International Journal of Sustainable Development and Planning
Vol. 19, No. 4, April, 2024, pp. 1547-1557
Journal homepage: http://iieta.org/journals/ijsdp

Developing Science, Technology, and Innovative Creativity to Meet the Requirements of Sustainable Development in Vietnam: Current Situation and Solutions

Nguyen Minh Tri[1*], Le Thanh Hoa[2]

[1] Center for Politics and National Defense Education, HUTECH University, Ho Chi Minh City 70000, Vietnam
[2] Faculty of Political Theory, Industrial University of Ho Chi Minh City, Ho Chi Minh City 70000, Vietnam

Corresponding Author Email: lethanhhoa@iuh.edu.vn

https://doi.org/10.18280/ijsdp.190431

Received: 2 February 2024
Revised: 29 March 2024
Accepted: 7 April 2024
Available online: 28 April 2024

Keywords:
science-technology, innovative creativity, solutions, sustainable development, Vietnam

ABSTRACT

In conjunction with labor, capital, and natural resources, the pivotal role of science, technology, and innovation in the socioeconomic advancement of nations and societies is indisputable. This domain has historically been instrumental in propelling societal advancement, augmenting the standard of living, and fortifying national security. Nonetheless, the prevailing scenario evinces myriad challenges confronting science, technology, and innovation, particularly amidst the epoch of the Fourth Industrial Revolution. To harness the full potential of science, technology, and innovation, holistic strategies must be devised and implemented. The objective is to fulfill the requisites of sustainable socioeconomic progress, particularly amidst the pervasive impact of the Fourth Industrial Revolution across all facets of societal existence. Research endeavors will be directed towards scrutinizing and appraising the current landscape, alongside offering recommendations and remedies to foster the sustainable evolution of science-technology, innovation, and sustainable development in Vietnam.

1. INTRODUCTION

In the era of strong globalization and profound innovation, creativity has seen numerous breakthroughs, especially in correctly identifying the role and position of science, technology, and innovation in socio-economic development. Vietnam has achieved significant accomplishments in this regard. However, science, technology, and innovation have not yet become the driving force for sustainable socioeconomic development, as the national innovation system is still in its infancy and self-developing. Activities in innovation, research, and development (R&D) in business remain limited, with few enterprises pursuing innovative strategies. Training centers mainly focus on education and have not adequately invested in research. Moreover, if research does occur, its applicability is often low. All of these challenges are negatively impacting Vietnam's goal of sustainable development. Therefore, to optimize the role of science, technology, and innovation, a comprehensive system of solutions is needed to develop science, technology, and innovation to meet Vietnam's sustainable development requirements in the context of the Fourth Industrial Revolution profoundly impacting all aspects of social life.

2. LITERATURE REVIEW

Research on the development of science, technology, and innovation to meet the requirements of sustainable development has attracted a large number of international and domestic organizations.

In the study "Developing Science, Technology, and Innovation Indicators: What We Can Learn from the Past," the authors highlight the nuanced nature of indicators related to science, technology, and innovation (STI), emphasizing their susceptibility to both effective utilization and potential misinterpretation, akin to other statistical measures. The escalating adoption of these indicators can be attributed to the dynamic interplay between various factors influencing supply and demand. The burgeoning accessibility of a diverse array of STI metrics, facilitated by advancements in computerized systems, has opened up constructive avenues to cater to the growing demand from both public and private sectors for tailored statistical insights. These endeavors often center around leveraging science and technology's capabilities to address practical challenges and advance economic objectives [1].

In the article "Making Technological Innovation Work for Sustainable Development," the authors present insightful perspectives and actionable proposals aimed at effectively leveraging technological innovation for sustainable development. The paper offers practical recommendations to unlock the full potential of innovation in advancing sustainability goals, including (i) the Establishment of channels for regularized learning across diverse domains of practice. (ii) Development of measures that systematically incorporate the interests of underserved populations throughout the innovation process. (iii) Reform of institutions

to realign innovation systems towards sustainable development objectives, ensuring comprehensive consideration of all innovation stages and scales from the outset [2].

Furthermore, employing a zero-inflated negative binomial regression model and utilizing data on 2074 patents granted to US organizations within the pharmaceutical industry, the empirical analysis reveals significant insights. The findings demonstrate a positive and curvilinear relationship between the proportion of scientific knowledge in convergence and innovation impact. Additionally, the study identifies that the organization's scientific capacity, regional scientific knowledge spillover, and knowledge maturity positively moderate the relationship between convergence and innovation impact. The authors emphasize the criticality of integrating science and technology convergence and offer implications for enhancing the outcomes of organizational research and development [3].

The study titled "The Role of Science, Technology, and Innovation in the UN 2030 Agenda" underscores the imperative to redefine the essence of STI and align it with the Sustainable Development Goals (SDGs). It advocates for a strategic shift in investment patterns within STIs to effectively address the SDGs. Moreover, it posits that the Means of Implementation (MoIs) outlined in the UN 2030 agenda must be amalgamated to devise innovative financial, governance, and public policy frameworks across all echelons. Such initiatives are deemed essential for the reorientation of STI and for effecting transformative changes in economic, social, environmental, and political systems to achieve the SDGs. The paper further evaluates the implications of this framework for the UN's global Technology Facilitation Mechanism (TFM), which aims to facilitate STI access, transfer, and capacities among nations towards SDG attainment [4].

In the article "Technological Innovation and Sustainable Development: Does the Stage of Development Matter?" the authors delve deeply into the intricate relationship between technological innovation and sustainable development across 75 countries of varying economic statuses. Their comprehensive analysis sheds light on how technological innovation impacts economic progress, social well-being, and environmental sustainability differently depending on a country's level of development. Through meticulous examination and rigorous methodologies, the study uncovers that affluent nations reap substantial benefits across all dimensions of sustainable development through technological innovation. Conversely, middle-income countries predominantly experience positive effects in economic growth and environmental preservation, while low-income nations see minimal impact. Furthermore, the article doesn't just stop at findings; it offers valuable insights into future research directions and provides actionable policy recommendations to harness the potential of technological innovation for sustainable development [5].

The article "Beyond Technology Transfer: Innovation Cooperation to Advance Sustainable Development in Developing Countries" elucidates that the crux of the post-2015 development agenda lies in a revitalized dedication to sustainable development and the assurance of fostering an economically, socially, and environmentally sustainable future for both present and future generations. It acknowledges the imperative for poverty eradication, the transformation of unsustainable consumption and production patterns, and the preservation and effective management of natural resources as fundamental objectives crucial for sustainable development. Consequently, the SD action agenda encompasses a broad spectrum of interconnected domains, including but not limited to poverty eradication, food security, nutrition and sustainable agriculture, water and sanitation, energy, climate change, health and population, and gender empowerment (UNDP, 2016). These objectives are translated into actionable initiatives delineated within the framework of 17 UN Sustainable Development Goals (SDGs) and a comprehensive set of 169 indicators [6].

In Vietnam, researchers have exhibited a profound interest in dissecting the dynamics of science and technology within the broader scope of global and human evolution. For instance, my research project titled "Science and Technology in the Context of Global and Human Transformation - Theoretical and Practical Issues" delves deeply into the origins, essence, and evolutionary trajectory of science and technology. It meticulously elucidates their intricate interplay with production processes, highlighting their indispensable role in shaping cognitive functions and orchestrating global transformation. Moreover, the study meticulously scrutinizes their indispensable contribution as the cornerstone and driving force behind Vietnam's ambitious endeavors in industrialization and modernization. This encompasses their pivotal role in procuring state-of-the-art production equipment, fostering human resource development through comprehensive training initiatives, refining production management mechanisms, and significantly advancing the nation toward the attainment of sustainable development objectives [7].

Furthermore, the discourse on "Sustainable Economics" by Holger [8] highlighted the imperative of reforming traditional economic paradigms to cultivate new awareness and frameworks conducive to sustainable economic practices. The author posits that the 21st century presents humanity with a critical juncture, wherein choices must be made between a century of sustainable development or one marred by climate and resource conflicts. Emphasizing the lessons gleaned from global economic downturns, the work advocates for a fundamental restructuring of economic principles, emphasizing ethical foundations and individual responsibilities, and introduces the foundational elements for a novel comprehension of economic science.

The book "Science and Technology with the Process of Industrialization and Modernization in Ho Chi Minh City Today", third chapters, presents general theoretical issues about science and technology, points out the current situation of some The role of science and technology in the process of industrialization and modernization in Ho Chi Minh City today; From there, propose main directions and solutions to further promote the role of science and technology in the process of industrialization and modernization, contributing to clarifying the content, characteristics, and current situation. about the role of science and technology in the process of industrialization and modernization in Ho Chi Minh City today [9]. Through a meticulous examination of potential future limitations inherent in this model, the authors draw upon insights garnered from global economic crises and transitions in growth paradigms. Consequently, they unveil fundamental opportunities and challenges that Vietnam is poised to encounter in the post-crisis era. Moreover, the book articulates a vision for a sustainable, efficient, and human-centric growth model spanning the period from 2011 to 2030. This envisioned model is strategically crafted to harness

Vietnam's international competitive advantages optimally, thereby paving the way for enduring economic prosperity [10]; Vietnam's Economic Growth Model in the Post-Crisis and Global Economic Recession Period" presents a comprehensive framework aimed at deciphering economic growth models, particularly within the nuanced context of Vietnam's post-crisis economic landscape. Meticulously dissecting the current state of Vietnam's economic growth in terms of its pace, quality, and sustainability, the book unveils the inherent deficiencies of the existing growth paradigm.

The study titled "Science and Technology Development in Vietnam: Current Situation and Solutions" offers a comprehensive evaluation of the trajectory of scientific and technological progress in Vietnam spanning the last 35 years. Despite significant advancements contributing to economic and societal progress, persistent shortcomings, such as underutilization and obsolescence of science and technology in productive activities, alongside a notable productivity gap compared to neighboring nations, remain prevalent. These deficiencies pose formidable challenges to reforming the prevailing economic growth model to align with the imperatives of rapid and sustainable development. To confront these challenges head-on, the study advocates for the implementation of a holistic set of solutions [11]; and propose four solutions for scientific and technological development: (i) thoroughly and fully realize the role of science-technology in each step, each strategy, and each policy of socio-economic development in general in the entire political system of Vietnam; (ii) develop a strategy for strong development of science-technology as a basis for improving productivity, quality, efficiency, and competitiveness of industries, fields, and the whole economy, promoting restructuring economy and renewing the economic growth model, promoting R&D, innovative start-ups, and applications combined with technology development, especially in new industries and fields with potential and strengths; (iii) focus on building core technological capabilities, promoting productivity and quality, and taking advantage of the achievements of the Industrial Revolution 4.0; (iv) promote breakthroughs in building synchronous infrastructure with several modern works [12].

In essence, while extant research has shed light on various perspectives and roles concerning science, technology, and innovation in sustainable development, there remains a notable dearth of studies specifically focused on the development of these sectors within Vietnam. Leveraging the insights gleaned from these studies, this article endeavors to evaluate and address the progress of science, technology, and innovative creativity to meet the requirements of sustainable development in Vietnam. It aims to provide actionable solutions aimed at fostering their advancement to effectively tackle the imperatives of sustainable development.

3. METHODOLOGY

3.1 Theoretical research methods

3.1.1 Awareness of science, technology, and innovation

As stipulated by the Law on Science and Technology of Vietnam, 2013, scientific and technological activities encompass a wide array of endeavors aimed at advancing the fields of science and technology. These activities include research, experimentation, technology development, technology application, scientific and technological services, innovation, and other creative pursuits. The overarching goal is to foster progress and innovation within the realm of science and technology [13]. Furthermore, the development of science and technology in Vietnam encompasses the entire spectrum of research and applications, drawing upon the outcomes of both basic and applied research. Through processes such as experimentation and pilot production, existing technologies are refined, and novel technologies are developed. These advancements are intended for implementation in various sectors, including production and daily life, to serve humanity by enhancing productivity and efficiency levels.

Innovation and creativity involve the process of generating or applying new ideas, laws, products, services, or work processes that are novel and advanced. It can occur in various areas of life, from business and industry to healthcare, education, and the arts. Innovation entails applying existing achievements or creating new technologies and techniques to enhance efficiency and quality in production, as well as optimizing management processes in all economic and social aspects. Innovation is not only about creating something new but also about promoting creativity and innovative thinking within organizations and communities. It can contribute to economic development, improve the quality of life, and address societal challenges.

In theoretical frameworks of economic growth models, a common premise asserts that productivity enhancement is achieved through the application of scientific research and technological advancements, with innovation serving as the primary driver for sustainable economic development within nations. Central to this process is the investment in research and development (R&D) activities, which constitute the focal point of science, technology, and innovation advancement. Such investments impact productivity through two primary channels: *Process Innovations*: R&D endeavors contribute to the generation of process innovations, enabling existing products to be manufactured more efficiently and/or of higher quality. By refining production methods and streamlining operations, R&D activities facilitate productivity gains within industries. *Capacity-Building*: Another crucial aspect of R&D investment lies in capacity-building. This involves enhancing the capabilities of individuals and institutions to identify, synchronize, and leverage innovation activities conducted by businesses and specialists across various sectors. Capacity-building initiatives drive productivity improvements by fostering a conducive environment for innovation diffusion and adoption.

Moreover, the ongoing digital transformation catalyzed by the Fourth Industrial Revolution plays a pivotal role in augmenting access to information and fostering collaboration in R&D efforts. This transformation opens up new avenues for R&D collaboration, thereby facilitating knowledge exchange, skill transfer, and technological advancements. Consequently, it not only enhances productivity but also creates employment opportunities, fosters efficiency, and promotes transparency in both the political and business landscapes of nations [14].

In practical terms, the analysis of input contribution proportions to growth also shows that productivity consistently accounts for a significant share, exceeding 70% in developed countries and over 50% in Southeast Asian countries. The information technology and communication sector is estimated to impact GDP growth by 1.4% in emerging markets and up to 2.5% in China [15]. Moreover, at the macroeconomic level, it is estimated that a 1% increase in the digital ecosystem development index has the potential to drive

a 0.13% increase in per capita GDP [16].

Therefore, the driving force for growth in Vietnam at present and in the foreseeable future lies in increasing productivity, with the contribution level expected to continuously rise, achieved through the development of science, technology, and innovation at the macroeconomic level.

Throughout the integration process, the Communist Party of Vietnam has increasingly emphasized the pivotal role and significance of science and technology in driving socio-economic development. The Party has underscored that robust advancements in science and technology serve as potent catalysts for accelerating the country's industrialization, modernization, and the transition towards a knowledge-based economy. Such progress is deemed essential for fostering rapid and sustainable development, alongside augmenting the contribution ratio of comprehensive productivity factors to overall growth [17]. Moreover, the Party has articulated its commitment to promoting an economic growth model centered on enhancing productivity, and scientific and technological progress, fostering innovation, and cultivating high-quality human resources [18]. This strategic direction underscores the importance of leveraging scientific and technological advancements to propel economic transformation and sustainable development. Concurrently, the Party has emphasized the imperative of strengthening the development of key economic sectors and fields, leveraging their potential, advantages, and significant growth opportunities. These sectors are envisioned to serve as the driving force behind Vietnam's growth trajectory, enabling the nation to catch up, progress, and even surpass regional and global benchmarks in select domains [19]. This strategic focus reflects the Party's commitment to leveraging science, technology, and innovation as integral components of Vietnam's development agenda, aimed at securing long-term prosperity and competitiveness on the global stage.

3.1.2 Awareness of sustainable development

In 1980 the publication of the "World Conservation Strategy," highlighted the urgent need for sustainability and its inexorable trajectory within human societal progress. Initially, sustainable development was narrowly defined, primarily focusing on ecological sustainability and the imperative of conserving biological resources to achieve sustainability. However, a pivotal moment came in 1987 with the release of the report "Our Common Future" by the World Commission on Environment and Development (WCED) of the United Nations. This report expanded the notion of sustainable development, defining it as a development paradigm that seeks to meet the present generation without compromising the ability of future generations to meet their own needs. This broader perspective emphasized not only the efficient utilization of natural resources but also the necessity of ensuring a healthy environment conducive to human well-being throughout the development process.

Subsequent global conferences further refined and elaborated upon the concept of sustainable development. The Earth Summit on Environment and Development held in Rio de Janeiro in 1992, followed by the World Summit on Sustainable Development in Johannesburg in 2002 and the Rio+20 Conference in 2012, reaffirmed and reinforced the principles of sustainable development. These conferences underscored that sustainable development entails the close, rational, and harmonious integration of three fundamental aspects: economic development, social development, and environmental protection. In essence, sustainable development represents a holistic approach to development that recognizes the interdependence of economic, social, and environmental factors, aiming to achieve long-term prosperity while preserving and enhancing the well-being of present and future generations.

Therefore, sustainable development entails a multifaceted approach that encompasses several dimensions of development simultaneously: sustainable economic growth, the establishment of a prosperous and equitable society, the maintenance of stability, the preservation of cultural diversity, and the promotion of a healthy environment with sustained resources. Consequently, a comprehensive ethical framework for sustainable development is guided by several key principles:

Firstly, sustainable economic development requires securing enduring economic growth through large-scale, efficient, and effective methods. This entails transitioning towards modernization by leveraging resources, particularly science and technology, with maximum efficiency. Additionally, it involves progressively enhancing the competitiveness of the economy while ensuring stability in economic growth.

Secondly, sustainable social development involves attaining advancement and social equity, eliminating poverty, guaranteeing social welfare and security, and improving the standard of living for all members of society.

Thirdly, sustainable environmental development underscores that societal progress must not be achieved at the expense of environmental deterioration. It emphasizes the importance of safeguarding ecological systems and ensuring that future generations can benefit from natural resources and a pristine environment. Throughout the developmental journey, responsible exploitation and utilization of natural resources are paramount, alongside endeavors to safeguard, nurture, and rejuvenate them, uphold ecological equilibrium and biodiversity, and minimize environmental degradation.

So, sustainable development is a concept in which development is carried out to ensure a balance between economic, social, and environmental aspects, while also ensuring that both present and future generations have access to resources and environments to meet their needs without compromising the ability of future generations to meet theirs. Sustainable development focuses on optimizing economic, social, and environmental development so as not to cause irreversible damage to the environment and society, and to ensure social justice and equity. This often involves using resources wisely, minimizing pollution, protecting and restoring the environment, improving quality of life, and encouraging responsible and thoughtful economic development. The crucial issue of sustainable development entails the integration of sustainable practices across all three pillars: economy, society, and environment. However, it is imperative to emphasize the interconnection and mutual reinforcement among these pillars throughout the developmental process, ensuring a symbiotic relationship and coherence to achieve logical and harmonious progress. Sustainable economic development serves as a prerequisite and foundation for sustainable social and environmental development, with a focus on fostering a conducive social and natural environment that is both aesthetically pleasing and healthful, thereby facilitating comprehensive human development as the ultimate objective for rapid, sustainable,

innovative, and inclusive national advancement. Nonetheless, it is essential to establish a swift, sustainable, innovative, and inclusive national development model that is universally applicable across all sectors, regions, and localities to ensure uniformity and enhance efficiency.

3.2 Specific research methods

In this article, the author employs the methodological approach of dialectical materialism in their research. They adopt a comprehensive perspective to assess the significance of advancing science, technology, and innovative creativity in addressing the imperatives of sustainable development, as well as Vietnam's stance on enhancing these areas to support its sustainable growth. This approach posits that every entity exists, moves, and evolves within specific spatial and temporal contexts, with these conditions directly impacting the development of the country's economic sector. When an entity persists within different temporal and spatial conditions, its attributes and characteristics may vary, potentially undergoing complete transformations. Hence, the research endeavors to foster science, technology, and innovation to align with Vietnam's current phase of sustainable development.

Furthermore, the article utilizes data analysis techniques drawing from Vietnamese sources such as the General Statistics Office, governmental reports, and international organizations focusing on science, technology, and sustainable development in Vietnam. Through the examination of this data, the current state of Vietnam's economic sector development is evaluated, enabling the formulation of recommendations aimed at bolstering the advancement of science, technology, and innovative creativity to meet the demands of sustainable development in Vietnam in the foreseeable future.

4. RESULTS AND DISCUSSION

4.1 The results of the development of science, technology, and innovation meet the requirements of sustainable development in Vietnam

In recent years, advancements in the realms of science, technology, and innovation have emerged as pivotal drivers of socio-economic development in our country, concurrently bolstering national security and defense efforts while aligning with the objectives set forth by the Party and the State. These achievements not only underscore the central role of science and technology in propelling economic and societal progress but also elevate the quality and efficacy of labor. Notably, the quality of economic growth has improved markedly, accompanied by a significant improvement in labor productivity. Specifically, the contribution of total factor productivity (production results brought about by improving the efficiency of using fixed assets and labor or tangible factors, thanks to the impact of intangible factors such as technological innovation, cooperation, etc.)rationalizing production, improving management, improving labor qualifications of workers - TFP) into overall growth has witnessed a remarkable surge, from an average of 26.40% in the period 2001 - 2010, increased to 33.60% in the period 2011 - 2015 and to an impressive 47.7% in the next period of 2016 - 2020 (see Figure 1). There is a clear change in the context of contributions to society, especially from businesses, with state budget and business investment accounting for 52% and 48% of research and application activities, respectively. application, technology transfer, and innovation [20]. It can be seen that TFP production rationalization, improved management, and improved labor qualifications of workers...) are constantly improving, Vietnam is recognized as one of the countries with a positive TFP growth rate and belongs to the group of countries with increased TFP among APO member countries. Thus, productivity growth contributed extremely importantly to economic growth in the past period and will play an even more important role in the coming period. With the goal set by the Resolution of the 13th Party Congress which is an average social labor productivity growth rate of over 6.5%/year, the contribution of increased labor productivity to economic growth is even more significant. This reflects the important role and contribution of businesses through investment in research, application, transfer, and technology innovation.

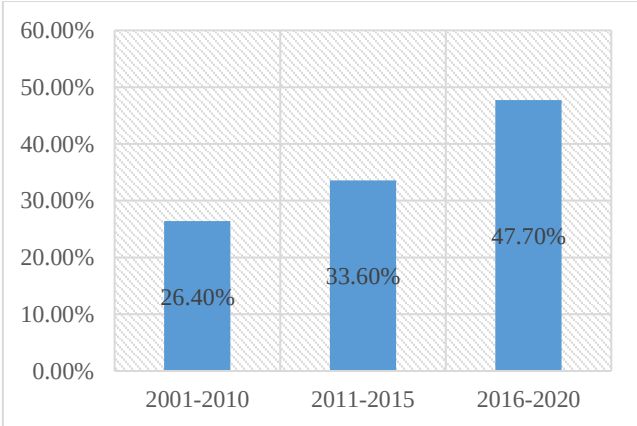

Figure 1. TFP contribution to GDP growth in the period 2001-2020 [20]

Vietnam has made significant strides in fostering scientific research and technology development infrastructure, with a robust network comprising 687 scientific research and technology development organizations, 236 universities, 3 national high-tech parks, 13 high-tech application industrial zones, 8 concentrated information technology zones, and an impressive workforce of nearly 67,000 research personnel. Additionally, the establishment of industrial technology research institutes, modeled on advanced global standards, further underscores the nation's commitment to innovation across both public and private sectors. These endeavors have yielded tangible results, as evidenced by the notable increase in the productivity of total factors within the economy. Over the period from 2011 to 2020, this productivity surged from 33.5% during 2011-2015 to an impressive 45.7% during 2016-2020. Moreover, the proportion of high-tech product exports in the total value of goods exports soared to 50% in 2020, signifying a substantial shift towards innovation-led growth. These achievements reaffirm the pivotal role of science and technology as the primary driving force behind Vietnam's socio-economic development trajectory. Moreover, they have contributed significantly to enhancing the quality and efficiency of labor, with notable improvements observed in the quality of growth and labor productivity. Notably, the contribution of TFP to growth surged from an average of 33.6% during 2011-2015 to an impressive 45.2% during 2016-2020, surpassing the targeted threshold of 35%. This remarkable progress underscores the significant role and

contribution of businesses in driving innovation, technology transfer, and research activities, with both state budget and enterprise investments playing a pivotal role in fostering these endeavors [20].

The technology landscape in Vietnam is witnessing a robust expansion, marked by the emergence of 15 technology trading platforms and 9 cutting-edge business incubators. Complementing these are over 50 incubators and enterprises dedicated to nurturing entrepreneurship and fostering innovation. Moreover, the country boasts a network of 186 industrial property representation organizations and a widespread array of applied science and technology transfer centers nationwide [21]. Substantial investments are being made in information resources and digital platforms, enhancing connectivity and accessibility across the community. This flourishing startup ecosystem and burgeoning technology market are underpinned by a growing emphasis on intellectual property rights and stringent standards, measurements, and quality control mechanisms. These favorable conditions are paving the way for the emergence of numerous promising startups. However, despite a recent uptick in personnel specializing in science and technology, their representation within the total workforce of individuals over 15 years old remains relatively low, standing at just 0.5% [17].

In terms of innovation, Vietnam has made significant strides. According to the Global Innovation Index (GII) 2021 report, economies with medium incomes are contributing to reshaping the landscape of innovation, including China, Turkey, Vietnam, India, and the Philippines. China remains the only middle-income economy within the top 30 most innovative economies globally. Few other middle-income economies have attempted to catch up with China's innovation. Turkey (41st), Thailand (43rd), Vietnam (44th), Russia (45th), India (46th), Ukraine (49th), and Montenegro (50th) made it into the top 50 GII this year. Particularly, the economies of TVIP (Turkey, Vietnam, India, and the Philippines) are catching up systematically. Apart from China, these four special economies collectively have the potential to change the global innovation landscape for the better [22]

Particularly noteworthy is Vietnam's ascent by 10 ranks in the innovation index since 2015. In the Global Innovation Index ranking of 2021, Vietnam climbed to the 44th position out of 132 countries/economies, after the World Intellectual Property Organization (WIPO) updated GDP figures using Vietnam's new calculation method. The startup ecosystem and innovation in Vietnam are rapidly evolving and thriving. Investment capital for innovative startups is increasing rapidly. The amount of investment announced in innovative startup enterprises has reached approximately $1 billion consecutively in the past two years, tripling from 2017, positioning Vietnam as the third most dynamic country in the Southeast Asia region for innovative startups [23] (Figure 2).

	High-income group	Upper middle-income group	Lower middle-income group	Low-income group
Performance above expectations for level of development	Switzerland	China	Viet Nam	Rwanda
	Sweden	Bulgaria	India	Malawi
	United States of America	Thailand	Ukraine	Madagascar
	United Kingdom	Brazil	Philippines	Tajikistan
	Republic of Korea	Iran (Islamic Republic of)	Mongolia	Burkina Faso
	Netherlands	South Africa	Republic of Moldova	Uganda
	Finland	Peru	Tunisia	Mozambique
	Singapore	Malaysia	Morocco	Mali
	Denmark	Turkey	Kenya	Togo
	Germany	Russian Federation	United Republic of Tanzania	Niger
	France	Montenegro	Uzbekistan	Ethiopia
	Japan	Serbia	Cabo Verde	Guinea
	Hong Kong, China	Mexico	El Salvador	Yemen
	Israel	Costa Rica	Kyrgyzstan	
	Canada	North Macedonia	Pakistan	
	Iceland	Belarus	Bolivia (Plurinational State of)	
	Austria	Georgia	Senegal	
	Ireland	Colombia	Honduras	
	Norway	Armenia	Cambodia	
	Estonia	Jamaica	Nepal	
	Belgium	Bosnia and Herzegovina	Ghana	
	Luxembourg	Azerbaijan	Zimbabwe	
	Czech Republic	Jordan	Zambia	
	Australia	Albania	Egypt	

Figure 2. Innovation performance at different income levels (2021) [24]

The higher education system in Vietnam plays a crucial and dominant role in publishing scientific research both domestically and internationally, contributing approximately 70% of international publications to the Web of Science (WoS) database and about 90% to the Scopus database, as well as over 50% of papers published in reputable national journals [25]. The number of papers published in Vietnam's ISI databases (Statistics on ISIKNOWLEDGE) has been steadily increasing annually. Vietnam's prowess in certain natural science disciplines, notably Mathematics, Physics, and Chemistry, continues to be distinguished within the ASEAN region. The country maintains its leading position in these

fields, showcasing remarkable growth in international publications. Over the period from 2016 to 2020, Vietnam achieved an average annual growth rate of 25.68% in international publications. In the Southeast Asian region, Vietnam stands out as the fifth-largest contributor to international publications during this timeframe, with a total of 48,366 publications. While Thailand leads the region with 87,971 publications, Vietnam's impressive performance underscores its significant contribution to scientific research and scholarly output.

Notably, Vietnam's international publications exhibited a robust upward trajectory in 2020, with the number of publications in the first 10 months surpassing a notable 16% compared to the previous year. This upward trend highlights the nation's commitment to advancing scientific research and innovation, positioning itself as a key player in the global scientific community [26].

The strides made in science and technology have significantly bolstered Vietnam's standing on the global stage. As evidenced by the Global Innovation Index (GII) report for 2019, published by the World Intellectual Property Organization (WIPO), Vietnam's GII ranking has shown steady improvement. In 2019, Vietnam climbed to the 42nd position out of 129 economies, marking a three-place advancement from the previous year and a remarkable 17-place rise from 2016. In the subsequent year, 2020, Vietnam sustained its impressive performance, maintaining the 42nd position out of 131 countries and economies assessed. This achievement not only underscores Vietnam's consistent progress in innovation but also solidifies its position as a leading innovator within the ASEAN region. Notably, Vietnam ranks third in ASEAN, following Singapore and Malaysia, and leads the group of 29 countries and economies with similar income levels. Statistics from Scopus database data show that, from 2018 until now, Vietnam is still ranked 5th in international publications in the Southeast Asian region (see Table 1) [26].

Table 1. International publication in Southeast Asian countries

Ordinal Number	Country	2018	2019	2020	2021	2022	Total Number
1	Indonesia	35.205	48.090	51.627	52.057	42.106	229.103
2	Malaysia	35.134	38.395	39.250	42.273	44.180	199.232
3	Singapore	23.667	24.347	25.768	26.719	27.552	128.053
4	Thailand	19.310	20.457	22.036	25.182	28.291	115.276
5	Vietnam	8.958	12.696	18.179	18.284	18.569	76.686
6	Philippines	4.036	5.874	6.034	6.949	7.238	30.131
7	Brunei	612	630	793	929	1.189	4.153
8	Myanmar	607	792	1.067	864	602	3.932
9	Cambodia	514	535	570	636	695	2.950
10	Laos	317	357	347	353	330	1.704

This remarkable ascent in the global innovation landscape reflects Vietnam's unwavering commitment to fostering a culture of innovation, research, and technological advancement. It underscores the nation's proactive efforts to leverage science and technology as key drivers of socio-economic development and to position itself as a competitive player in the global innovation ecosystem [19].

In recent years, Vietnam has witnessed significant advancements in science, technology, and innovation, marking a transformative journey closely intertwined with production and daily life. These developments have played a pivotal role in enhancing productivity, quality, and efficiency across diverse sectors of the economy. Notably, the value of domestic products has experienced a remarkable surge, escalating from 599 billion dongs in 1986 to over 6,293 trillion dongs in 2020. This impressive growth trajectory has propelled Vietnam out of the group of low-income countries since 2008, underscoring the nation's economic evolution and prosperity. Furthermore, Vietnam's position on the international stage has seen notable consolidation and enhancement, reflecting its growing stature as a key player in the global arena. These achievements stand as a testament to Vietnam's unwavering commitment to leveraging science, technology, and innovation as catalysts for socio-economic development and national advancement. Moving forward, continued investment in these areas will be essential to sustain and amplify the positive transformations witnessed, further solidifying Vietnam's position as a dynamic and thriving economy on the global stage [19].

The achievements attained thus far serve as crucial continuations of previous accomplishments, providing a significant foundation for development in the coming period. Looking towards 2030 and beyond, the global landscape is projected to continue evolving rapidly, becoming more complex and unpredictable. World economic and trade growth, as well as international investment, are trending downwards, while global public debt is increasing, and international financial and monetary markets harbor numerous risks. Science, technology, and innovation, amidst the fourth industrial revolution, are progressing swiftly, catalyzing profound and multidimensional impacts worldwide. Science, technology, and innovation are increasingly becoming decisive factors in each nation's competitive capacity. Digital technology will propel the development of digital economies and societies, reshaping state governance, production models, business practices, consumption patterns, and cultural and social life.

4.2 Limitations to the development of science, technology, and innovation to meet the requirements of sustainable development in Vietnam

Alongside significant contributions to socio-economic development, in recent times, scientific activities, technology, and innovation in Vietnam have also encountered some limitations such as:

The legal framework supporting science, technology, and innovation is still burdensome with administrative procedures, failing to create a conducive environment to unleash creativity and attract talent. Training and fostering human resources, especially young talents in educational institutions, are theory-heavy, and lacking practical experience. Investment in science

and technology remains low, and its effectiveness is yet to be realized. The Fourth Industrial Revolution, especially digital technology, is rapidly advancing, bringing breakthroughs in many fields and intensifying competitive pressures among countries worldwide. However, Vietnam's indices in science, technology, and innovation have not reached high levels.

Science, technology, and innovation have not fully assumed their role as "top national priorities" and are not truly the most important driving force for developing production forces. "The technological capacity of the economy is still low. The industry mainly focuses on processing and assembly, with low value-added; supporting industries develop slowly, the rate of localization is low, and participation in global value chains is still limited" [19]. The technology level of Foreign Direct Investment (FDI) enterprises in Vietnam primarily consists of medium technology, comprising approximately 80% of FDI ventures. High technology enterprises represent only about 6%, with the remainder falling under the category of low technology. In Vietnam, FDI activities predominantly revolve around outsourcing, yielding relatively low added value and maintaining minimal integration with domestic economic sectors. The country's ranking in terms of technology transfer from FDI stands at a modest 4.1, lagging behind Cambodia at 4.7 points and the Philippines at 4.5 points. Comparatively, Singapore scored 5.9 points and Malaysia 5.4 points during the same period.

Overall, Vietnam's standing in the realm of science and technology still falls short of that observed in leading countries within the Southeast Asian region. While certain sectors, such as information technology, telecommunications, oil and gas, aviation, finance, and banking, have demonstrated rapid technological advancements, many manufacturing enterprises continue to rely on outdated technologies, trailing behind global benchmarks. Moreover, the capacity for technology absorption and innovation among domestic enterprises remains constrained. Universities, despite their crucial role in research and innovation, exhibit modest capabilities in research and application. Furthermore, the technical infrastructure and equipment supporting scientific and technological activities are inadequate and lack synchronization. In several localities, investment budgets allocated for science and technology development have been underutilized or misappropriated. The deficiency extends to machinery and equipment in scientific and technological application centers, as well as quality measurement standardization centers, which suffer from inadequacy, obsolescence, and a lack of timely and synchronized investment and procurement. Addressing these shortcomings will be imperative to bolster Vietnam's competitiveness and ensure its sustainable development in an increasingly technology-driven global landscape. According to the General Statistics Office, most Vietnamese businesses are using technology that is 2-3 generations behind the world average, of which 76% of technology was imported from abroad in the 1960s - 1970s; 75% of equipment has been fully depreciated; 50% of equipment is refurbished. The technology level in FDI enterprises is mainly average technology level, heavy on processing and assembly, and the proportion of high technology is small. Support technology is weak and slow to develop. In 2019, Vietnam's innovation index continued to improve to 42/129 economies, up 17 places compared to 2016, but the knowledge economy index (KEI) - an index that reflects Innovation directly creates motivation for socio-economic development but is still very limited (although there has been improvement). Vietnam's KEI index in 2019 was 3.51, of which the innovation index is 2.72, much lower than Singapore (8.44), Malaysia (6.07), and Thailand (5.52). Vietnam's innovation still has a large gap compared to other countries in the region, reflected in the number of inventions and patents applied in Vietnam being much lower than in other countries [27].

Several major indicators in science and technology have not met the requirements. By 2020, Vietnam's science and technology level had not reached that of the leading ASEAN countries. There has been a lack of breakthrough solutions for internal sector development, and the growth model does not yet rely on a foundation of science, technology, and innovation. Economic autonomy remains low, with significant dependence on external factors [19]. Although the current science and technology market has had certain developments, the supply of science and technology market is slow to develop (because science and technology human resources are still limited in both quantity and quality) lack of skills and innovation capacity, the number of high- and middle-level professional and technical human resources in Vietnam still accounts for a small proportion of the total workforce. In 2017, the proportion of high-level technical expertise accounts for only about 7.2% of labor); The number of enterprises investing in research in the field of science and technology currently accounts for only nearly 9%; The number of enterprises with direct activities related to scientific research and development is only about 400 enterprises (too few compared to the scale of over 750 thousand enterprises operating in various fields today); The "demand side" of the science and technology market is still underdeveloped (in terms of scale, level and quality), and has not created a strong attraction to promote the "supply side" of development and innovation with practical application [27].

Furthermore, Vietnam's national innovation system is still in the process of formation. The elements and relationships within the national innovation system are gradually being perfected but are still unclear. Research and development activities within the business sector are limited, and the capacity for technology application and absorption among enterprises remains low. Training activities in higher education institutions lack integration with scientific research and industry. There is a lack of design for many scientific, technological, and innovative tasks with broad interdisciplinary impact, resulting in specific programs not meeting expectations and failing to produce truly groundbreaking scientific and technological products.

The constraints and shortcomings mentioned above indicate that the field of science and technology has not yet been truly regarded as a top priority in national policies and has not fully assumed its role as the primary driver of economic and social development [19]. Specifically:

i) Management levels, industries, enterprises, and science and technology organizations still lack full awareness of the important role and position of science and technology in the sustainable development of the country in the long term.

ii) Despite progress, the management mechanisms, innovation policies, and activities for science and technology development are still hindered by bureaucratic obstacles and are not adequately aligned with market mechanisms, failing to encourage and attract active participation from experts and scientists. The mechanisms for research funding and the uptake of research results remain limited.

iii) The quality of the science and technology workforce

does not match the quantity, and the occupational structure is not appropriate. Furthermore, the mechanisms and policies regarding personnel in the field of science and technology are still overly bureaucratic, lacking sufficient encouragement and incentives to promote the creativity of the workforce.

iv) The global economic downturn has created many difficulties for production and business activities, necessitating privatization. As a result, most businesses are focusing on solutions such as mergers, acquisitions, enterprise restructuring, and addressing financial issues, reducing attention to science and technology activities.

4.3 The solution for the development of science, technology, and innovative creativity to meet the requirements of sustainable development in Vietnam

Firstly, it is imperative to enhance mechanisms and policies related to science, technology, and innovation. The development of legal frameworks in this domain should be based on the practical development of the industry and must focus on discussions and evaluations regarding the issuance and implementation of the Party and State's directives and orientations in promoting industrialization and modernization of the country. Additionally, there needs to be a clear articulation of the achievements attained as well as an in-depth analysis of the existing limitations and weaknesses along with their underlying causes.

Innovating and improving mechanisms and policies for mobilizing, allocating, and utilizing investment capital for science and technology activities is a critical priority. It is essential to continue refining policies regarding state budget investment in science and technology activities, avoiding overlapping allocation and dispersion of funds while ensuring the effectiveness and robust development of the intellectual labor force through enhancing education and talent training.

International experience demonstrates that innovation plays a pivotal role in the development of all aspects of society, especially economic growth. The primary driver of labor productivity is innovation, with a focus on the development and application of high technology. Innovation is identified with five key inputs: macrostructure, human resources and research, infrastructure, market and business environment, and two key outputs: knowledge products and technology, and innovative products. Depending on specific conditions, each country may choose its path and model. Success depends on each country's ability to recognize, grasp, apply, and develop technological advances.

Currently, countries within the ASEAN bloc have recognized this issue. The World Economic Forum on ASEAN in 2018 in Hanoi (September 13, 2018) emphasized the importance of each country proactively harnessing entrepreneurial spirit, promoting innovation with a multidimensional, long-term vision for sustainable development in the era of the Fourth Industrial Revolution.

Secondly, it is crucial to develop a robust strategy for the advancement of science, technology, and innovation as the foundation for enhancing productivity, quality, efficiency, and competitiveness across industries, sectors, and the entire economy. This involves driving economic restructuring and innovating economic growth models, promoting research and development (R&D), fostering innovative entrepreneurship, and integrating applications with technological development, especially in promising new sectors and fields of strength.

Innovating and refining mechanisms and policies for mobilizing, allocating, and efficiently utilizing investment capital for science and technology activities is essential. Continuing to improve state budget investment policies for science and technology activities should aim to avoid overlapping allocations, ensure effective utilization, and promote the strong development of the intellectual labor force through enhancing education and talent training.

Continued innovation in investment and financial mechanisms for science, technology, and innovation based on healthy competition and relying on outcome and efficiency indicators is necessary. This requires flexibility and simplification of procedures for selecting scientific and technological tasks, as well as implementing financial settlements according to international standards to reduce administrative burdens on scientists.

Moreover, it is necessary to establish supportive policies for enterprises operating in the fields of science, technology, and innovation in terms of finance. If possible, tax exemptions or reductions on corporate income tax, land lease fees, and interest on investment credit loans should be considered to create favorable conditions for enterprises to continue investing in scientific research, developing infrastructure, and human resources, thereby generating new quality and competitive products in the market.

Thirdly, there needs to be a focus on enhancing social investment resources in the fields of science, technology, and innovation, particularly from the perspective of businesses. Additionally, attention should be directed towards the development of social sciences and humanities, and fostering close connections and synchronization between social sciences and humanities with natural sciences, engineering, and technology to serve the rapid and sustainable development of the country. To achieve this, continued investment in developing and modernizing infrastructure and scientific and technological capabilities is necessary, along with a focus on enhancing enterprises' capacity for technological leadership and innovation. Encouraging the import and transfer of advanced technology from the world and promoting industrialization and modernization based on scientific and technological progress and innovation require further strengthening of all social resources to create more favorable conditions for research, entrepreneurship, application, and technology transfer more effectively. Developing public research and development organizations towards autonomy and responsibility in research, development, and innovation activities is also crucial. Promoting coordination between research and development organizations and enterprises in conducting research, application, and technology transfer to serve socio-economic development is essential. Protecting, and enforcing the development and exploitation of intellectual property in line with new trade agreements; establishing guidelines to ensure effective enforcement of intellectual property rights, addressing intellectual property infringement, and synchronizing solutions to expedite processing and address backlog issues are also essential.

Fourthly, there is a need to develop high-quality human resources in the fields of science, technology, and innovation. To achieve this, comprehensive innovation in education and training needs to be strengthened, and high-quality human resources need to be trained and nurtured to meet development requirements in the context of the rapidly evolving Fourth Industrial Revolution. Diversifying training methods towards "open" education, adjusting human resource training according to labor market needs, and linking it with

modernization development are crucial. Focus should be placed on enhancing skills education and application of information technology, and digital technology, and implementing a roadmap for digital skill popularization at all levels of education. Moreover, emphasis should be placed on practical technology application and combat skills for students, and learners at educational institutions specializing in science and technology.

Fifthly, developing the market for research and development and international cooperation towards strategic partner selection based on close integration between research and development cooperation and science and technology development with economic and defense cooperation to build cooperation contents, signing bilateral and multilateral agreements, focusing on appropriate technology transfer to serve national, sectoral, regional, and local development goals. Additionally, applying high-tech engineering technology in managing science and technology activities reduces administrative procedures for scientists and organizations operating in the field of science and technology. To promote innovation and digital transformation in the private sector, there needs to be an environment for innovation and digital transformation and the promotion of a culture of innovation and digital transformation within each enterprise. More importantly, there needs to be a culture of innovation spreading from leadership to the lowest level employees of the enterprise. Only then can enterprises truly become the center of the national science, technology, and innovation system.

5. CONCLUSIONS

The advancement of science, technology, and innovative creativity serves as a critical barometer reflecting a country's level and quality of development. It stands as a cornerstone for meeting the multifaceted requirements of economic, social, and environmental progress sustainably. Throughout Vietnam's developmental trajectory, this domain has emerged as a linchpin in driving rapid and sustainable advancement, not only on a national scale but also within organizations and enterprises. This is particularly evident in the context of the Fourth Industrial Revolution and the profound digital transformation sweeping across various sectors. However, the journey towards enhancing science, technology, and innovative creativity is not without its challenges and hurdles. To surmount these obstacles and propel sustainable development in this domain, Vietnam must embark on a multifaceted approach encompassing comprehensive solutions. By doing so, Vietnam can harness the full potential of science, technology, and innovative creativity, paving the way for continued progress and prosperity in the face of evolving global dynamics.

ACKNOWLEDGMENT

This research was fully funded by HUTECH University (Grant No.: 2024.11.GDCTQP).

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