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PECULIARITIES OF THE DIGITAL AND SUSTAINABLE DEVELOPMENT OF CHINESE CIVIL BLASTING INDUSTRY ENTERPRISES

Introduction. The development of China's civil blasting industry is an important aspect of the national economy, in particular to support infrastructure construction, mining and other strategically important sectors. However, the industry faces significant challenges, such as the impact of the global financial crisis, the need to comply with stringent environmental regulations, increased safety requirements and innovation. The trend towards automation, digitalisation and the use of green materials underscores the need to analyse the industry to ensure its sustainable development. The study of this topic is relevant both for understanding the prospects for the industry's development in the face of current challenges and for identifying strategies for adapting to global trends.

Problem statement. China's civil blasting industry has shown steady growth in recent years, but the pace of development remains volatile, particularly due to external economic factors such as the global financial crisis and fluctuations in product demand. Key challenges include the high cost of production due to dependence on raw materials, the need to modernise production facilities, comply with strict regulatory requirements and improve safety. The industry also needs to adapt to new trends, including the use of environmentally friendly materials, increased production efficiency through automation and digital technologies, and the introduction of innovative management methods.

The purpose of the article is to study the peculiarities of the development of Chinese civil blasting industry enterprises and justification of the need to implement digital technologies and innovative blasting methods to ensure sustainable development.

Main research material. China is the world's largest explosives manufacturer and the blasting sector is key to its national economy. As infrastructure growth and urbanization has increased in recent years, the need for blasting services has remained increasing, which has encouraged the explosion of China's blasting industry. The industry is fueled by construction, mining and infrastructure projects and is highly focused on safety and efficiency. Extended blasting technologies and new techniques are still being deployed to improve productivity. Meanwhile, China is also seeking alternative blasting solutions, such as green materials and eco-friendly methods that have a low carbon footprint. But they haven't yet mainstreamed into the industry and they don't really do much to support the sector in general (fig. 1).





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© Publisher Institute of Industrial Economy of National Academy of Sciences of Ukraine, 2024 © Publisher State Higher Education Institution "Luhansk Taras Shevchenko National University", 2024 The Chinese government vetoes new civil explosives equipment manufacturers with tight access control systems and safety management requirements being the biggest hurdles to the civil explosive industry. As civil explosives are flammable and explosive, China requires a license to manufacture, sell, buy and transport civil explosives and the entire industry is strictly controlled by the relevant authorities as a qualification barrier. No unit or individual can make, sell, buy or transport civil explosives without approval, nor blast. The civil explosives market is tightly controlled by the state. In China, the supervision of civil explosive devices and services is mostly summed up as follows (fig. 2):

(1) Government enforces a licensing system for production, sale, transport and blasting of civil explosive devices and all operations are closely monitored by competent authorities;

(2) Government regulates the circulation of civil explosive components. Government set up a civilian explosive information management system to manage the identification of civilian explosives.



Fig. 2. The Chinese civil blasting industry chain is combed [2]

All civil explosives manufacturing, selling, circulating and use of civilian explosives require realname registration to track the circulation of civilian explosives. In the sales scenario, industrial explosives are dangerous products that are sold as dangerous products in transport, the freight rate is higher and sales radius is not more than 200km. Industrial detonators are small, lightweight, and transport cost a small fraction of the cost of industrial explosives, transportation no restriction, little constraint on cross-regional sales. The gross product of China's civil explosives industry grew at a moderate rate between 2020 and 2024. The gross domestic product has grown by 1.02% over 2020-2021 because of the epidemic and lack of demand. In 2021, the industry started to recover gradually, and GDP rose to 34.438 billion yuan, 2.53% higher. In 2022, the industry registered a high rise of 14.00% to reach 39.04 billion yuan due to rising demand and recovery in the market. In 2023, the growth rate declined to 10.93% but still the market was doing well (fig. 3).



Fig. 3. China's civil explosive production enterprises cumulative gross product in 2020-2024 [3]

But the GDP growth rate is forecasted to be 4.75 per cent at 45.237 billion yuan in 2024, which suggests that the industry is hit by the global financial crisis and experiencing growth constraints. On the whole, economic growth in the civil explosives market during

this time, and especially in 2022 was promising. But future growth will be dependent on the economic conditions, the demand and the industry's adaptation and the industry have to be flexible to slow down.



Fig. 4. China civil blasting industry main business income, profit, blasting service income in 2020-2024 [4]

The civil explosives market has recorded relatively volatile growth over the years 2019 to 2024 in all the major economic measures like gross product and main business income. The GDP in 2019-2020 slightly rose from 33.50 billion yuan to 33.588 billion yuan, 1.02% growth year on year, the market demand was still weak. The main business income was 38.186 billion yuan in 2020, low growth, and 0.21% growth year on year (fig. 4). The gross domestic product grew to 34.438 billion yuan in 2021, 2.53%, industry slowly came back and main business income was 38.716 billion yuan, 1.10%. The gross domestic product in 2022 has grown sharply with the gross domestic product of 39.40 billion yuan increasing by 14.00%; The main business revenue was mainly 43.744 billion yuan rising by 12.92%. The Gross domestic product of 2023 has been 43.658 billion yuan, 10.93%, the main business profit is even higher at 49.951 billion yuan, 14.19%, the gross profit is also sharply up to 8.527 billion yuan, 44.99%. But in 2024, gross product will be 45.237 billion yuan, which is 4.75% up, main business income will be 51.523 billion yuan, which is 3.91% up, and total profit will be 7.845 billion yuan, which is 7.161 down, the profits of industry are under threat. In all, although the civil explosive industry shows promising growth prospects, especially in 2022 and 2023 to achieve strong growth, with the economic gloom in 2024, the future growth may be

slowed down, should closely monitor the market demand and external economic factors, in order to retain the industry's flexibleness to deal with risks.

The information indicates that China's civil blasting industry has remained a relatively well-integrated development in many links, indicative of the industry's health and development prospects.

In recent years, the industrial system of China's civil blasting industry has continuously been fine-tuned. The number of production firms (clusters) declined from 76 to 50, and the top 10 enterprises' share of gross domestic product rose from 49% to 59% (fig. 5). 35 plants were closed down and shuttered, 95 production lines shut down, licensed capacity of packaged industrial explosives was slashed by 420,000 tons, mixed explosives' production capacity at enterprise site was reduced by 35%, the entire upgrade of industrial digital electronic detonators resulted in phased outcomes, and the catastrophic overcapacity situation was mitigated. This has made innovation possible in huge ways. The R&D investment rate of leading backbone companies rose from 2.8% to 3.5%, while many new breakthroughs were made and successfully applied to products, process technology, and manufacturing equipment. The industrial governance apparatus has been incrementally improved.



Fig. 5. Changes in the number of civil blasting production enterprises and market concentration in China in 2020-2024 [5]

Digital technologies in civilian blasting are used to optimise blasting processes and improve the accuracy and efficiency of operations. They help to control the use of explosives, reduce costs and improve safety on construction sites and during drilling operations. For example, modern blasting monitoring and control systems provide accurate data on the movement and condition of materials used during blasting.

The Digital Blasting Systems Market, valued at USD 4.5 billion in 2022, is expected to grow at a compound annual growth rate (CAGR) of 9.2% from 2024 to 2030, reaching an estimated USD 9.0 billion by 2030 [6]. Advancements in various technologies are driving the growth of the digital blasting systems market [6]:

- *Internet of Things (IoT)*: IoT enables real-time data collection and analysis from blast sensors, enhancing decision-making and boosting operational efficiency.

-*Artificial Intelligence* (*AI*): AI leverages historical data to predict blast outcomes, allowing for optimized blast designs and reduced variability.

– Automation: Automation enhances safety and minimizes human error by enabling operators to remotely set parameters and control detonations.

The Chinese government urges blasting enterprises to develop intelligent situations like production process, equipment management, safety management, "artificial intelligence +" and "extended reality +" to make the process more effective, collaborative processes, optimal resource utilization, intelligent decision-making. Relevant enterprises are urged to compare with national benchmarks like the intelligent manufacturing Capability Maturity Model, implementing pilot tests of smart scenarios, smart workshops and smart sites and test them first (fig. 6).





In China, currently, over 97% of industrial explosive production lines in the civil blasting sector are equipped with continuous and automated production systems, and over 85% of industrial detonator production lines are equipped with automatic filling and human-machine isolation production, putting 11,000 workers out of danger. Additionally, they provide high-tech manufacturing enterprises with the aim of enhancing cooperation with older civil explosive enterprises and the integration of high-tech, information technology and manufacturing equipment.

China's civil blasting companies are different from foreign ones in drivers and technology (table 1). China's industry is very much policy driven, resulting in rapid digitalization by application. The global players, on the other hand, have a market imperative and hence are less influenced by it but more well-used. China's focus on digitalization and AI in operations, whereas the international players on big data and smart systems for decision-making. Both face change management challenges.

Table 1

Comparison Dimension	Chinese civil explosives enterprises	International enterprises		
Drivers	Policy direction is more prominent	Market pressure and technology are the		
		primary drivers		
Technology by	Mostly digital uses in infrastructure building	Lower technology use cases such as		
Application	and mining	mining, construction, and city planning		
Adoption Rate	Due to the two-pronged policy-market	International enterprises have lower		
	forces, the adoption rate for digital	adoption rates in some areas, but generally		
	transformation of Chinese enterprises is high	stronger		
Innovation Motive	With high-tech devices to better process, analyze, and use information and, with increasing robotics and automation devices gradually	Focus on technological innovation by utilizing big data and intelligent systems to enhance decision-making capacity		
Higher Adoption Rate	More enterprises acknowledge digitalization	Companies are becoming increasingly		
	and increase digital tool adoption and use	aware and open to digitalization thereby		
		technologies		
New Techniques	More extensive use of virtual simulation and	Implementation of more sophisticated		
	AI perception technologies in blast sites to	technologies and operations practices to		
	provide more natural technical assistance	improve site surveillance and accident-		
		prevention		
Market Receptivity	Policy-informed market responsiveness can	Companies can react quickly to market		
	be relatively quick and flexible to changes in	shifts and become more market competi-		
	market demand	tive		
Change Management	Various difficulties to modernize staff	Several difficulties to manage during		
	competencies and enhance management	change, though their methods and solutions		
processes during change		might vary		
Case Study on	Transformation to foster industry	Applying cases of success both within and		
Successive	transformation for quality and global	outside the industry to drive technological		
Transformative Change	competitiveness	and management innovation, competi-		
		tiveness		

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Developed by the authors on the basis of [8].

Despite the critical need to use blasting in the civilian sector, it has a negative impact on the environment, with vibrations and noise potentially damaging buildings and infrastructure while disrupting ecosystems and harming wildlife. The dust and debris generated can lead to air and water pollution, posing health risks to nearby communities. Additionally, rock fragmentation from blasting can cause soil erosion, trigger landslides, and contribute to land degradation [9].

Therefore, given the current trends and regulatory requirements that have been updated following the

adoption of China's Sustainable Development Plan, the implementation of sustainable practices by civil blasting enterprises is becoming a prerequisite for their further development.

Sustainable blasting involves adopting practices like utilizing renewable energy sources, launching reforestation initiatives, and promoting sustainable water management. By incorporating these strategies, blasting companies can safeguard the environment and support the well-being of local communities. Key benefits of sustainable blasting include lowering greenhouse gas emissions, preserving wildlife and natural habitats, and minimizing water pollution. The main sustainable blasting techniques include [9]:

– precision blasting, which involves meticulous planning and execution to minimize rock fragmentation, dust, and debris. It reduces the environmental impact and mitigates effects on nearby communities by limiting air and water pollution and minimizing damage to buildings and infrastructure. Furthermore, precision blasting can lower the energy demands of mining operations, thereby reducing greenhouse gas emissions.

- the use of non-toxic and environmentally *friendly explosives*, designed to minimize harm to both the environment and human health.

- the use of electronic detonators – reduce the amount of noise and vibration created during blasting.

China's civil blasting industry, as outlined in the 14th Five-Year Plan, is set to prioritize digitalization and green development [10]. The sector will focus on enhanced safety standards, targeting zero accidents and ensuring 100% of companies achieve safety production standardization at Level 2 or above. Research and development investment will increase to 3.5% of total sales to drive technological innovation and further digitalization. Additionally, over 40% of hazardous labor tasks will be automated to improve efficiency and reduce workplace injuries (table 2).

technologies. However, the industry needs to actively

innovate to mitigate the impact of external risks, such as

global financial crises and environmental requirements.

The main ways to ensure sustainable development are to

strengthen the regulatory framework, increase resource

efficiency and switch to low-carbon technologies. An

important aspect is the development of research

programmes and increased investment in production modernisation, which will not only improve the

industry's competitiveness but also ensure its long-term

Table 2

"14th Five-Year Plan"	main expected indicators for the civil blasting industry [10]	
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Indicator	2020	2025	Туре
1. Number of major production safety accidents	0	0	Expected
2. Rate of enterprises meeting safety production standardization			
level II and above (%)	-	100	Binding
3. Proportion of R&D expenditure of leading enterprises to			
operating income (%)	2.8	3.5	Expected
4. Proportion of robotic replacement for existing hazardous			
position operators (%)	-	≥40	Expected
5. Minimum licensed production capacity of packaged			
industrial explosives production line (tons/year)	>10000	≥12000	Binding
6. Proportion of licensed capacity for on-site mixed explosives			
(%)	≥30	≥35	Binding
7. Number of production enterprises (groups)	76	≤50	Expected
8. Proportion of industry production value of the top 10 civil			
explosive enterprises (%)	49	≥60	Expected

The industry will streamline operations by reducing the number of production enterprises to 50 or fewer and increasing the minimum licensed production capacity for packaged industrial explosives to 12,000 tons annually. These measures aim to boost market competitiveness, promote sustainable resource utilization, and enhance the industry's long-term environmental and economic sustainability.

Conclusion. An analysis of the development of China's civilian blasting industry shows significant potential for further growth, in particular through digitalisation, automation and the introduction of green

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Копішинська К., Ян В. Особливості цифрового та сталого розвитку підприємств цивільної вибухової промисловості Китаю

Статтю присвячено дослідженню особливості цифрового та сталого розвитку підприємств цивільної вибухової промисловості Китаю. Проаналізовано основні економічні результати підприємств галузі за останні п'ять років. Здійснено порівняльний аналіз функціонування цивільних вибухових підприємств Китаю та міжнародними підприємствами. Визначено ключові напрями впровадження цифрових технологій для забезпечення розвитку підприємств галузі. Обґрунтовано необхідність використання сталих методів вибухових робіт для відповідності діяльності регуляторним нормам згідно плану сталого розвитку Китаю.

Ключові слова: цивільна вибухова промисловість, цифровізація, сталий розвиток, штучний інтелект, сталі методи вибухових робіт.

Kopishynska K., Yang W. Peculiarities of the Digital and Sustainable Development of Chinese Civil Blasting Industry Enterprises

The article is devoted to the study of the peculiarities of digital and sustainable development of enterprises of the civil blasting industry in China. The main economic results of enterprises in the industry over the past five years are analysed. A comparative analysis of the functioning of civil blasting enterprises in China and international enterprises is carried out. The key directions of introduction of digital technologies to ensure the development of enterprises in the industry are identified. The necessity of using sustainable blasting methods to comply with regulatory standards in accordance with the China Sustainable Development Plan is substantiated.

Keywords: civil blasting industry, digitalisation, sustainable development, artificial intelligence, sustainable blasting methods.

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