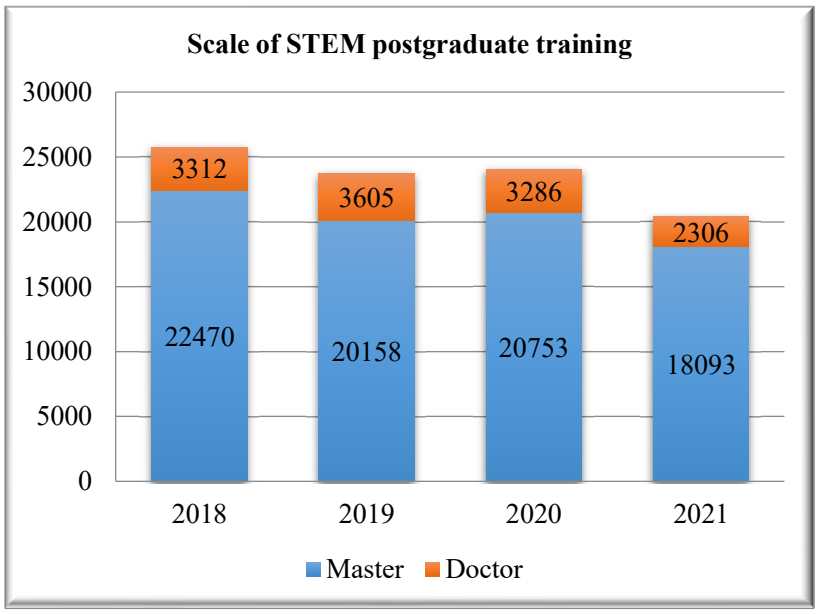
The imbalance in education and training leads to a situation where human resources are both redundant, lacking, and weak. In addition, the management, organization of exams, testing, and evaluation revealed many weaknesses, leading to the quality of training not keeping up with reality and still suffering from severe performance problems. International learning models are applied but lack evaluation, stereotyped and mechanical application. Opening and allowing the opening of many training programs with many types of ownership and training fields but not managing them leads to poor quality of education and training in general. Degrees are formal and do not properly evaluate the learner's capacity... Notably, the scale of postgraduate training is very low and has not increased over the past many years, in 2021 it will only reach approximately 122 thousand (110 thousand students of masters and 12 thousand doctoral students). So, calculating the ratio to the population is less than 1/3 of Malaysia and Thailand and 1/2 of Singapore and the Philippines, approximately 1/9 times the average of OECD countries (Thu Luong , 2023) . (See figue 4)

Figure 4: Scale of postgraduate training



Notably, the scale of postgraduate training in STEM (Science, Technology, Engineering, Math) (UNESCO, ISCED-F 2013) has declined greatly in recent years and accounts for less than 4.0% of the total. The scale of training for STEM qualifications and there is a big difference between training fields. (see figue 5)

Figure 5: Scale of postgraduate training in STEM fields



Source : https://vov2.vov.vn/giao-duc-dao-tao/quy-mo-dao-tao-sau-dh-khoi-nganh-stem-rat-thap-va-co-xu-huong-ngay-cang-giam-42846

The ratio of highly qualified human resources, especially master's and doctoral degrees in STEM fields, demonstrates the level of development of science and technology and the entire economy. Training at postgraduate levels in STEM fields provides essential human resources for the development of technology fields, especially high technology to serve structural transformation and develop a knowledge-based economy based on science technology and innovation, digital transformation.

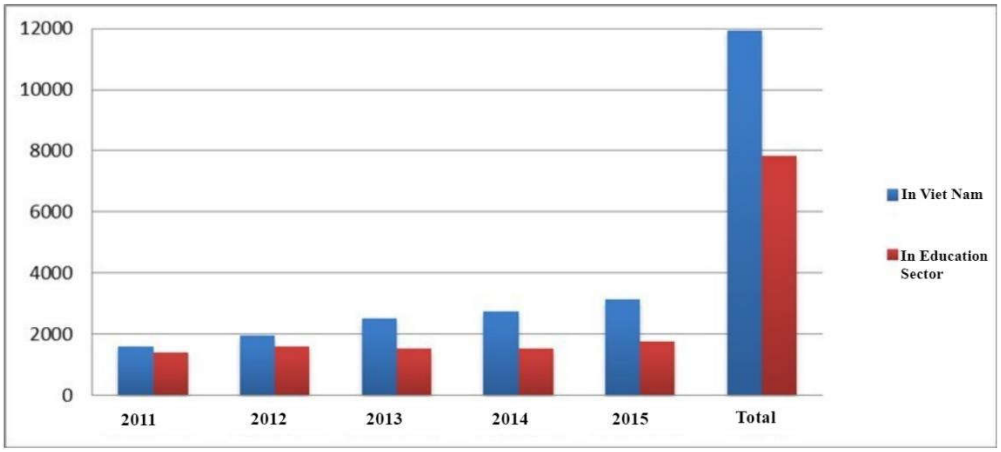
However, 2021 statistics also show that, of the 59 higher education institutions and research institutes offering doctoral training in STEM fields with a total of 2,579 graduate students, only 20 training institutions have 20 or more graduate students. And this number accounts for nearly 90% of the total biomass research in this industry. The low scale and scarcity of postgraduate training is a worrying situation for socio-economic development orientation in the context of the Fourth Industrial Revolution.

The shortage of high-quality human resources in STEM fields in the Vietnamese labor market in recent years, especially human resources in the field of information technology, has been analyzed and evaluated by many reports. This is the main bottleneck in developing a knowledge-based economy, a digital economy based on science, technology and innovation, especially in industries where Vietnam has potential such as information technology and energy. innovation, health care... The lack of scientific, technical and technological human resources is also an obstacle in attracting large corporations and businesses to invest in new or expand production and services, shifting investment structure to R&D activities in high-tech fields.

+ On cooperation between scientists, managers and businesses to commercialize research results

The issue of commercialization of research results, technology transfer from research contributes to actively promoting the development of the science and technology market. Notably, compared with other regions, the results of science and technology activities of higher education institutions are higher, the total number of scientific and technological products of the university sector accounts for more than two thirds in the whole country. (Hiếu Nguyễn, 2017) (see figure 6)

Figure 6. Number of Commercialized S&T Products from Universities in period of 2011 – 2015 (statistics in 2017)



Source:https://giaoducthoidai.vn/nganh-giao-duc-chiem-2-3-tong-so-san-pham-khoa-hoc-cong-nghe-post274909.html

Currently, the country has nearly 141 thousand scientists, about 650 thousand enterprises and 261 universities, but the relationship between enterprises and universities is quite weak, and commercialized scientific and technological products are still too few. Science and technology market has not yet formed.

Data on implementation of scientific and technological activities in the academic year 2019-2020 shows that training institutions have deployed 493 state-level scientific research projects, 137 utility solution patents, and 67 invention patents, 1,088 technology transfer contracts. (The Ministry of Education and Training, 2018.)

In Ho Chi Minh City, the largest city in Vietnam, through the survey, in the period 2014-2018, there were 1,587 scientific research projects with results. In which, the number of successfully commercialized projects accounts for a relatively low rate of 12.7%. The number of research topics that have been completed and ready to be transferred accounted for 37.2%. The rate of 50.1% is that the projects are at pilot scale, laboratories... need support, continue to conduct research before commercialization. (Cesti.gov.vn, 2018) (See Table 2)

Table 2. Number of topics accepted in the period 2014 - 2018 through surveys at institutes and universities

Research topic has been accepted	Quantity	Rate
Research topic needs further research investment	795	50.1%
Research topic ready to be transferred	591	37.2%
The research topic has been commercialized	201	12.7%
Total	1.587	100%

Source: https://cesti.gov.vn/

In Vietnam, the relationship between universities and businesses is very weak, there are no enterprises located in universities where scientists can be shareholders, where researchers can invest, and are a place for students to participate in internship programs at these businesses and organizations to gain experience and improve their skills. Some higher education institutions already have businesses, but they do not operate according to the nature of a market economy. Because according to the Law on Civil Service (2010), public employees are not allowed to do business. (National Assembly of Vietnam, 2010)

Therefore, there is currently no enterprise in the university in the true sense to create an ecosystem between businesses, people and scientists.

3.2. The limitations and weaknesses major in the management, use and development of S&T human resources

As presented above, in addition to those achievements, there are some limitations and weaknesses major in the management, use and development of S&T human resources in Vietnam:

(i) The quality is not compatible with the quantity Over the past few years, the number of S&T human resources increased dramatically but not equally in organizations generally and in public administrative centers in particularly, the quantity was inadequate and the quality is low, these were not capable of a useful tool to boost S&T development comprehensively.

Despite the large number of S&T staff having doctorate and master degree, there are not enough talented and leading scientists, qualified contractors to control national and international S&T duties as well as excellent scientists in prior aspects of S&T… The ability to work in groups, professionalism, and the ability to use foreign languages as communication and working tools of human resources is still limited. (The Ministry of Education and Training, 2018**)**

The biggest challenges for Vietnamese S&T human resources are that the fall in highly-skilled labor force facing the shortage in top leading personnel and young employees; attracting and recruiting skilled workforce is not appealing; policies and strategies for

S&T human resources enhancement are not adopted motivate, training and education are limited. Lacking of top leading scientists and experts providing guidance in research and application activities is considered be the biggest weakness of Vietnam's S&T human resources. (Education Media Center, 2017)

In addition, teamwork and collaborative efforts of S&T workforce is not so strong. Due to the lack of cooperation and connection among scientists, it is difficult to establish a durable and long-run oriented research team. As a result, S&T duties are separated, no coordination between different groups in order to fulfill the essential S&T tasks in a large scale. According to the assessment of the World Bank in 2019, Viet Nam's human resources quality got 3.79 out of 10 points, ranked the 11th position in 12 Asian countries.

(ii) Plenty but unreasonable structure and distribution in S&T human resources There is a big gap in S&T human resources organization and distribute on among regions and areas. Most of S&T workforce concentrate in Hanoi, Ho Chi Minh City meanwhile there are not enough S&T specialists and workforce in provinces in Red River Delta, Northwest region, Highland region and Mekong River Delta...The high-skilled S&T human resources are also unevenly distributed locally, mainly in 5 municipalities while there is a limited number of employees having doctorate degrees, most of them are engineers and technical staff. As a consequence, it leads to a shortage of researchers who are capable of taking S&T duties, especially in remote and mountainous area. Scientists honored with title, order I, II accounted for a small percentage in the total number of officers and most of them work in Central Committee. The Scientists honored with order III made up the largest percentage while ones honored with order IV is lowest. Research assistant title is hardly found in local committee. On the other hand, the distribution of S&T human resources between operation and regions is unreasonable. There is a huge difference between the proportion of researchers working in local and central committee and not significant change is recorded over years (Thanh, Do Tuan, 2020).

(iii) Cooperation between scientists and businesses to commercialize research results is weak The survey results show that most of the projects are only at pilot scale, laboratory scale, have not been applied in real life and production, lack of funds to improve technology, lack of facilities. material for trial production. In addition, the lack of commercialization support services in the context of not effectively organizing a specialized department, the introduction and promotion of research results is also a concern of the institutes - universities. In addition, most institutes and universities also have difficulties in orienting research objectives and evaluating/valuing research results. Meanwhile, businesses are not ready to receive research results and invest in technology to apply.

On the other hand, the application of research and development results of science and technology organizations in general and universities in particular in Vietnam to

production and business is still limited. Only about 5-10% of research topics have been applied to production and business. About 10% of the topics have the potential to be put into production and business, but due to a number of reasons, the results of these topics cannot be applied to production and business**.** (Tam, Đang Thị To, 2020)

The survey results also show that, in the group of subjects who have completed and mastered technology such as science and technology enterprises, the main obstacle is the lack of investment capital to expand production scale, research and improve high, increased publicity and lack of policies to promote commercialization of research results.

Notably, the commercialization process has not been completed, the role and measures of the regulatory agency have not been clarified, in increasing support for the promotion of research results ... to help establish a direct bridge, bring research results to businesses in need. In addition, the issue of investment capital and credit guarantee for research results with great potential to further improve technology have not been paid enough attention. On the other hand, the requirements to be approached, more support from science and technology services such as assessment, technology valuation, technology transfer consulting, intellectual property consulting also need more attention for agencies. (Cesti.gov.vn)

4. LIMITATIONS AND ASSESSMENTS

Based on the assessment and analysis of information and data, the article has identified the causes of success as well as limitations and weaknesses in the development of science and technology human resources in Vietnam over the past 20 years, to serve as a basis for proposing specific solutions in the next future, include:

First of all, S&T human resources identification as well as the criteria for evaluating talented people are not really convincing. There are two main human resources segments in every country: one is in charge of contribute to the wealth of a society and one is in charge of government management. People find it complicated in identifying these two segments. For example, some consider S&T managing staff as S&T human resources, educational administrators as teachers? Why so? The reason is low social awareness. It is generally believed that everyone working in S&T department is under the scope of S&T research. Due to that common norm, the beneficiaries of preferential policies for S&T human resources are various while the government budget for S&T development is limited, which is not motivated enough to encourage the direct workforce working and dedicating in this aspect.

To be considered as a talent, there is a tendency to evaluate based on qualifications and certificates. In fact, there is a wide range of training methods and training assessment method around the world. Some nations established a training assessment system compatible with its training system, so the qualifications reflect the capacity of learners

accurate but some nations do not. A talented individual should be recognized according to his/her ability to apply his/her knowledge, skills and attitude in work, towards colleagues and citizens and his/her performance in fulfilling a task. **(**Tuan Thanh, 2019)

Secondly, development strategies and S&T human resources planning is not effective. Although ministries and localities have established all types of S&T staff's training and development plans, the local ministries and authorities have not yet achieved the development and human resources as desired. The main reason is that the quality of the plans is not immense. Obviously, if the quality was high, it would achieve its goals and not lead to a dissatisfactory condition. There are problems in actual implementation of the plans, the application is not synchronized with the targets, which requires complex processes. (Phuong, Dinh Viet, 2022),

Thirdly, attracting and recruiting high quality S&T human resources are not implemented simultaneously and unanimously.-In terms of salary and benefits, a direct S&T research officer is given more supports than a public servant. However, a public servant somehow has a higher income. As a result, working as a S&T research officer is not as attractive as working as a public servant in local S&T managing organizations. -Specific standards for S&T human resources are qualitative, not detailed-oriented, which causes subjectivity in recruitment. Therefore, the criteria used for recruitment are unlikely to attract the right talent. According to a survey conducted by Vietnam net, among the responses to question "Which factor can retain and attract talented people in the public organizations?", 43.95% out of 28,401 responses claimed that it should have a transparent recruitment and appointment process.(Giang Truc, 2008) **.**

Fourth, attracting and recruiting high quality S&T human resources are not followed closely by incentive and meritocratic policies. The same management mechanism is applied in state management agencies as well as S&T organizations. There is no difference in coefficients salary, pay rise policy between employees, so human capital flight is becoming more and more popular. Although S&T inventions are protected by Intellectual Property Law, it is so hard to control fraudulent certificates that the inventors could not obtain sufficient earning.
Although training policies have been implemented for many years, the results are not favorable. People who were sent to study abroad do not return to work in their locality; some were not assigned proper position so they gave up.

The fact is that value and talent deportation is not as highly appreciated as talent attraction. It will be a waste of talent if they are not assigned and relocated properly.
Lastly, it has not established an appropriate mechanism to connect S&T organizations with manufacturing plants. To enhance applied science, scientific products must be accurately evaluated and be easily traded and conveniently exchanged. Yet we have not created a transparent, free S&T market; scientific products must be considered as a good in market economy and intellectual property must be protected in a serious

manner. Due to the lack of S&T market, it is not desirable enough for S&T development.

5. RECOMMENDATIONS

In order to create a breakthrough in S&T human resources development meeting the requirements of Vietnam in the new situation and under the effects of current challenges, such as consequence of Covid-19 pandemic, international conflict, strategic adjustment, strategic competition among major countries, it is crucial for ministries, bureaus to implement these solutions completely and unanimously:

(i) Finalize mechanisms and policies to manage the use and development of S&T human resources in accordance with the new situation including renewing perception and raise awareness of the Party's committees and authorities about the role and position of the S&T staff. Simultaneously, strengthen the leadership of the Party and management and administration of all levels of government in the construction and development of S&T staff. Especially, develop S&T human resources to adapt to the Fourth Industrial Revolution and international integration, exclusively focus on high-quality S&T human resources, a team of experts, leading scientists in the industry, digital workforce, technology management, corporate governance and human care.
-Renovate training mechanisms and policies to improve professional and technical qualifications of S&T human resources, focus on deploying and supporting talent, honor S&T staff and have attractive policies to enhance young scientists' capacity.
- Enhance policies to nurture talents. In which, focus on organizational structure and S&T human resources distribution to achieve S&T goals.

(ii) on rationally investing, allocating and using the state budget for S&T human resources development. Develop budget allocation plans on promoting the implementation of training programs and goal-oriented projects, ensuring social equality. Especially, pay enough attention to the renovation of financial management and the self-responsibility mechanism of S&T organizations. At the same time, promote socialization to increase the capital mobilization for S&T human resources development

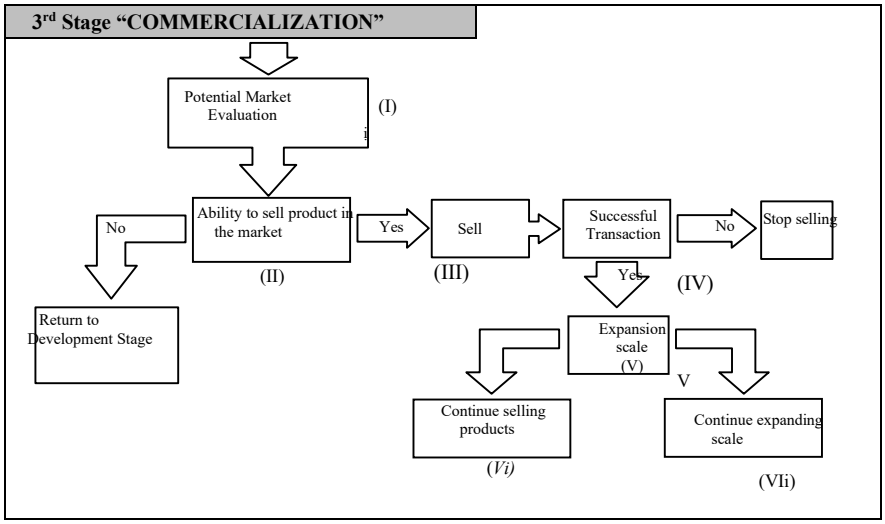
(iii) Strengthen cooperation between scientists, managers and businesses to commercialize research results.To successfully commercialize research results, it requires a lot of cooperation from many organizations and individuals. In particular, managers need to closely connect with scientists throughout the process from idea formation, investment, testing, production to successful commercialization of research results, completion improve technology and bring products to the consumer market.

Once researchers have passed the research and development phase of new products and new markets, they move on to commercialization. The commercialization process needs to research and advise on the applicability of scientific products to which

industries and markets. Especially, it is possible to determine the technical process, patent or utility solution patent, etc. to convert or move from the position of a "technology" to the position of a "business" activity. claim profit.

In the process of commercializing research results (see figure 7), if the product is to be sold, it is necessary to assess the market potential of the product (including the technology, as well as the products derived from that technology (I). In other words, whether the market accepts the product or not. (II) On the other hand, products from R&D activities can be sold and put on the market. (III) At this stage, a series of activities for technology transfer take place with the aim of successful transaction (IV); expand the application (V), continue the transaction (VI) and continue to expand the scope of application (VII).(Dung Bui Tien, 2015 and authors) .

Figure 7 .The process of commercializing scientific and technological research products



(Vi) Promote international cooperation in S&T human resources development; vary categories of partners and international cooperation; select strategic partners, combine S&T with economic cooperation. Focus on attracting Vietnamese and international experts in researching, teaching and consulting in S&T field. Maximize the autonomy and self-responsibility of S&T organizations in international cooperation. Continue to expand abroad training programs for S&T staff to experience the international academic environment and train their capacity in researching activities.

6. CONCLUSION

In general, mechanisms and policies in Vietnam have promoted the field of science and technology; S&T human resources are especially developed, growing in both quantity and quality; make an important contribution to the process of socio-economic development; meet the requirements of the industrialization and modernization of the country. However, there are still limitations in the training, recruitment, deployment and motivation of S&T staff, hindering the common goals.

By analyzing and evaluating both synthesis and specificity, the paper outlines a fairly comprehensive picture of Vietnam's S&T human resources over the past time in terms of organizational structure, attraction of S&T human resources, quality of science and technology. quantity and structure of human resources for science and technology. In particular, the paper highlights the limitations, weaknesses and causes in the management, use and development of human resources for science and technology. At the same time, it offers specific solutions and recommendations such as: organization of a statement. reasonable human resource space, attracting high-quality human resources and talents, promoting scientists and enterprises to commercialize research results for state agencies and organizations responsible for S&T have appropriate policies for Vietnam's S&T human resources to develop commensurate with the country's goals set out in the coming decades in the context that the 4.0 technology revolution is accelerating like a dance, if Vietnam does not want to fall behind countries. The paper can also serve as a research basis to apply and develop Vietnam's scientific and technological human resources throughout the process of industrialization and modernization of the country.

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