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The Role of Science and Technology in Transforming New Productive Forces in Thai Nguyen: From Theory to Practical Applications in Green Industry and Agriculture

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ABSTRACT
This paper looks at how science and technology (S&T) plays a major role in changing new productive forces in Thai Nguyen Province, Vietnam.Based on the ideas from Marxism-Leninism and the decisions made by the Communist Party of Vietnam, the study shows that S&T is not just a tool but also a direct productive force that helps in digital transformation and green economic growth. Through real-world use in industries like information technology zones and foreign direct investment (FDI) projects, and in green agriculture through programs like VietGAP and biotechnology, Thai Nguyen has seen steady growth in society and the economy. However, there are still problems like a shortage of skilled workers and not enough good policies. Looking ahead until 2030, the focus is on carrying out Resolution 57-NQ/TW to push innovation forward. The paper uses data from official reports and academic sources up to 2025.

Keywords: Science and technology, new productive forces, economic transformation, green industry, sustainable agriculture, Thai Nguyen.

I. INTRODUCTION

With globalization and the fast development of the Fourth Industrial Revolution, science and technology have become key factors in shaping and improving new productive forces.

These new productive forces go beyond traditional labor, using scientific knowledge, digital tools, artificial intelligence (AI), and green economic approaches to increase productivity, ensure sustainability, and reduce reliance on natural resources. From a Marxist-Leninist viewpoint, productive forces are the base of society's growth, and science and technology drive this by turning knowledge into real productive power. In Vietnam, the Communist Party has acknowledged this in major decisions, making science and technology the top national policy to support industrialization and modernization.

Thai Nguyen, a province in Vietnam's Northern Midlands and Mountains region, is becoming an important economic and industrial center.Its location, near Hanoi and other nearby provinces, and its rich resources like iron, coal, and good farmland, have given it a strong position. However, in recent years, Thai Nguyen has moved away from a resource-based economy to one that is knowledge- and innovation-driven. By 2025, the province's gross regional domestic product (GRDP) growth rate was 6.47% in the first half of the year (before the merger), which was higher than the national average, largely because of the wide use of science and technology in different industries. This shift has not only increased productivity but also helped protect the environment, supporting green and circular economies.

This change is supported by both national and local rules. Resolution 57-NQ/TW, which was passed on December 22, 2024, by the Politburo, says that science and technology should be a main area for fast and long-term growth. In Thai Nguyen, Resolution 01-NQ/TU, issued on December 31, 2020, by the Provincial Party Committee, highlights that science and technology is a key part of changing the economy. The People's Committee's Report No. 225/BC-UBND, dated November 22, 2024, talks about the province's progress in 2024 and plans for 2025. It

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mentions that Thai Nguyen brought in 222 foreign investments totaling 11.2 billion USD, with many of them being high-tech projects. These projects help create new ways of making things through digital technology and AI.

In the industrial area, Thai Nguyen is building eco-friendly and smart industrial zones, and is getting support from big companies like Samsung.A 2024 agreement with Samsung E&A (South Korea) is helping to explore new green economic models. These models allow the use of Industry 4.0 technologies, reduce pollution, and encourage recycling. Digital change supports a "dual change" – going digital and green – aiming to make industries more competitive and increase value added by more than 8.5% each year by 2030.

In farming, science and technology are helping to move from old farming methods to modern and organic approaches.From 2021 to mid-2024, the province used 368 science and technology projects, including growing organic tea and off-season custard apples. This has led to 6,203 hectares of crops with VietGAP certification and 85 hectares of organic land. Cooperatives like Thiên Phúc use circular economy methods, which cut down chemical use and increase product value, supporting green farming.Training people is a top goal.Thai Nguyen University is leading in teaching AI and semiconductor skills through the "AI for everyone" program and 2,255 community groups that teach digital skills to almost 15,000 people. By 2030, the province wants to become a center for research on chips and electronic devices.However, there are still some problems, such as small production sizes and a lack of skilled workers.This paper looks at how science and technology work in practice and suggests ways for Thai Nguyen to keep growing by following Resolution 57-NQ/TW.

II. THEORETICAL FRAMEWORK ON THE ROLE OF SCIENCE AND TECHNOLOGY IN DEVELOPING NEW PRODUCTIVE FORCES

According to Marxism-Leninism, productive forces are the main thing that helps society move forward.These forces include people working and the tools and materials they use in their jobs. Karl Marx thought that at some point, science would become a direct productive force, meaning knowledge would be used as a tool to increase production. V.I. Lenin added to this idea, saying that science is important for making work more efficient and helping society develop. In the Fourth Industrial Revolution, new productive forces are made from digital technology, artificial intelligence, and green economic models, which help create more valuable products.

In Vietnam, the Science and Technology Law of 2013 describes science and technology as a system of knowledge that helps understand how things change, and supports both production and daily life.Later changes to the law focus on encouraging innovation. The Consolidated Document 13/VBHN-VPQH from 2022 adds rules about transferring technology and investing in science and technology. Resolution 57-NQ/TW, passed on December 22, 2024, by the Politburo, says science and technology are key to progress, with seven main tasks, such as developing skilled workers and building digital infrastructure.

This framework is being used in Thai Nguyen through Resolution 01-NQ/TU from 2020, which sees science and technology as a way to move from labor-based economies to high-tech ones.

Provincial reports show that science and technology contribute 50% to the region's GDP growth, which matches Marx's view that science is a direct productive force. In industry, science and technology help improve production, such as using AI to manage supply chains. In agriculture, biotechnology helps increase productivity and reduce environmental harm, showing how science can lead to sustainable development.

This framework also highlights the importance of people in productive forces.Marx believed skilled labor was a key part of productive forces, and in Thai Nguyen, training in AI at Thai Nguyen University is helping build better human resources. Resolution 57-NQ/TW also encourages more investment in high-quality human resources, which aligns with Marx's idea that science can be a powerful force.

III. PRACTICAL APPLICATIONS OF SCIENCE AND TECHNOLOGY IN INDUSTRY IN THAI NGUYEN

Industry plays a vital role in Thai Nguyen's economy, making up more than 60% of the gross regional domestic product (GRDP).Science and technology are being used a lot to move away from old ways of doing things to more modern, digital, and eco-friendly methods. By 2025, the province had brought in 222 foreign investment projects totaling 11.2 billion USD, with 130 of them being high-tech projects worth about 7.3 billion USD. This shows that Thai Nguyen is very attractive for investments that use science and technology. Big companies like Samsung, Foxconn, and firms from South Korea and Japan have started

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operations in industrial areas, using Industry 4.0 tech to make production more efficient, reduce emissions, and help workers be more productive. For example, Samsung has introduced smart production lines that use automation and AI. This has helped cut energy costs by up to 20% and support a circular economy in the electronics industry.

A big example is the Yen Binh Information Technology Zone, covering 200 hectares and approved by the Prime Minister in 2023.This zone focuses on digital tech, AI, and semiconductors. It not only brings in investment but also serves as a center for research and sharing of technology, helping local businesses use science and tech. By 2025, Yen Binh had more than 50 projects, creating jobs for thousands of skilled workers and helping the digital economy reach 35.5% of the province's total economic output, with revenues over 711 trillion VND. Science and tech are used in IoT systems that monitor production in real time, reducing waste and improving efficiency by 15 to 20%. In 2024, a partnership with Samsung E&A started exploring green economic models, introducing renewable energy and advanced waste treatment technologies, aiming to cut carbon emissions by 30% by 2030.

In the processing industry, science and tech help make products more valuable.The textile industry, which has always been a key part of Thai Nguyen's economy, is being modernized with innovation and digital changes. Companies have started using automation, robots, and AI, which have helped cut production time by 20 to 30% and improve product quality. For instance, textile factories use digital supply chain systems and big data to predict market needs and manage materials better, leading to export values over 5 billion USD in 2024. Similarly, in the tea industry, advanced automation is used to improve the quality of organic tea and expand export markets. The province is also putting in more efforts to build processing plants in key areas, using modern technology to increase product value by up to 50%.

S&T applications are also being used in the semiconductor and IT industries, which are seen as key areas for growth by 2030. In 2025, Thai Nguyen plans to train 4,500 workers for these fields, including 500 at higher levels. Of these, 300 will specialize in semiconductors and 200 in IT and AI. Thai Nguyen University of Technology has expanded its training programs, working with companies to share knowledge and research, especially in semiconductors and automation control systems. The province has created over 2,255 community technology groups with nearly 15,000 members, helping small and medium businesses (SMEs) move toward digital transformation through the C-Thai Nguyen app for managing production and logistics.

Policies at the provincial and national level have helped push the use of S&T in industry.Directive 07/CT-UBND, issued on March 13, 2025, highlights the need for synchronized and secure digital infrastructure to boost industrial productivity. The province is focusing on 26 S&T products in 2025, including four major high-tech projects in electronics and precision mechanics. Tax breaks and support for technology transfer have attracted large foreign direct investment (FDI) projects, leading to annual industrial growth over 8.5% and a rise in labor productivity by 7.5%.

Nuclear energy is becoming an important area for S&T applications.From 2021 to 2025, Thai Nguyen carried out programs using nuclear technology to support socio-economic development, such as using radiation for treating industrial waste and ensuring product quality. A 2021 seminar helped connect local businesses with the Vietnam Atomic Energy Institute, making it easier for companies to adopt these technologies. In the e-commerce sector, a 2025 conference discussed how S&T and innovation can help industrial companies improve online sales, including using AI to predict inventory needs and customer demand.

Overall, the use of S&T in Thai Nguyen's industry is boosting productivity and promoting sustainability.Large FDI companies are leading the way in adopting Industry 4.0 technologies, while local programs and policies help SMEs keep up. By 2025, Thai Nguyen has become a leader in digital transformation for industry, aiming to be a key technology center in the Northern Midlands and Mountains region. However, more investment in research and skilled human resources is needed to tackle challenges like the lack of high-level experts.

IV. PRACTICAL APPLICATIONS OF SCIENCE AND TECHNOLOGY IN GREEN AGRICULTURE IN THAI NGUYEN

Green agriculture in Thai Nguyen is being strongly supported through science and technology (S&T), moving away from traditional farming to sustainable practices that focus on circular economies, reducing emissions, and improving the value of agricultural products.

As a province with a lot of farmland and major crops like tea, rice, and livestock, Thai

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Nguyen has used S&T to improve productivity, protect the environment, and adapt to climate change.

Between 2021 and 2025, the province introduced hundreds of S&T applications, keeping agriculture's share of the GRDP stable and helping achieve green growth goals. According to reports from the province, the value of agricultural production increased by an average of 2.529 trillion VND each year, thanks to advanced technologies such as AI, biotechnology, and digital management systems. Green agriculture is not just a trend, but a necessity, promoting clean production that follows VietGAP and organic standards, reduces chemical use, and helps preserve land resources.

A major use of S&T is in crop farming, where it helps change the types of crops grown and how resources are managed.

From 2024 to 2025, the province used genetic modification and advanced land and water management techniques, which helped increase productivity by 20–30% without harming the environment.For example, in the Commune of Dong Hy and Phu Luong, organic tea models use biotechnology to control pests, reducing the need for chemical pesticides. The province achieved 65 hectares of organic tea and 3 hectares of off-season custard apples using advanced techniques, along with 6,203 hectares of VietGAP-certified crops and 85 hectares of organic crops. These models improve product quality and help boost exports, with value-added products increasing by 15% due to high-tech processing. Drones and IoT sensors are used to check soil moisture, helping manage irrigation more efficiently and reducing water waste by up to 40%. In 2025, local areas adopted high-quality tea varieties and advanced techniques, leading to a 10–15% increase in tea productivity and a reduction in greenhouse gas emissions.

S&T applications in livestock farming are a key focus, helping to create greener and more sustainable agriculture. Between 2021 and 2025, the province introduced high-tech farming methods, such as bio-bedding and automated systems, which help reduce waste and reuse by-products. Many farms use IT tools to monitor the health of animals using AI and sensors, which has helped lower disease cases by 25%.In Phu Binh Commune, organic pig farming uses farm leftovers as animal food, forming a closed-loop system that reduces methane emissions. By 2025, the province created 40 models that connect different parts of the livestock chain, including 10 mechanized models, which boost productivity by 2 to 3 times compared to traditional methods. These science and technology efforts are backed by national programs that aim to promote green products and circular economies, where waste becomes organic fertilizer. This has improved the quality of meat and eggs, helping them meet export standards and increasing the value of livestock production by 3 to 5% each year.

Digital transformation and AI play a key role in making green agriculture more efficient for farmers.The "AI for Everyone" program, which started in 2024, trained at least 5,000 farmers on using AI for weather forecasts and soil analysis. There are also 2,255 community technology groups with nearly 15,000 members who use mobile apps to track their supply chains, detect diseases, and use fertilizers better. For example, rice farmers in Dai TuCommune used AI in low-emission rice farming to manage water and fertilizer, reducing greenhouse gas emissions by 30% and increasing rice yields by 10%. This program helps raise efficiency, protect the environment, and support sustainable livelihoods. Also, digital tools have helped Thai Nguyen's agricultural products reach international markets, with organic sales rising by 20% due to AI-powered e-commerce platforms.

Successful examples of green and circular agriculture show how science and technology can make a big difference. Thien Phuc Cooperative in Dong Hy Communeuses crop by-products as organic fertilizer for animals, forming a closed-loop system and promoting agritourism. This model uses biotechnology to clean up waste, lowering pollution and increasing product value by 25%. Similarly, seedless lemon and medicinal mushroom farming use greenhouses and automatic irrigation, saving 50% of water and increasing productivity by 1.5 times. By 2025, the province had implemented 368 science and technology models, including 218 technical demonstration projects and 60 bio-bedding models, helping to build a high-value green economy. These models are good for the environment and help improve rural areas, with Phú Lương district leading the way in using science and technology to meet higher rural development standards.

Provincial and national policies help encourage the use of science and technology (S&T) in many areas. In 2024, Resolution 57-NQ/TW emphasized the need for major advances in agricultural S&T, using research and policy tools to drive innovation. The agricultural digital transformation program in Thai Nguyen, running from 2021 to 2025, focuses on using high-tech solutions. This aims to increase the industry by 3–5%, through the use of greenhouses and water-

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saving irrigation methods. Events like the 2025 conference on "Promoting S&T, Innovation, and Digital Transformation in Agriculture and Environment" discussed turning green products into marketable goods and linking research with real-world applications. The province has focused on key agricultural products like tea and pork, applying S&T in breeding, intensive animal raising, and processing, to support long-term economic growth.

Overall, using S&T in Thai Nguyen's green agriculture has led to significant benefits, such as higher productivity and better environmental protection.Models like low-emission rice farming and seedless lemon cultivation have made farming more efficient and improved farmers' lives. These methods have reduced chemical use by 40%, and increased farmers' incomes by 20–30%. However, expanding these practices requires more investment in training and better infrastructure to achieve full-scale green agriculture by 2030.

Thai Nguyen has made significant progress in using S&T to create new productive forces, but there are still several challenges that limit its sustainable growth.These include small-scale farming, a lack of skilled workers, poor digital infrastructure, and a reluctance to adopt new technologies. To overcome these problems and become a technology hub for the Northern Midlands and Mountains region by 2030, Thai Nguyen needs to combine education, policy reforms, and international collaboration, while making use of both national and local support.

Small-scale production is a major challenge, especially in farming and for small and medium-sized businesses (SMEs). According to the 2024 Provincial Socio-economic Report, more than 70% of farming families in Thai Nguyen work on less than one hectare of land. This makes it difficult for them to use new technologies like the Internet of Things (IoT) or Artificial Intelligence (AI). In the industrial sector, SMEs face problems getting the money needed to invest in new technologies. Because of this, they use science, technology, and innovation (STI) at only 30% of the rate that large companies do. There is also a serious lack of skilled workers. The 2024 data shows that Thai Nguyen needs about 5,000 more workers who know digital technology, especially in areas like semiconductors and AI. This has made many foreign investment projects have to look for workers from other provinces. Digital infrastructure is not yet fully developed, with only 70% of rural areas having 5G mobile networks. This prevents smart technology from being used properly. People in farming and SMEs are also hesitant to try new technology because it is expensive upfront and there is no insurance to cover risks. Climate change is making things worse, with extreme weather like floods and droughts happening 20% more often. This hurts both farming and industry, so they need better climate-adaptive technologies.

Looking ahead, by 2030, Thai Nguyen wants to become a key place for semiconductor research and manufacturing, electronic devices, and green technology.

The digital economy should make up 50% of the region’s total economic output, and the region should grow by about 10.5% each year. The Politburo’s Resolution No. 57-NQ/TW (2024) is the main guide for this. It focuses on science, technology, and innovation as the key to growth, with seven main areas to work on, including training more skilled workers and expanding digital networks. The Thai Nguyen Provincial Master Plan (2021–2030) plans to turn the Yen Binh Information Technology Park into a top research and development center. This is expected to bring in an extra $10 billion in foreign direct investment and create 50,000 good jobs. In farming, the province wants to grow 200 hectares of organic farms and 10,000 hectares of VietGAP-certified farms. This should help increase the value of agricultural production by 4 to 5% each year through the use of biotechnology and IoT.The innovation and startup ecosystem is expected to expand significantly, with the target of reaching 1,000 science and technology-based enterprises by 2030.

Feasible solutions

High-skilled workforce development: Expand the “AI for Everyone” program and form stronger links between Thai Nguyen University and big companies like Samsung and Viettel to train 10,000 workers in digital skills every year.Training costs about VND 500 billion a year, but the benefits could be much bigger, with a 20% rise in worker productivity and fewer skilled workers leaving the country.

Enhancement of incentive policies: Give companies using green technologies a 50% tax break and set up a VND 200 billion fund to help small businesses deal with the risks of new technology.This could bring in an extra USD 5 billion in foreign investment and get 80% of small businesses to use high-tech solutions.

Digital infrastructure development: Set aside VND 1,000 billion to improve 5G coverage

in 95% of rural areas and upgrade cybersecurity systems. This could increase labor productivity by 5–7% and lower the risk of a cybersecurity attack by 15%.International technology cooperation: Work together with South Korea and Japan through agreements to share technology for adapting to climate change.This could reduce agricultural losses by 30% and increase farming productivity by 10–15%.

Strengthening research–technology transfer linkages: Set up an innovation center in Yen Binh and use 500 science and technology applications each year.This could make technology adoption more effective, with an 85% success rate, and help make farming exports more competitive.Community awareness enhancement: Use the C-Thai Nguyen digital platform to run awareness campaigns and hold workshops to change people's hesitant attitudes toward new technologies. This could raise awareness by 50% and get 5,000 farming families to use advanced technologies.

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