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Policy of Development of High-tech in China: Lessons for Ukraine

China in the late 1980s, has embarked on a new path of high-tech manufactury development that is in line with its ambitions. The philosophy of China's innovation and industrial policy is based on the idea that the achievement of competitive manufactury must be through the national high-tech zones and high-tech enterprises, creating new products and processes based on indigenous innovation. The purpose of the study is to to explore the Chinese experience on policy and mechanisms of development of high-tech manufacturies and to analyze of statistical tools to assess its implications; to assess the appropriateness or feasibility of their application in modern economic conditions of Ukraine. The study's results have enhanced the existing understanding of the effect of State on accelerating the process structural transformation of the economy and its qualitative technological growth. Discovered the fact, that the Chinese Government is providing substantial support in the form of subsidies and tax incentives for establishment of special high-tech zones and high-tech enterprises for encourage the production of new and high-tech products and processes. It was revealed that, in order to grasp the economic operation and scientific, technological, industrial development of high-tech zones and high-tech enterprises, statistical investigation system was specially formulated in addition to official statistics of the High-tech industries. It is proven that China's state-led innovation development model has successfully accompanied and stimulated the growth of high-tech over the last 30 years; and has produced numerous endogenous technological innovations. Analysis revealed that considerable efforts in the field of policy of China transforming the industry into a high-tech sector of the economy and a powerful player in the global market have outstanding performance. The article presents the new indicator EVA – coefficient of Comparative Advantages in the Domestic Value Added Exports and formula for its calculation is provided which allow the assessment of the position of China's high-tech industries, widening the 'revealed comparative advantage' concept. This study shows some important conclusions about the determinants of success of the Chinese government in increase of resources for the modernization of industrial technologies, building and strengthening of potential of domestic high-tech manufacturies. It would be advisable to take into account some important levers of influence, following the example of China, when choosing mechanisms for the economic recovery of Ukraine after war.

Key words: *China, high-tech, manufactury, national high-tech zone, high-tech enterprise, government policy, comparative advantages, domestic value added in gross exports.*

Introduction. The scientific and technological innovation has entered an unprecedentedly active period and profoundly changed global politics, economy, and people's lives. It was bolstered also by outbreaks of COVID-19 and the full-scale invasion and occupation of a portion of Ukraine's territory of russian troops. In 2022, Ukrainians faced severe challenges and the most tragic events since the Second World War; it has led to numerous casualties and the disruption of infrastructure and industrial facilities. But it soon became apparent that Ukraine was confronted with a challenge it was not prepared to deal with, because the Ukrainian industry doesn't have sufficient resources and incapable of responding effectively, and therefore there is a dependence of high-tech imports (primarily, military items). The absence of a purposeful state policy for the development of high-tech industry (for many years Ukrainian scientists drew attention to the need for such a policy [1]) makes it impossible the prompt replies to these threats; in addition, its absence will make it harder to post-war recovery.

New innovative industrialization policy-making in Ukraine requires appropriate research for selective reproduction the best reforms served serving as a basis for accelerated development. The aim of the article is to clarify the main conditions and policy mechanisms (in the example of China) that contribute to the accelerated modernization of industry, structural changes and the emergence of high-technology industries; to evaluate the system statistical monitoring of their results.

Literature review. In several studies conducted by Chinese scientists, mainly aimed at studying the guiding philosophy of the developmental state and the evolution of high-tech, it was found the influence of government policy on the formation of high-tech zones on high-tech enterprises innovation (in particular, the Chinese scientists find that certification of high-tech enterprises has significantly promoted the innovation activities and access to foreign markets) [2–5]. At the same time, pressing questions remain: how has the high-tech industrial landscape of the China in changed, and what political decisions have influenced these changes and how keeps statistics?

Ukrainian scientists analyzed the phenomenon of innovative development of Chinese industry [6; 7]. The basic tools of the State policy which promoted the transformation of the high-tech industries into a key segment of Chinese economy and strengthened the country's position on the world market are a subject which has been little explored, but Chinese experience little applied in Ukraine. In this regard, the article examines of China's regulations and programs, which created the foundations for the National high-tech zones (NHTZs) and high-tech enterprises (HTEs) in China and contributed to their development.

Results and discussion. In 1986, at the beginning of the seventh five-year of the socio-economic development of China (1986–1990) mentioned industrial policy for the first time at the national level, and proposed the direction and principles of improvements of industrial structure: "Actively use new technologies to transform traditional industries and traditional products, focusing on develop knowledge-intensive and technology-intensive products, strive to open up new production fields, and promote the formation and development of several emerging industries" [8, p. 315].

The basic regulatory and programmatic documents

1. 863 Program. On March 3, 1986, four scientists submitted Suggestions on Tracking the World's Strategic High-Tech Development, formulating China's development plan for high technology. Deng Xiaoping approved the start of the project, and the State Council decided to initiate the National High-Tech R&D Program – the 863 Program [9]. At this time, they would never have imagined that the implementation time of the plan will amount 15 years, with a total investment about 10 billion yuan.

863 Program was aimed at pooling of researchers to conduct frontier-oriented R&D and to stimulate its S&T advances in relevant fields, at educating a new generation high-caliber technological talents, at establishing foundations emerging of high-tech industries for to narrow China's gaps with developed nations. Based on the development trend of world high technology and country's needs and actual possibilities, 863 Program selected 15 thematic projects in 7 technical fields including biology, aerospace, information, laser, automation, energy, and materials to start high-tech climbing. In 1996, the field of marine technology was added.

15 years after 863 Program was launched, it prolonged (during the 10th Five-year Plan period, 2001–2005). The program continued to promote a number of cutting-edge projects and was guided by encouraging R&D in subjects which impose the most significant impact, such as: information technology, biology and modern agricultural technology, aerospace technology, and advanced defense technology and other [10]. The Chinese Government has stressed: "According to the requirements of taking a new road to industrialization, we will speed up the adjustment of industrial structure" [11]. But for this you need to introduce high-tech and advanced technologies to transform and upgrade traditional industries, support key industries and backbone enterprises to carry out technological transformation, and support large-scale manufacturing enterprises (to improve product development and technological innovation capabilities).

The cornerstone of the technological breakthrough on the basis of national innovation was National Medium and Long-Term Plan for the Development of Science and Technology (2006–2020) [12], which focused further government measures on indigenous innovations. This Program unfolded an ambitious blueprint for building a powerful science, technology and innovation capacities, and improving the economy's ability to ensure the development of advanced technologies and develop important high-tech goods based on endogenous innovations, speedup their implementation in the industrial scale. It has set a new benchmark for 863 Program and opened the public procurement market for innovative products. "Indigenously innovated products and technologies that meet the needs of national defense or national security shall be prioritized for procurement. The departments, participating in the public procurement, involving national security, should first purchase domestic independent innovation products, and procurement contracts should be given priority to enterprises or scientific research institutions with independent innovation capabilities" the document says [13].

In fact, 863 Program had three stages [14]:

- 1986 to 2000: tracking of advanced technology and active development;

- 2001–2005: implementation of a strategic transformation from tracking cutting-edge developments to in-house developments;
- 2006–2015: accelerated deployment of indigenous technologies to drive further growth.

In 2016, with the introduction of the National Key R&D Program, the 863 Program ended its historical mission and was merged with other programs.

2. State High-Tech Development Plan (Torch Program). In August of 1988, the State Council of China officially approved the launch of Torch Program (that is the High-tech Industry Development Plan). Its purpose is to promote the commercialization of results of the 863 Program through the establishment of high-tech industrial development zones. To accomplish this challenge, in 1991, the authorized state agencies promulgated the Interim Provisions on Several Policies for NHTZs and the Provisions on the Tax Policy of the NHTZs [15]. The State Council Promulgated the Circular [16] (Circular 1991), and the foundation for the basis for creating new High Technology Industries in the NHTZs had been laid. The Annex 1 of Circular 1991 contained information about the identification procedure for HTEs in NHTZs. In 1996, in order to facilitate standardization of approaches for identification of HTEs across the country, the Circular for HTEs outside the NHTZs (Circular 1996) were developed [17].

A decade later, in 2000, the Circular 1991 was perfected and published updated (Circular 2000) [18]: the new conditions of identification have been clarified, and the fields of high and new technology were extended (in addition to new techniques and technologies applied in the transformation of traditional industries, new technologies for environmental protection; ocean engineering technology; nuclear application technology were added).

In 2008, Circular [19] (Circular 2008) abolished both of the previous ones (Circular 1996 and Circular 2000), by combining them into one. In the new document, in Chapter III “Conditions and Procedures”, Article 10 “High-tech enterprise certification” the updated conditions of identification have established; and high-tech fields, supported by the state, were clarified (the items were consolidated into 8 categories).

In 2015, the government approved the strategy “Made in China 2025” [20]. According to the strategy, China’s technologies and high-tech industrialisation will increase the efficiency of the economic system and will strengthen its global economic-political influence; and the development of NHTZs is an important component of this Program. In 2016, the Circular 2008 and the Notice on Renaming and Review of HTEs (Guokehuozi [2011] No. 123) ware abolished [21].

After many years of efforts and targeted innovation development measures of industries, the authorities have relaxed the HTEs recognition requirements in some respects. In 2016, the criteria for identifying HTEs were adjusted [21], in particular, it was clarified that the ratio of the total R&D expenses of the enterprise to the total sales revenue of the same period in the past three fiscal years shall comply the following requirements: enterprises with sales revenue of less than 50 million yuan (inclusive) in the most recent year, the proportion shall not be less than 5%; with a sales revenue of 50 million yuan to 200 million yuan (inclusive) – the proportion shall not be less than 4%; the proportion of enterprises with sales revenue of more than 200 million yuan in the most recent year shall not be less than 3%; at the same time the total R&D expenses incurred by the enterprise on the territory of China account for no less than 60% of the total R&D expenses; the income from high-tech products – for no less than 60% of the total income of the enterprise [21].

As the comparative analysis made by the author’s [22] shows, Circular 2016 does not radically transform the HTEs rules of Circular 2008. The changes in the document have increased small medium sized business participation in the process of earning HNTE status; also revised the list of priority technologies for certification HNTEs purposes.

By analyzing the normative documents, we can come to the conclusion about evolving approaches to identification and certification HNTEs. But, from 2016 to today (2023), basis for identification is the Administrative Measures for the Identification of HTEs (Guokefahuo [2016] No. 32); and the Guidelines for the Administration of HTEs Certification (Guokefahuo [2016] No. 195). In addition to these documents, it is also the System for Relevant Certification Matters Recognized as HTEs (Guo Ke Fa Huo [2021] No. 362) was adopted (it concerns to the provision of patent information and intellectual property certificates etc.).

Preferential tax policies for high-tech enterprises

The tax incentives to encourage technology innovation are the primary facility to support [23]. In 2023, there are such preferences and subsidies in high-tech activity.

1. Tax reduction and exemption. HNTEs treatment, which reduces a qualified taxpayer’s applicable corporate income tax (CIT) rate from the standard 25 percent to 15 percent (the tax rate is reduced by 10 points, and the tax amount is reduced by 40%) is one of China’s core tax incentives that encourage innovation [24].

Starting from January 1, 2018, an additional preferential tax treatment has been granted to HNTEs [24]:

a) Losses of qualified HNTEs that occur five years prior to the year in which they become qualified and have not been made up – shall be allowed to be carried forward to subsequent years to be made up, and the maximum carry-forward period is up to 10 years (for normal enterprises, the maximum carry-forward period for losses is only five years);

b) HNTEs can enjoy a one-off pre-tax deduction for equipment and instruments (fixed assets other than houses and buildings) newly purchased during the period from October 1, 2022 to December 31, 2022, and such deduction is allowed to be 100 percent weighted.

The additional R&D expenses deduction ratio of technology-based small- and medium-sized enterprises has been raised [24]. On April 1, 2022, the Ministry of Finance, together with the State Taxation Administration and the Ministry of Science and Technology, released the Announcement on Further Raising Percentage of Extra Tax Reduction on Pre-tax Research and Development Expense for Small and Medium Technology Enterprises, which stipulate that if the R&D expenses do not form intangible assets and are included in the current profits and losses, on the basis of actual deduction, an additional 100 percent of such R&D expenses could be deducted from the taxable income amount; if the R&D expenses have formed intangible assets, they can be amortized before CIT at 200 percent of the actual cost of intangible assets [24].

2. Direct rewards. After obtaining the high-tech certification, enterprise can get hundreds of thousands to millions of local financial rewards (the rewards are different in different provinces and cities);

3. Financing loans. It is easier to obtain VC investment and loans from major banks;

4. The preferential agreements in the government procurement. The products of HTEs can be included in the government procurement system with priority.

In NHTZs the mechanisms of state support (they function at all stages of the innovation process) also expanded, in particular [12]:

- in the form of subsidies – for the creation of university science parks, and for conducting research and technological innovation, for participation in large special scientific and technological projects and management of these projects, and for obtaining intellectual property rights;
- in the form of partial reimbursement of costs – for the introduction of research results in production and in the establishment of new enterprises.

In addition to incentives for R&D and innovation, introduced a number of preferences for investors in the NHTZs, including [12]: lease benefits for land under industrial facilities, income tax and VAT benefits for start-ups, financial assistance for the purchase of productive equipment, and its leasing. There are also incentives to attract professionals and young specialists to the enterprises and institutions in NHTZs – they are provided with subsidies for housing purchase, as well as financial assistance. In addition, companies located in NHTZs receive bonuses related to infrastructure, including access to electricity, water and other utilities, as well as to recycling and disposal of general waste of manufacturing.

According to China Science and Technology Statistical Yearbook, in 2016–2020, Additional Deductions or Exemptions on R&D Expenditure totaled 671.2 billion yuan, Tax Reduction or Exemption for HTEs – 783.4 billion yuan (Table 1, data from [25]).

Table 1

Implementation of Relevant Government Policies

Indicator	2016	2017	2018	2019	2020
Additional Deductions or Exemptions on R&D Expenditure, 100 million yuan	610.3	706.4	1101.5	1872.3	2421.9
Tax Reduction or Exemption for High-tech Enterprises, 100 million yuan	1009.4	1305.3	1514.0	1844.1	2161.6

Statistics of China's High-tech manufacturing

In China's official statistics the High-tech industry classification is the basis for to study the trends in the high-tech [26]. It is based on the National Economic Industry Classification, and reclassifies the relevant activities that meet the characteristics of high-tech industries, so as to facilitate the acquisition, sorting and reprocessing of statistical data, and carry out statistics for the whole country and regions (monitoring, analysis, forecast).

The field of statistics on high-tech is undergoing great changes under the influence of innovations in manufacturies. In China the early 2000s, statistical tools are being developed. In 2002, the High-tech Industry Statistical Classification Catalog (Classification 2002) was introduced (a more detailed presentation in [27, p. 98–111]). In 2013, the Classification 2002 was revised and amended in view of the National Economic Industry Classification (GB/T4754-2011) as the High-tech Industry (Manufacturing) Classification (2013) (Classification 2013) [28].

On June 30, 2017, the new National Economic Industry Classification (GB/T 4754-2017) was officially promulgated. In view of the fact, the Classification 2013 was revised, adjusted its structure and corresponding industry codes; and High-tech Industry (Manufacturing) Classification (2017) (Classification 2017) was introduced [29].

There are 6 major industry categories in the Classification 2017, which is consistent with the Classification 2013; there are 34 industry categories (an increase of 5 compared with the Classification 2013), a total of 85 industry sub-categories (an increase of 23). In order to be consistent with the new Classification (GB/T 4754-2017), the Classification 2017 has changed the names of the four industries, including:

- from "the biological drug manufacturing" to "the manufacture of biological pharmaceutical products",
- from "the spacecraft manufacturing" to "the manufacture of spacecraft and launch vehicles",
- from "the audio-visual equipment manufacturing" to "the manufacture of non-professional audio-visual equipment",

Table 2

High-tech Industry (Manufacturing) Classification 2017

Large class	Medium class	Name
01		**Pharmaceutical manufacturing**
	011	Chemical manufacturing
	012	Chinese herbal medicine processing
	013	Chinese patent medicine production
	014	Manufacturing of Veterinary Drugs
	015	Manufacturing of biopharmaceutical products
	016	Sanitary materials and medical supplies manufacturing
	017	Pharmaceutical excipients and packaging materials
02		**Aviation, spacecraft and equipment manufacturing**
	021	Aircraft Manufacturing
	022	Manufacturing of Spacecraft and Launch Vehicles
	023	Aviation and aerospace related equipment manufacturing
	024	Manufacturing of other aerospace vehicles
	025	Aerospace Repair
03		**Electronic and Communication Equipment Manufacturing**
	031	Manufacturing of special equipment for the electronics industry
	032	Optical fiber, optical cable and lithium-ion battery manufacturing
	033	Manufacturing of communication equipment, radar and supporting equipment
	034	Manufacturing of broadcasting and television equipment
	035	Manufacturing of non-professional audio-visual equipment
	036	Electronic device manufacturing
	037	Manufacturing of electronic components and electronic special materials
	038	Manufacturing of Smart Consumer Devices
	039	Manufacturing of other electronic equipment
04		**Computer and office equipment manufacturing**
	041	Computer Manufacturing
	042	Computer Parts Manufacturing
	043	Computer Peripheral Manufacturing
	044	Manufacturing of Industrial Control Computers and Systems
	045	Information Security Equipment Manufacturing
	046	Other Computer Manufacturing
	047	Office Equipment Manufacturing
05		**Medical equipment and instrumentation manufacturing**
	051	Medical equipment and equipment manufacturing
	052	General instrumentation manufacturing
	053	Manufacturing of special instruments and meters
	054	Optical Instrument Manufacturing
	055	Other instrumentation manufacturing
06		**Information Chemicals Manufacturing**
	061	Manufacturing of Information Chemicals

• from "the electronic component manufacturing" to "the manufacture of electronic components and electronic special materials".

The emergence of new high-tech industries led to changes in the Classification (GB/T 4754-2017) and therefore the Classification 2017. The 31 industry sub-categories have been added to this classification, among them are: culture of information chemicals manufacturing, information chemicals-based medical production, genetic engineering drug and vaccine manufacturing, manufacturing of wearable smart devices, manufacturing of smart vehicle equipment, manufacturing of intelligent unmanned aerial vehicles, manufacturing of other smart consumer devices, industrial control computer and system manufacturing, information security equipment manufacturing etc.

The Classification 2017 divides the high-tech industry into three layers (which are represented by Arabic numerals, instead of Chinese characters): the first layer is the high-tech industry category, which is represented by a 2-digit code; the second layer is the medium category, which is coded by a 3-digit number (Table 2, constructed by the authors using information from [29]); the third layer is the small category, which is represented by a 4-digit code.

Accumulated information is presented in the China Statistical Yearbook, the China Statistical Yearbook on High Technology Industry and the China Statistical Yearbook on Science and Technology. Statistical indicators such as added value, operating income, profit, R&D investment, Employment (etc.) of high-tech Manufacturing reflect the development scale and level of country's high-tech industries, also meeting the needs of international comparisons.

Table 3

Main economic indicators of high-tech industries in total

Indicator	2014	2015	2016	2017	2018	2019	2020
Number of enterprises, unit	27939	29631	30798	32027	33573	35833	40194
Revenue, 100 million yuan	127368	139969	153796	159376	157001	158849	174613
Exports of high-tech products, USD 100 million	6605.0	6552.1	6035.7	6674.4	7468.2	7307.1	7762.5
Share in total export, %	28.2	28.8	28.8	29.5	30.0	29.2	30.0

Table 4

Main economic indicators of high-tech industries by sector

Industry	Number of enterprises, unit	Revenue, 100 million yuan	R&D expenditure as a percentage of revenue, %
Pharmaceuticals	8170	25054	3.13
Electronic and telecommunication equipment	21412	110086	2.66
Computers and office equipment	2524	23070	1.20
Medical equipment and meters	7256	11804	3.79
Electronic Chemicals	181	604	1.43

Official statistics allowed the authors to measure the main economic indicators of high-tech industries in total and by sub-sector (Table 3, 4, data from [30]).

Statistics of China's NHTZs and HTEs

In order to grasp the economic operation and scientific, technological, industrial development of NHTZs and HTEs, statistical investigation system was specially formulated (in addition to official statistics of the High-tech industries) [31; 32]. This statistical system is based on the comprehensive statistical annual report of NHTZs, including the comprehensive their development. At the same time, it focuses on the basic situation: economic operation, staffing, scientific and technological activities and projects of HTEs (enterprises within the statistical scope of NHTZs and HTEs outside NHTZs). This statistical investigation system is organized by the Torch High-tech Industry Development Center of the Ministry of Science and Technology and implemented in different levels. The NHTZs management committees and local science and technology departments shall fill in the report, or shall be responsible for the organization, data review and reporting of the statistical work of enterprises within their respective jurisdictions.

Torch High Technology Industry Development Center prepares a yearly report China Torch Statistical Yearbook (which is approved by the National Bureau of Statistics) on the basis of the accumulated data [33]. The yearbook contains the following base parts: 1. National high technology industrial development zones; 2. High technology enterprises in China; 3. Technology business incubators; 4. Mass makerspaces (innovative incubators); 5. National university science parks; 6. National torch software industrial bases; 7. National torch specialized industrial bases; 8. Innovative industrial clusters; 9. Technology market in China; 10. National technology transfer centers; and also 11. Explanatory notes on main indicators. The analysis of the accumulated data allows to estimate policy outcomes.

Based on the annual statistical data of NHTZs in the country in 1995–2021, the situation and development of NHTZs and HTEs were analyzed (Figures 1, 2, constructed by the authors using data from [33]).

In particular, in 2021, a total of 181 541 enterprises in 169 NHTZs across the country was included in the statistics (a year-on-year increase of 9.8%); but compared to 1995, is up 1299% (12 980 enterprises). Also, major economic indicators of NHTZs reached a historic maximum: operating income of 49.5 billion yuan, a total industrial output value of 29.3 billion yuan, a net profit of 3.6 billion yuan, a taxes submitted of 2.1 billion yuan, a total export volume over $7.5 billion.

The majority (71,2%) of enterprises, which work in NHTZ' high-tech manufacturing (20578 unit), have the certificate HTEs. The largest number of companies in high-tech manufacturing belongs to industries such as: manufacture of electronic and communication equipment (9186 unit), manufacture of medical equipments and measuring instrument (6672 unit), manufacture of medicines (2943 unit). Almost 40.2% of all China's HTEs (that belong to high-tech manufacturing) work in NHTZs. (Table 5, data from [33]).

The number of HTEs in the country has increased from 12547 in 1996 to 269 896 in 2020, and more 330 000 in 2021. The number of Year End Number of Employees has increased by 18 times, and reached 38,6 million people. In 2020 the major economic

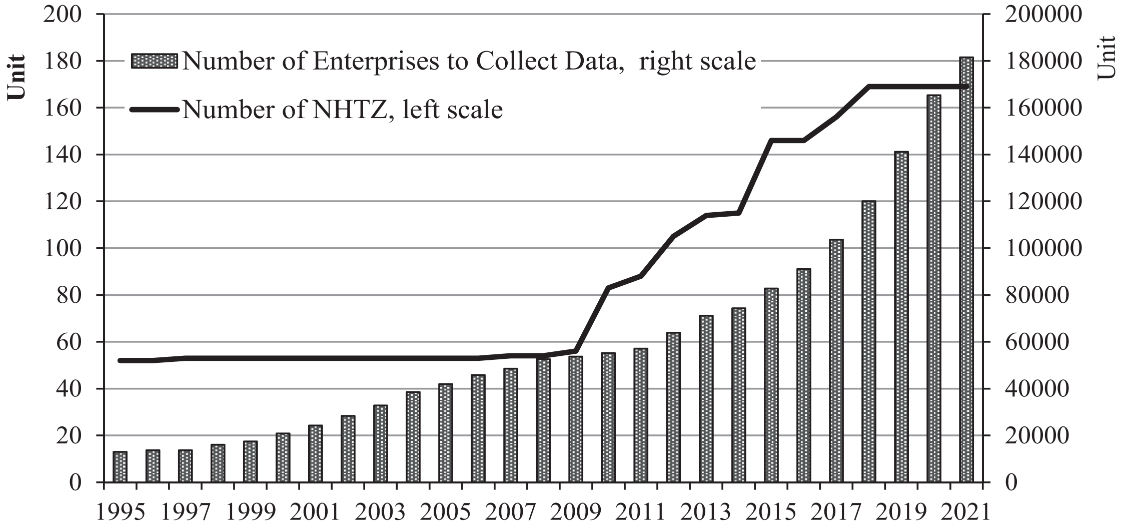

Fig. 1. Dynamics of the number of NHTZs and HTEs in NHTZs, China, 1995–2021

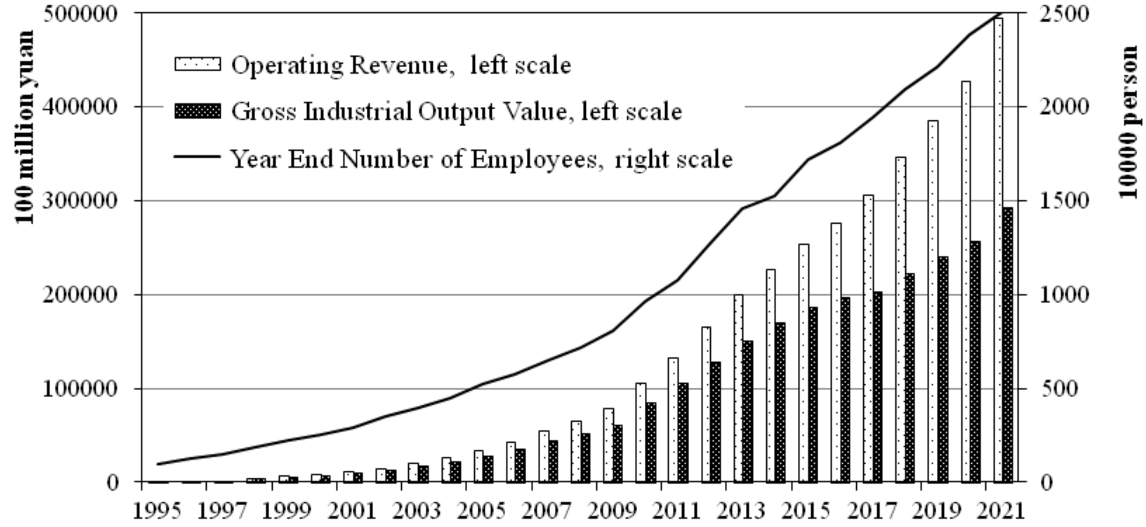

Fig. 2. Dynamics of certain indicators of NHTZs, China, 1995–2021

Table 5

Main economic indicators of high-tech manufactories in NHTZs

Indicator	Number of enterprises to collect data, unit	Share of HTEs in number of enterprises to collect data, %	Share of NHTZs's HTEs in number of country's HTEs, %
Total	20578	71.20	40.17
Manufacture of Medicines	2943	67.65	38.69
Manufacture of Aircrafts and Spacecraft and Related Equipment	506	79.05	41.97
Manufacture of Electronic and Communication Equipment	9186	70.59	36.47
Manulacture of Computers and Office Equipment	1218	68.39	38.65
Manufacture of Medical Equipments and Measuring Instrument	6672	73.74	47.37
Manufacture of Information Chemicals	53	45.28	44.44

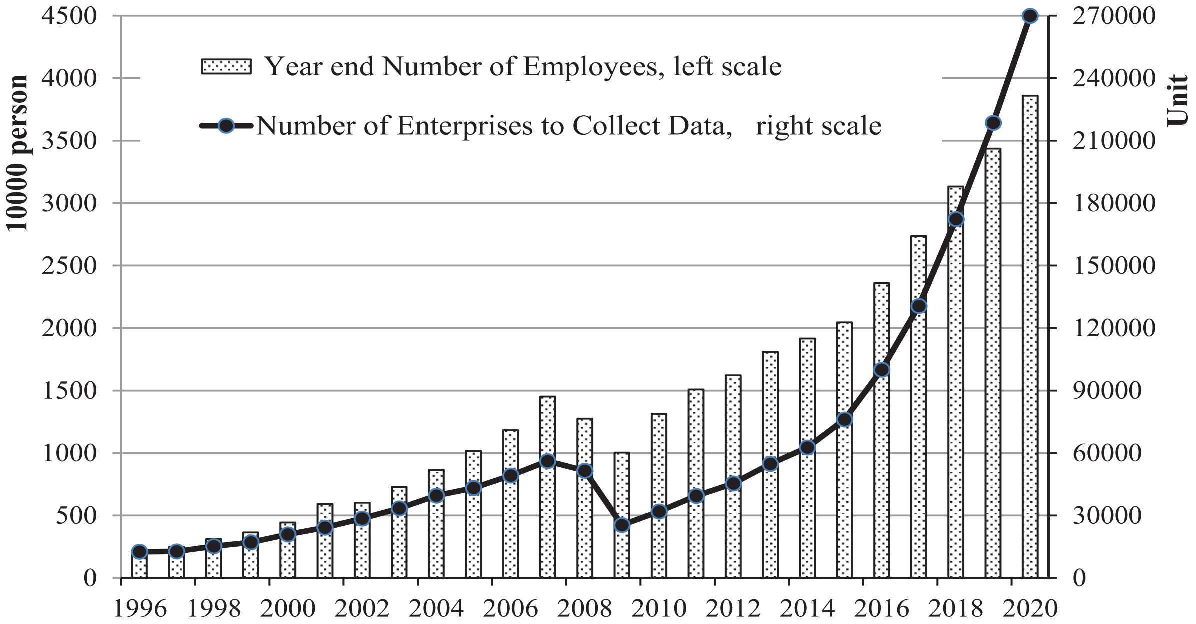

Fig. 3. Dynamics of the number of HTEs and the number of employees in HTEs, China, 1996–2020

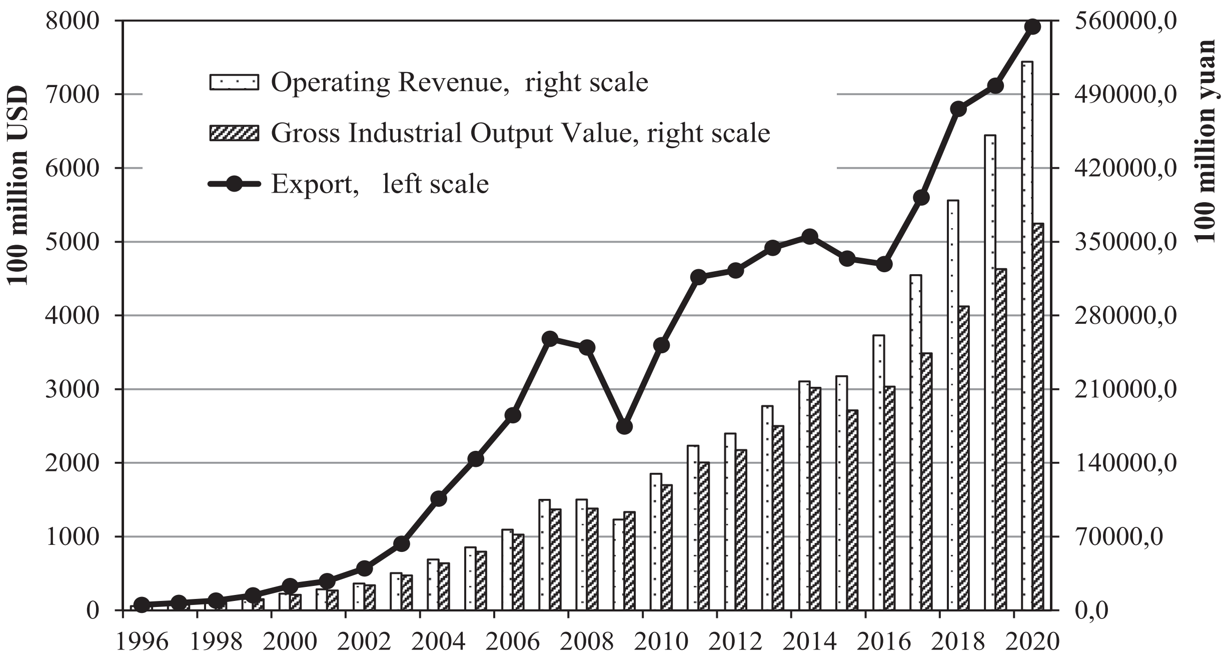

Fig. 4. Dynamics of certain indicators of HTEs, China, 1996–2020

indicators of HTEs reached a historic maximum (Figures 3, 4. constructed by the authors using data from [33]):

- Operating revenue of 52.1 billion yuan (from 0.4 billion yuan in 1996);
- Gross industrial output value rose to 36.7 billion yuan (from 0.4 yuan in 1996);
- Net profit – to 35.1 billion yuan (from 0.3 billion yuan in 1996);
- Taxes submitted – to 18.4 billion yuan (from 0.2 billion yuan in 1996);
- Total export volume – to $971.9 billion (from $7.4 billion in 1996).

International statistics of high-tech activities

U.S. National Science Foundation (NSF) monitors the high-tech activities of countries of the world, including China [34]. In the NSF's methodology Knowledge- and technology-intensive (KTI) industries defined in view of the OECD' methodology. In particular, nine KTI manufacturing industries were chosen (NSF collects statistics and analyses activities).

Export is considered an indicator of competitiveness of high-tech activities of countries in the world market. According to NSF, world exports of KTI products rose to $7405.7 million in 2018 (from $2560.6 million in 2002), with China' exports increased from $125.1 million (2002) to $1228.5 million (2018). As a result of different growth rates China' share skyrocketed from 4.9% (2002) to 16.6% (2018). KTI manufacturing industries exports comprise a large share of exports (more than 50%) for all KTI products; in doing so the indicator of China is 57% in 2018.

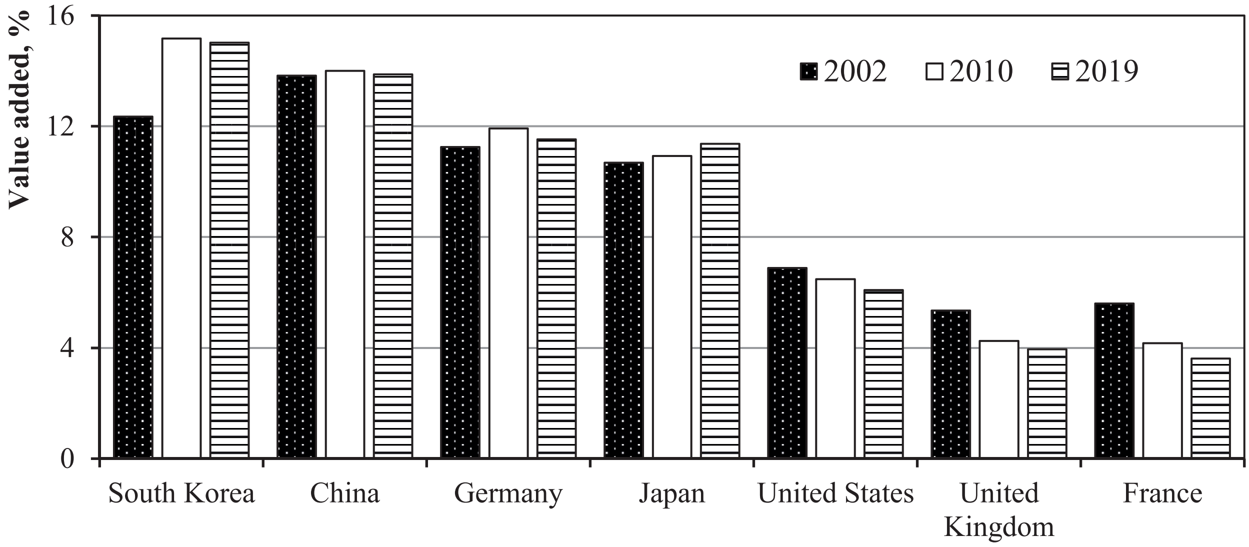

Fig. 5. Value added of KTI manufacturing industries as a share of country's GDP

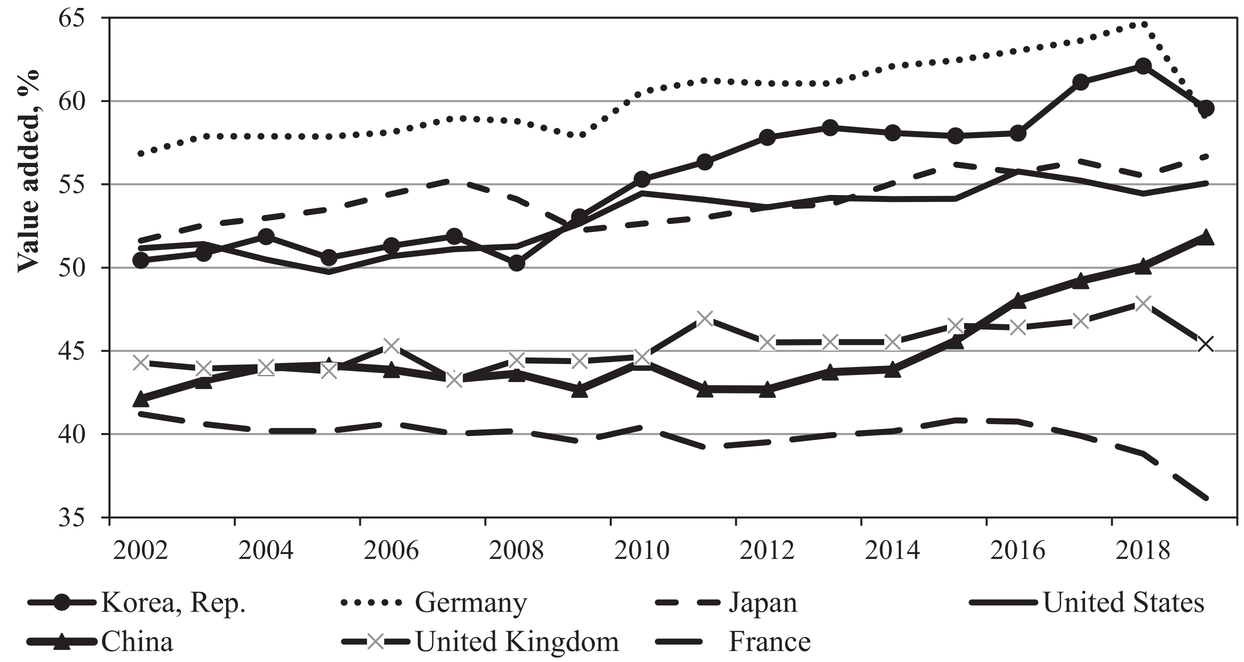

Fig. 6. Value added of KTI manufacturing industries as a share of manufacturing value added for selected countries

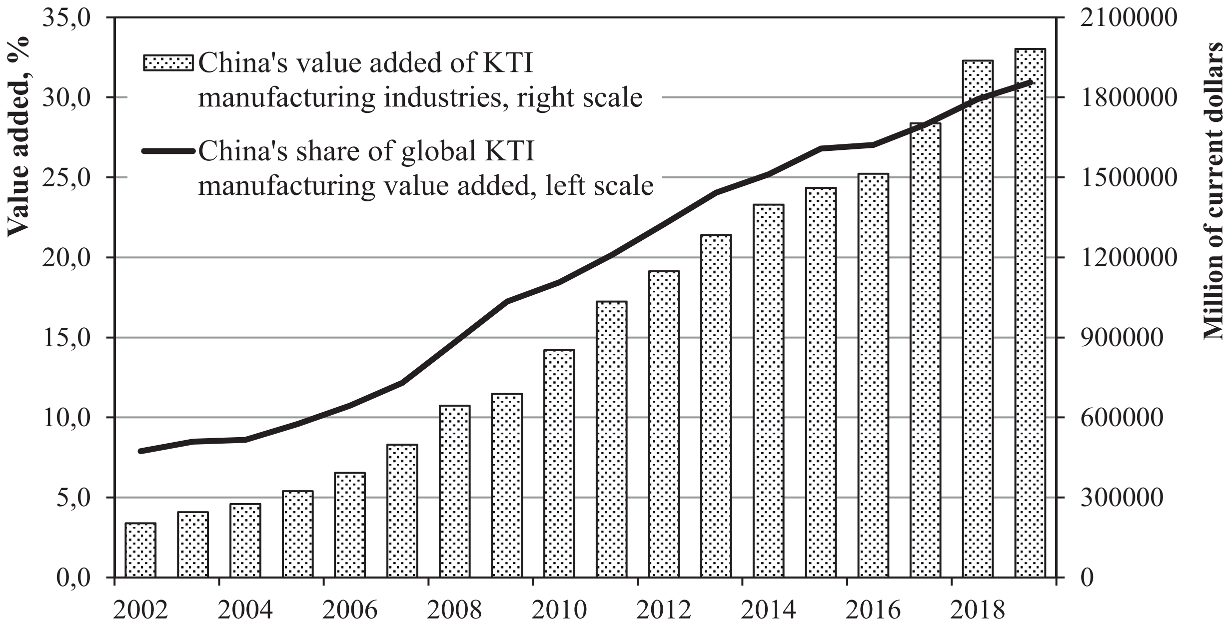

Fig. 7. Dynamics of China's Value added of KTI manufacturing industries

Another important indicator for KTI manufacturing industries is value added. China's KTI manufacturing industries generated nearly $1.9 trillion in value added in 2019 and accounted for over 13.9% of domestic GDP. In comparison, Germany's High-tech Manufacturing generated nearly $0.4 trillion in value added in 2019 and accounted for over 11.5% of domestic GDP (Figure 5, constructed by the authors using data from [34; 35]).

KTI manufacturing industries accounted for 51,8% of total China's manufacturing value added in 2019 (in 2002, about 43%). In comparison, South Korea's and Germany's KTI manufacturing industries accounted about 60% of total country's manufacturing value added. (Figures 6, constructed by the authors using information from [34; 35])

According to NSF [34], the global value added by KTI manufacturing industries rose to $ 6407464 million in 2019 (from $ 2576987 million in 2002), with China' indicator increased from $ 203326 million (2002) to $ 1981928 million (2019). As a result of different growth rates China' share skyrocketed from 7.9% (2002) to 30.9% (2019), Figure 7 (constructed by the authors using information from [34]).

The United States leads the global economy to create added value in the air and spacecraft industry, medical and dental instruments, and pharmaceuticals. But China was able to achieve a global presence in high-tech manufacturing and to press the leaders; and to increase its share of global added value in the air and spacecraft industry (to 8% in 2019). Changes in the structure of the global economy (in value creation of KTI

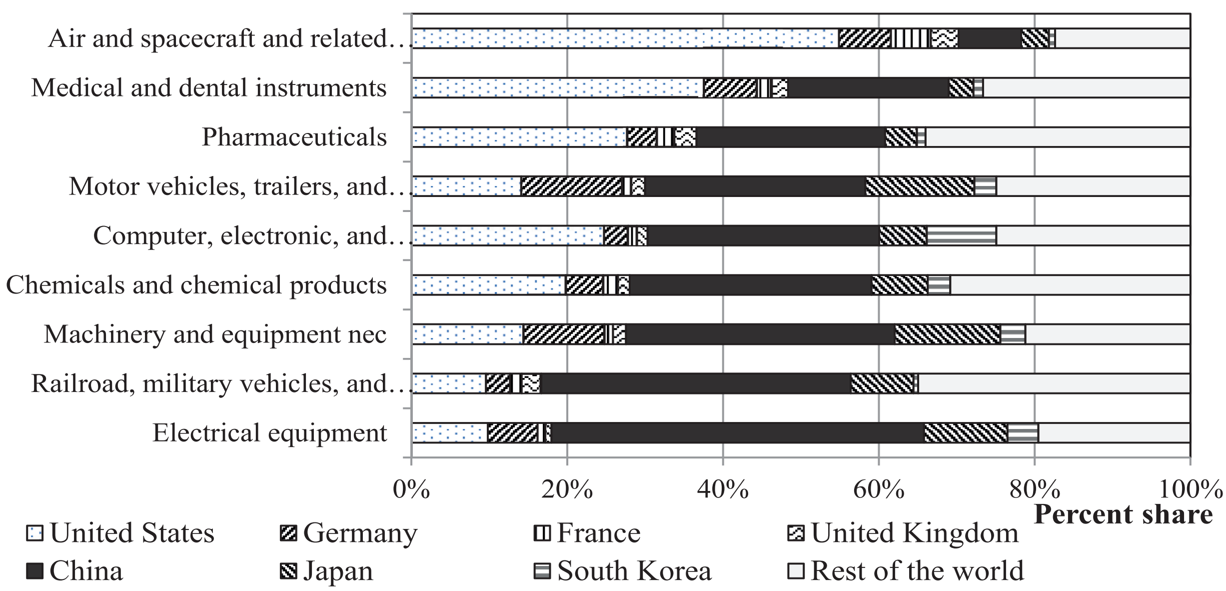

Fig. 8. Country share of global KTI manufacturing value added, by KTI industry, 2019

manufacturing industries) were the following. In 2019, China increased its share to the maximum since 2002 of: medical and dental instruments (21.0%), pharmaceuticals (24.0%), computer, electronic, and optical products (29.7%), railroad and other transport equipment (39.8%); chemicals and chemical products (31.0%); motor vehicles, trailers, and semi-trailers (28.2%), electrical equipment industry (47.8%), other machinery and equipment industry (34.0%). (Figure 8 from [34]).

The authors' approach to determining international comparative advantages of high-tech industry

The high-tech goods by KTI industries (that are exported to other countries) are produced within global value chains with inputs from many countries (use of intermediate goods and services). Gross trade export of high-tech goods provide useful insights, however, these flows do not provide information to gauge the value contributed by country.

The work of O. Salikhova for performance assessment of high-tech industries in the contextof globalization proposed new approaches to determining international comparative advantages based on the specialization criterion: Revealed Specializationof Production – RSP; Comparative Advantage in Value Added Activity – CAVA; Revealed Effective Export – REX [27].

To assess the value added created by the country's activities in the production of goods for export, the OECD accumulates statistics of foreign trade on value added (TiVA database) [36]. This database accumulates, among other things; data from the indicator "domestic value added in gross exports", labelled as EXGR_DVA (internal value added can be decomposed into the following components: employee remuneration; gross operating income; mixed income; production taxes less production subsidies). The scientists named this indicator Value-Added Exports and used as a measure of the domestic value added embodied in exports.

To assess the comparative advantages of a country in a particular industry exportof goods, O. Krekhivskyi suggest using coefficient of Comparative Advantage in Embodying Domestic Value Added in Exports (EVA), calculating it using the formula [37]:

$$EVA_{ij} = \frac{ExDVA_{ij}}{\sum_{i=1}^{I} ExDVA_{ij}} \div \frac{\sum_{j=1}^{J} ExDVA_{ij}}{\sum_{j=1}^{J} \sum_{i=1}^{I} ExDVA_{ij}}, \qquad (1)$$

where $ExDVA_{ij}$ – domestic value-added exports of j-th industry of i-th country; $\sum_{i=1}^{I} ExDVA_{ij}$ – total domestic value-added exports of j-th industry of I countries of the reference group (EU, OECD, World), $i=\overline{1,I}$; $\sum_{j=1}^{J} ExDVA_{ij}$ – total domestic value-added exports of J industries of i-th country, $j=\overline{1,J}$; $\sum_{j=1}^{J}\sum_{i=1}^{I} ExDVA_{ij}$ – total domestic value-added exports of J industries of I countries of the reference group.

Relative advantage of i-th country in embodying domestic value added in exports of j-th industry exists if the value of EVA > 1. That is, when the industry export of goods with added value of the country in the structure of industry exports of the reference group is higher than the total industrial export of goods with added value of the country in the structure of total industrial exports of the reference group. This indicates that the country is making more effective use of its comparative advantages in creating added value based on local resources, translating it into export-oriented goods [37].

In the calculation of the author's indicator (formula 1) use statistics of indicators from the TiVA database (OECD, 2021) for industries D21 Pharmaceuticals, medicinal, chemical and botanical products; D26 Computer, electronic and optical products; D28 Machinery and equipment: for $ExDVA_{ij}$: EXGR_DVA indicator: Domestic value added content of gross exports. The results of these estimates indicated that (Figures 9–11, constructed by the authors using information from [36]):

- the indicator EVA revealed the comparative advantages of China in the export of computer, electronic and optical products from 2002 to now;
- for machinery and equipment that figure hit a peak of 0,892 in 2018. Fast approaching 1, this China's industry had increased their comparative advantages in domestic value added export compared to other countries;
- for Pharmaceuticals China does not demonstrate a of Comparative Advantages in the Domestic Value Added Export (in Germany EVA is more 1, it indicates that thecountry is making more effective use of it s comparative advantages creating added value in in pharmaceutical industry based on local resources, translating it into export-oriented goods).

China has demonstrated that the NHTZs contribute to make breakthroughs in advanced technologies by optimizing innovative ecosystem, connecting innovative subjects, focusing industry and research resources in key areas, increasing their efficiency and ability. They have successfully facilitated the integration of technology and economy; have proved to be an effective and dynamic mechanism for to realize the transformation from promoting the industrialization of science and technology to focusing more on the source of innovation; and from integrating the economy to more actively supporting national development and security. Trends in the development of national technological champions – HTEs, also with the reinforcement of the financial assistance and

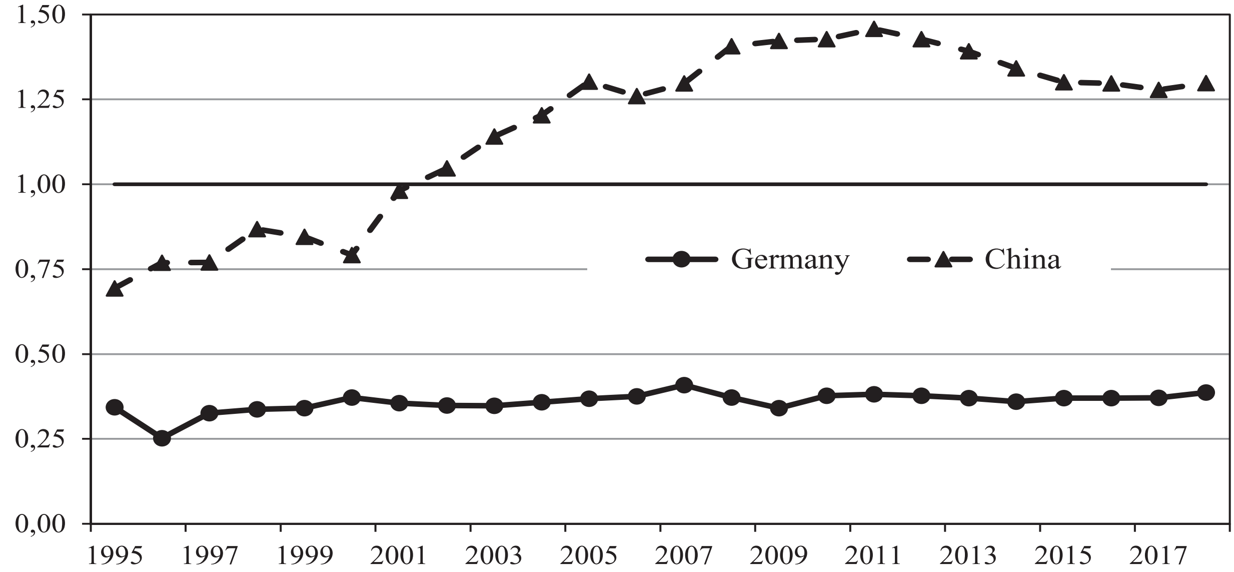

Fig. 9. Dynamics of EVA of D26 Computer, electronic and optical products. China and Germany of the Word reference group

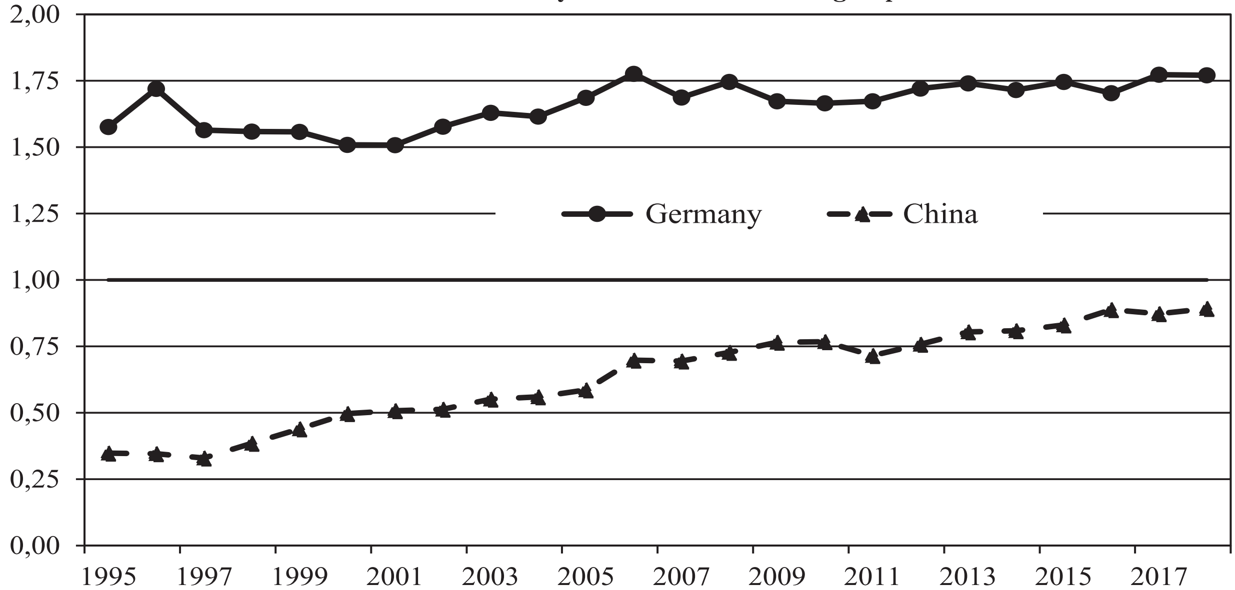

Fig. 10. Dynamics of EVA of D28 Machinery and equipment. China and Germany of the Word reference group

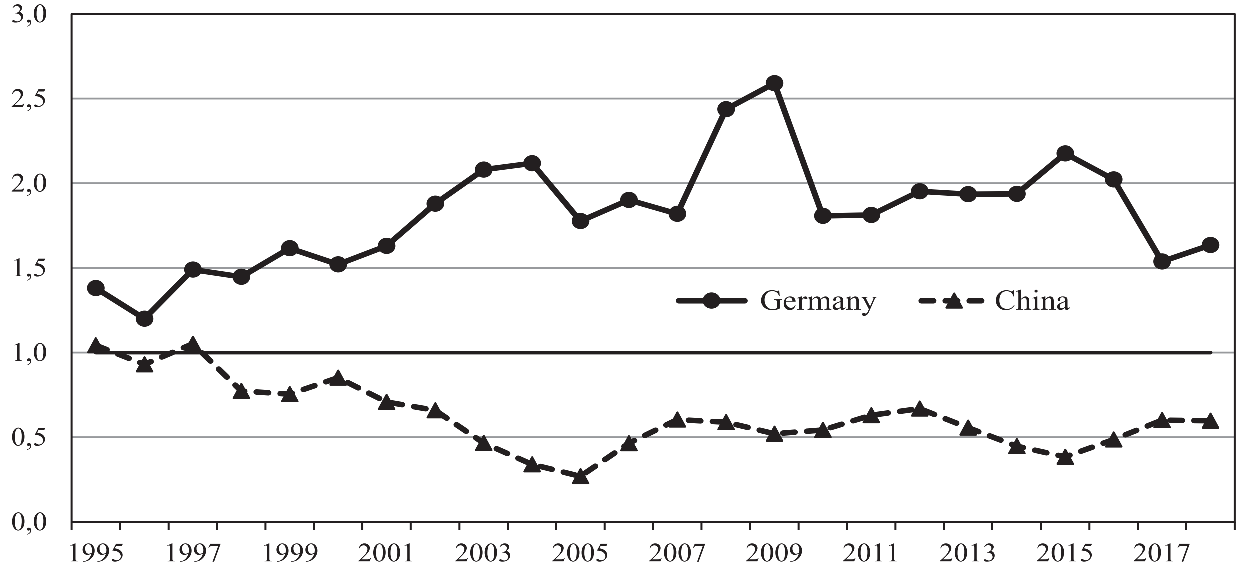

Fig. 11. Dynamics of EVA of D21 Pharmaceuticals. China and Germany of the Word reference group

the preferences (the measures taken in China), illustrate that this type of policy provides to achieve of technological self-reliance, also to increase economic power and to strengthening the position in the global economy.

Implementation of state policy has assisted in increasing the Comparative Advantages in the Domestic Value Added Export for a number of high-tech industries, but China continues to be catching up country.

Lessons for Ukraine

Summarizing the above, we can conclude that China's technological breakthrough based on innovation and the rise of high-tech manufacturing are due to the following determinants:

1. Implementation of Program 863 and the intensification of applied research and projects (for the development of high technologies) in combination with the Torch program and the establishment of NHTZs (for the development of high-tech industries and creation of start-ups) expedited the introduction of scientific achievements into production and turned the China into a global provider of high technology goods.

2. Introduction of the certification of HTEs to provide tax benefits, the introduction of tax incentives for R&D and for accelerated depreciation of fixed assets, and reduction of income tax for HTEs contributed to the modernization and increase of innovative potential of manufacturing.

3. The government's adherence to its chosen tools of the development of high-tech sector for almost 30 years helped to avoid "shuffling", ensured the involvement and dissemination of foreign technologies in the NHTZs and created own innovative products. Behind the figures, there are successes achieved as a result of the practical implementation of important initiatives of the State's policy are clear. In particular, NHTZs has made major breakthroughs in strategic areas such as the high-speed railways (using an integrated system of specialised rolling stock), Beidou navigation and 5G. NHTZs have also participated in a series of major projects, including the Deep-sea vehicles such as the Jiaolong bathyscaphe, the famous "Shenzhou Series Spaceship Project" and the launch of the Shenzhou-14, the R&D of COVID-19 vaccines [38].

A vivid example of the effectiveness of policy's tools is the C919 large passenger aircraft is a landmark project [20]. The successful maiden flight of the C919 (in 2017) means that after nearly half a century of hard exploration, there is a large passenger aircraft that belongs to China and is completely developed in accordance with the world's advanced standards and has completely independent intellectual property rights. The quantum information is a further example. In 2008, China developed a 20km-level 3-party quantum telephone network; in 2009, the Financial Information Quantum Communication Verification Network was officially opened in Beijing, which was the first time in the world that quantum communication technology was applied to the secure transmission of financial information.

The formation of NHTZs in Ukraine (following the example of China); the identification and certification HTEs; the creation favorable conditions for attracting and retaining specialists and development of technology-oriented startups; increased incentives for implementation of innovation by the real sector of the economy, the establishment of system of privileges and preferences will take it possible to quickly overcome the severe situation of the current downward pressure on the economy of war and crisis. All these measures will contribute to growth of economy, ensuring employment and promoting innovative entrepreneurship.

Purposeful and selective policy, aimed at building an endogenous nucleus of technological development in Ukraine (following the example of China) should be based on the following principles.

The first, it is necessary to choose of technology priorities (based on global issues and challenges, local resources and obstacles, tendencies in the development of advanced technologies) for Ukrainian economy.

The second, it is necessary to focus on improving the ability to technological innovate and strengthen the leading and exemplary role of HTEs, increasing their level of technological self-reliance; creation by the state of favourable conditions for investment and implement large-scale projects; forming the endogenous nucleus of technological dynamism of national economy on their basis.

The third, it is necessary to contribute to the formation of human resources and financially promote the creation of startups in technological priority areas. The development of technology-oriented startups, based on their own developments, should be central element of the state policy of encouraging innovative entrepreneurship in Ukraine.

Back in 2007, the authors substantiated the need to introduce a selective approach to the implementation of state policy for the development of high-tech industries in Ukraine, and proposed a methodological approach to identifying HTEs to optimize the process of granting state preferences. However, despite this argument and the successful similar practice of China, the suggestions for identification of HTEs, adoption of addressable approach in the state preferences provision and the development of the system for statistical monitoring, proposed by the authors, has not yet been implemented in Ukraine [1; 12].

Conclusions. This study found that the public policy aimed at developing domestic high-tech industry can turn them into locomotive of the economy of the country, providing high added value, strengthening of export performance indicators, closing the gaps with the leaders. The need for the rapid economic recovery of the state after war demands a range of measures aimed at attracting advanced foreign technologies and creating our own technologies for strengthening the potential not only to existing Ukraine's businesses but also for business start-ups in high-tech manufacturing (following China's example). Creation of the NHTZs in Ukraine, assistance to technology transfer, comprehensive stimulation of technological innovations and communication between science and production will significantly speed up the process of development and market launch of the local innovative products. Also, NHTZs can contribute in reducing unemployment, income will increase as a result of employment growth and a pick-up in wages growth, larger tax payments of businesses would increase budget revenue.

A key precondition for improving the economy is creating the preconditions for improving the investment climate, and launching of a mechanism for providing targeted preferences for HTEs to foster innovation. And based on this, priority direction for further research is to create of scientific and methodological support for the implementation of these measures in Ukraine, also establishing a system of statistical accounting and reporting in high-tech.

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28. Appendix 2. Comparison Table between Classification of High-tech Industries (Manufacturing) (2013) and Statistical Catalog of High-tech Industries (Guotongzi [2002] No. 33). *yearbookchina.com*. Retrieved February 7, 2023 from https://www.yearbookchina.com/navipage-n2017030050000119.html [in Chinese].

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Політика розвитку високих технологій у Китаї: уроки для України

Китай наприкінці 1980-х став на новий шлях розвитку високотехнологічного виробництва, що відповідає його амбіціям. Філософія інноваційної та промислової політики Китаю ґрунтується на ідеї, що досягнення конкурентоспроможного виробництва має здійснюватися за рахунок національних високотехнологічних зон та високотехнологічних підприємств, які забезпечують розвиток місцевих інновацій. Мета статті – вивчити китайський досвід реалізації політики та механізмів розвитку високотехнологічних виробництв та проаналізувати статистичні інструменти для оцінки його наслідків. Виявлено, що уряд Китаю надає значну підтримку у вигляді субсидій та податкових пільг для створення спеціальних високотехнологічних зон і високотехнологічних підприємств, заохочуючи виробництво нових та високотехнологічних продуктів і процесів. Встановлено, що для розуміння економічної діяльності та науково-технічного, промислового розвитку високотехнологічних зон і високотехнологічних підприємств спеціально розроблено систему статистичних досліджень на додаток до офіційної статистики високотехнологічних виробництв. Доведено, що державна модель інноваційного розвитку Китаю успішно ініціювала та стимулювала зростання високих технологій протягом останніх 30 років і сприяла ендогенним технологічним інноваціям. Аналіз показав, що значні зусилля в галузі політики Китаю щодо перетворення індустрії на високотехнологічний сектор економіки, а країни – на потужного гравця на світовому ринку мають визначні результати. У статті наведено новий показник EVA – коефіцієнт порівняльних переваг в експорті внутрішньої доданої вартості та формула для його розрахунку, що дозволяє оцінити становище високотехнологічних галузей Китаю у світовій торгівлі, розширюючи поняття "виявлена порівняльна перевага". Представлено авторське бачення детермінантів успіху уряду Китаю у нарощуванні інноваційного потенціалу національної високотехнологічної промисловості, які необхідно враховувати у процесі формування та реалізації механізмів відновлення економіки України після війни.

Ключові слова: *Китай, високі технології, промисловість, національна зона високих технологій, високотехнологічне підприємство, державна політика, порівняльні переваги, внутрішня додана вартість у валовому експорті.*

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