Innovation and digitalization in construction: new opportunities and challenges for investors and businesses

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Abstract. The article discusses the features of innovation and the possibilities of digitalization, which are extremely important for investors and enterprises. As the authors point out, the construction industry resists technological changes and produces a large amount of useless energy; "green" innovations should compensate for these shortcomings. The emergence of new and powerful digital transformations has provided the construction industry with a lot of opportunities. Along with the industrial revolution and the modernization of technology, all industries are changing their traditional ways of working and managing. However, the developing construction industry is lagging far behind this technological transformation. Traditional methods of design and operation have become obstacles in the process of its transformation. The construction industry has played an indispensable role in the economic growth of countries over the past decades, but now it must keep up with the times. Recently, industrial enterprises have begun to introduce new concepts, such as digital construction and parametric design. However, there is still no assessment of the effectiveness of digital reform at construction enterprises.

1 Introduction

The construction industry has maintained constant and stable rapid growth over the past 40 years and has become a national backbone industry with an annual output of more than $24 trillion. The construction industry market is so large that it employs more than 0.1 million firms and 50 million employees. However, with economic growth slowing down, people's enthusiasm for real estate is cooling, and thus construction firms can no longer earn as much income as before, some of which may even go bankrupt. Most firms in the construction industry adhere to traditional management methods [1] and have relatively low efficiency in resource allocation, which inevitably leads to a limitation of the benefits of the
enterprise [2]. Innovation, modernization and reform of the construction industry are extremely important to increase its competitiveness and ability to sustainable development [3].

2 Materials and methods

In the process of writing the work, articles and monographs were analyzed within the framework of the research topic, as well as comparative and analytical research methods were applied.

3 Results

According to the McKinsey Global Institute, digital innovation and transformation can provide a significant increase in productivity (about 15%) and cost reduction (about 6%). Despite the fact that the leaders of the construction industry have historically been slow to introduce advanced technologies, they accept these changes. Companies that support the introduction of new technologies will see an increase in benefits in the next few decades [4]. According to an industry survey conducted by Global Data, only 34% of construction companies expected an increase in technology spending due to the COVID-19 pandemic. For companies seeking to expand their market share, technologies can serve as a starting platform that allows them to take a leading position.

Digital transformation in construction is the integration of digital technologies into all areas of a construction company, optimization of operations and value creation. Cultural change is also an essential component of the digital transformation of construction: construction companies especially need to challenge the status quo and differentiate. The identification and use of technologies in new or improved use cases provides an important competitive advantage. The construction industry has changed significantly over the past few decades. Today, construction projects must be carried out incredibly efficiently, while ensuring the safety of their workers and balancing the shortage of materials and labor. The construction industry is currently facing a serious labor shortage due to the retirement of older workers (especially from the baby boomer generation) [5]. In the United States alone, there were about 300,000 construction jobs in 2019. Their number is expected to grow to almost 750,000 by 2026.

Many young workers simply do not engage in such professions. In addition, older workers are usually not tech savvy and are likely to resist the introduction of new technologies. Forcing too much change can lead to an increase in the retirement rate, resulting in the industry's workforce running out of already scarce resources. Many aspects of the construction industry still rely on outdated manual processes to track project status, order materials, fill out safety documentation, and perform actual work. The construction industry has suffered from trade wars between countries, which lead to an increase in the cost of materials. As geopolitical tensions increase around the world, additional tariffs and sanctions may unexpectedly lead to an increase in the cost of materials and labor. Inflation in some parts of the world has also exceeded the norm.

Demand for construction materials and services plummeted during the COVID-19 pandemic. As the global economy recovered, the demand for new construction began to grow. Many suppliers of raw materials cannot meet the demand, which leads to serious disruptions in schedules and an increase in material costs [6].

The World Green Building Council estimates that the construction industry accounts for approximately 39% of all carbon emissions in the world. As governments work to reduce carbon dioxide emissions, the construction industry will be pressured to adopt more
environmentally friendly construction methods. Experts do not expect that the construction industry will return to the level of 2019 until about 2023.

The construction industry is slow to introduce new technologies due to industry norms and worker resistance. However, digital transformation provides many advantages that need to be taken into account by construction industry managers.

The construction industry is known for its physically demanding work. Construction companies have long sought to improve safety practices at facilities to reduce the number of injuries and deaths in the workplace. Technologies such as wearable devices and remote monitoring can help improve safety performance by reducing the risk of lawsuits or workers’ compensation claims [7].

Professionals in the construction industry should work closely with their clients to create projects that meet the needs of their clients. New technologies such as virtual reality and augmented reality can help customers visualize their future space or remotely monitor current progress.

Many construction technologies and processes are based on proven methods that have existed for centuries. Despite the fact that there has been some modernization, there is still room for improvement. As more and more people get higher education, fewer and fewer people seek to get a qualified job in the field of trade. One survey of 35,000 employers in 36 countries showed that it is most difficult to fill vacancies of qualified workers. The development of technology can make these positions more attractive for young workers [8].

Over the past few years, construction costs have increased by more than 20%. This has forced construction companies to struggle to control costs and reduce waste wherever possible. Technology can help reduce these costs by providing project managers with better information planning and tracking.

Digital transformation allows you to change or improve processes through the introduction of new tools, systems and technologies aimed at improving the safety, profitability and productivity of facilities. There are many opportunities to thoughtfully implement these achievements without disrupting normal operation.

Construction workers can be equipped with wearable technologies that will help track the condition of the object, physical stress factors and the performance of the object. This type of information is valuable for solving safety problems, tracking labor productivity, and communicating quickly with employees.

Virtual reality can help construction site managers inspect construction sites from remote locations. It can also be used for customer demos and updates.

Some companies use drones to survey the area, take aerial photographs and make maps of hard-to-reach topography. This technology can also be used to safely inspect objects for hazards such as structural damage [9].

3D printing, which was once a technology for hobbyists, is becoming increasingly common in the construction industry. Today, large construction companies use 3D printing techniques to construct the main components of buildings (and in some cases entire structures). This technology is efficient and produces virtually no waste.

Technologies such as cloud computing and big data allow construction companies to move away from traditional methods of collecting and exchanging data on construction sites.

One of the biggest risks for the construction industry is workplace safety and injuries among workers. Tasks performed at work sites around the world require manual labor, often in conditions of using large machinery.

Although many developing countries do not track these statistics as closely as others, the World Congress on Occupational Safety and Health has estimated that workplace injuries (in all industries) cost the global economy more than $3 trillion each year.
Companies seeking to change the situation for the better are increasingly turning to technologies that help measure and collect data that can be used to improve construction safety [10].

Both workers and construction sites can be equipped with sensor networks designed to quickly detect unsafe conditions and alert workers. For example, carbon monoxide causes more deaths on construction sites than any other chemical or compound. Since this gas is difficult to detect, wearable oximeters attached to construction workers' helmets can monitor the level of oxygen in the blood, which drops as a result of carbon monoxide poisoning.

Any opportunity to remove people from construction sites reduces the likelihood of injuries and deaths. Virtual reality can contribute to this by allowing builders to "visit" facilities without being physically there. Some companies even turn to VR to conduct safety training (for example, driving large vehicles) in a controlled environment.

The more data is available, the better decisions companies can make in terms of security. Unfortunately, many companies still rely on manual processing of safety documentation during meetings, contractor safety checks and inspections. By digitizing these tools, field workers can serve as a source of huge amounts of data that can be used in analytical tools that help make decisions in real time [11].

Drones can be used to quickly and safely monitor workplaces for potential hazards (for example, an unstable roof of a building). As artificial intelligence (AI) improves, drones will be able to collect data that AI can transform into useful information or make safety recommendations to construction managers.

Technologies can significantly improve security processes across the industry through automation, data trend analysis, and monitoring tools. Companies that focus on technologies to solve safety problems will see a reduction in injury rates and a reduction in the cost of compensation claims.

Technology can play a significant role in the ability to hire and retain young workers. Many young workers have grown up with technology in their hands (such as cell phones, touchscreens and tablets). For many, construction work seems archaic and does not correspond to their skills or career interests [12].

One of the main obstacles that companies will have to overcome is the transition. Since a quarter of the construction workforce is over 55 years old, many workers are not interested in mastering new technologies. Many older workers simply want to maintain the status quo as they approach retirement. Forcing older workers to adopt technology may push them to retire earlier, which will exacerbate the skills gap.

Another problem is low productivity and inefficiency as a result of poor design processes, insufficient investment in skills development and innovation. This affects all employees of the electrical industry: from merchants to project managers and middle managers.

When workers retire, they are replaced by less experienced workers. In some countries, such as the United States, many young workers are being pushed to get a four-year college degree instead of a vocational education. In addition, the situation is aggravated by the global recession, the weakening of trade unions and the political agenda [13].

Accordingly, serious gaps in the skilled labor market create a shortage of talent in the entire construction industry due to the aging workforce and the low level of participation of young workers. Companies can use technology to attract young, tech-savvy workers by providing technology-oriented work and tools.

Climate change, government regulations and environmentally conscious consumers are putting pressure on the construction industry to reduce the impact on the environment. Most experts agree that buildings and infrastructure produce most of the world's carbon dioxide
emissions and use about a third of all energy. For this reason, the Paris Agreement prescribes to reduce energy consumption per square meter of buildings by 30% by 2030.

Construction companies have many options for implementing environmentally friendly technologies. Things like 3D printing and modular construction processes can increase efficiency, which also reduces the use of materials and energy. However, the most important element is to educate the existing workforce on what technologies exist and how they can be used to achieve sustainable development goals. These technologies include tools to reduce water and energy losses, conserve natural resources, and improve air and water quality. If done correctly, companies will be able to reduce costs and increase value while protecting sensitive ecosystems and limited natural resources [14].

Accordingly, the demand for environmentally friendly building materials and processes will continue to grow, as government regulation and market pressure are aimed at reducing carbon dioxide emissions worldwide. Construction companies can use new technologies to reduce energy consumption and waste materials.

The global supply chain has faced major disruptions due to the COVID-19 pandemic. Many suppliers have slowed production due to lower demand, laying off workers and stopping operations for the procurement of raw materials. Many companies failed to realize that the pandemic would last for several years. Some industry experts expected production and demand to stabilize by 2021. Unfortunately, this did not happen, which led to a further increase in the shortage of materials such as wood, cement, paints and coatings, as well as metals.

As the pandemic has subsided, suppliers are struggling to ramp up production to meet the growing demand. According to the Associated General Contractors of America (AGC), 75% of engineering and construction firms have experienced delays in the implementation of projects due to lack of materials. Increased lead times and delivery delays also affected approximately 57% of these companies. For many companies, materials are stuck in transit without an exact delivery date. This makes it incredibly difficult to plan projects correctly.

These delays and shortages, as well as high inflation, have largely contributed to the sharp increase in costs. In the first half of 2021, prices rose by double digits every month. Companies that can find ways to optimize their supply chains will have less impact. Technologies can be an excellent solution to many cost-related problems [15].

The ability to track and accurately predict delivery times helps to improve project schedules and reduce costs. One study found that many companies are focusing on blockchain technologies (53%) and the Internet of Things (51%) to improve supply chain systems.

It is extremely important for contractors to carefully follow the building codes set by the local government to ensure the safety of buildings. For this reason, most jurisdictions around the world require inspections at certain stages of the project to ensure that there are no hazards or reductions. Unfortunately, most inspections require a personal visit to the City Department of Construction. These inspections must be planned in advance and may lead to delays in the implementation of the project.

Construction is one of the oldest industries in the world, with a history dating back thousands of years. Unfortunately, many of the processes that are still in use today rely on manual efforts to complete work, track project progress, and collect data. A study conducted by TrackVia showed that more than half of all construction managers believe that manual processes make it difficult to effectively manage work sites or provide access to real-time data to make the right decisions [16].

There are several areas that you should pay attention to when implementing technologies that reduce the need for analog processes and systems. First, companies need to look for ways to improve data collection. In some cases, this can be done automatically using sensors or other tracking mechanisms unrelated to humans. However, in many cases,
construction companies will have to rely on employees who will provide data in a timely manner. The second part is how the collected data will be used and displayed for company management and field management.

Most employees have basic knowledge about mobile devices and can use them after minimal training. These devices can give employees and managers the ability to provide updates and information from workplaces in real time. This may require updating local mobile networks if communication in remote locations is poor [17].

The data should be easily accessible and presented in such a way as to provide real-time information about the state of the object and the status of the project. This is very important because almost 90 percent of managers had to get information from several systems to create valuable reports. Dashboards and automated reports can help simplify this process.

Companies that have implemented some technologies may need to consolidate the number of systems used. The switching time between multiple systems can be 400% longer than those that use a single data source.

Manual forms and documents can also be digitized to provide time savings (in some cases up to 40%) and reduce delays in transmitting information to decision makers.

Accordingly, the construction industry still faces a low level of technology adoption. Many processes and tools are still analog. Companies should focus on digitizing tools and simplifying information that is distributed across multiple fragmented systems [18].

Companies in the electrical industry need to act quickly if they want to remain competitive in the near future. There is an extremely high risk for companies that do not see the value and importance that technology will bring to the industry.

Companies that don't use technology will struggle with inefficient processes, higher costs due to waste, and slower supply chains. Few young employees will be attracted to companies that lack technology. In an industry that is already struggling to attract talent, low-tech E&C companies will not be a desirable employment option compared to other forward-thinking companies [19].

The supply chain, scheduling issues and project delays will continue to disappoint customers. In addition, firms that will be able to demonstrate their technology platforms will attract higher-quality projects and clients.

Technologies will play a key role in improving the environmental friendliness of construction. As the rules and expectations of the market become stricter, it will be easier for technology construction companies to adapt to compliance.

After the pandemic, the construction industry reached a record level (in July 2021, its revenue amounted to $1.57 trillion). This growth is expected to continue. For this reason, it is important for construction companies to develop and implement a carefully thought-out digital strategy.

4 Discussion

The digital revolution and information technologies have become a powerful driving force of the real economy [20] and have given a new impetus to innovation in many industries. In developed countries, the industrial model has been completely changed by digital infrastructure [21]. The digitalization revolution has actively stimulated and accelerated industrial reform of work processes to make them more efficient, including decision-making, resource allocation, production, design and construction processes. Digital technologies are an important tool for accelerating social revolution and economic development.

Being the backbone industry of the real economy, the construction industry has undergone many technological changes related to digitalization and has begun to undermine current labor life cycles. This transformation contributes to industrial adaptation to digital
technologies, possible modernization and qualitative development. Experts point out that a BIM model with real-time data can provide cyber-physical integration, providing real-time monitoring of assets and actions and improving the decision-making process. Also in the literature, smart construction is referred to as an interconnected, intelligent and efficient construction model based on a high degree of digitalization. Currently, other integrations are also being developed, such as prefabricated buildings, the creation of digital technology systems and the creation of intelligent platforms. These current applications of digital technologies have helped construction companies to improve quality, productivity and efficiency [22].

Experts widely discussed the factors influencing innovations and their economic results from the macro level to the micro level. There are many factors that influence innovation, including legal institutions, social culture, openness of the capital market, investor characteristics and corporate characteristics. Innovation is the most important driving force of regional economic growth, thus becoming the most important aspect of the government's attention. Although R&D is expensive, risky and has a long payback period, it often creates large positive side effects for the entire enterprise, thereby accelerating the development of companies and society as a whole.

The pursuit of high profits is one of the driving forces behind the modernization of companies. And technological innovations play an indispensable role in promoting corporate economic growth [23]. Investments in research and development can improve corporate innovation opportunities and increase competitiveness in the market. Meanwhile, it can also accelerate corporate transformation and modernization, thereby providing sufficient capacity for future development. Thus, if construction companies take actions to improve their technological innovations and transform the labor-intensive industry into a knowledge-intensive one, digital reform will also help optimize corporate operational efficiency and, thus, increase corporate competitiveness.

In recent years, it has become increasingly common sense in the construction industry to adapt to digital transformation. This modernization can help improve the quality of construction and the effectiveness of the program, mitigate the impact of risks and uncertainties, and thus increase corporate synthetic strength. Taking advantage of the benefits of digital reform, the construction industry can redefine its work, reconstruct its ecosystem and fundamentally transform.

Most companies in the construction industry independently research and try to develop technological innovations, thereby updating their production processes, as well as management through the use of new technologies. In the process of digital reform, the construction industry can creatively explore a new business model and move from the traditional physical space to the digital space, which will lead to the creation of a completely new industrial ecosphere. Technological innovations brought by digital reform can lead to high efficiency, accuracy and consistency of program operation management.

5 Conclusion

Thus, using innovative resources, as well as results to measure innovative investments at the company level, it can be explained that digital reform increases corporate innovative investments. Moreover, we investigate the basic mechanism of managers' foresight underlying this effect. Studies show that the stimulating effect of digital reform on innovative investments at the firm level is stronger in areas where relations between local authorities and firms within them are healthier. Experts demonstrate that the promotion of innovative investments caused by digital transformation really strengthens corporate opportunities for sustainable development and competitiveness.
Technological modernization and industrial transformation caused by digital reform will gradually have an impact on many areas of engineering construction and will contribute to the technological revolution in the construction industry. Corporate managers should attach great importance to digital reform and thus contribute to the innovation revolution in the future, improving future corporate potential and competitiveness.

References

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