

Artificial Intelligence and Firm Performance

Subjects: Business, Finance

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Developments in computer science, robotics, machine learning, and data accumulation have facilitated the application of advanced technologies in businesses. Among the cutting-edge technologies, Artificial Intelligence (AI) has gained growing attention in different sectors of society, industry, and business. The unprecedented novel coronavirus (COVID-19) pandemic has brought massive uncertainty and has negatively impacted health care, economy, population mobility, and numerous industries, including tourism, aviation, manufacturing, education, and other business sectors. The halted production, supply chain disruption, and shrinking customer activity led to a decline in company revenues and negatively affected corporate performance and the world economy.

Keywords: AI ; artificial intelligence ; pandemic ; firm performance ; risk

1. Introduction

Existing research documents the effects of the pandemic on stock performance at different levels, covering analysis at the global ([Ashraf 2020](#); [Chowdhury et al. 2022](#); [Erdem 2020](#); [Liu et al. 2020](#)), industry ([Ahmad et al. 2021](#); [Baek et al. 2020](#); [Huo and Qiu 2020](#)), and firm levels ([Davis et al. 2020](#); [Mazur et al. 2021](#)); these studies indicate that stock markets react differently to the COVID-19 pandemic across economies and sectors. For instance, countries in Asia generated greater negative abnormal returns compared to other economies ([Liu et al. 2020](#)). Firms with high exposure to travel, retail, airplane production, and energy supply fell quickly after the pandemic outbreak, whereas positive returns are found in firms related to healthcare, e-commerce, internet services, and clinical trials and material sectors ([Davis et al. 2020](#)); moreover, firms with better corporate financial positions ([Xiong et al. 2020](#)), financial flexibility ([Fahlenbrach et al. 2021](#)), and less exposure to the global supply chain ([Ding et al. 2021](#)) show greater resilience in the wake of the COVID-19 outbreak.

The COVID-19 pandemic has changed how firms operate under the new social norms and has amplified the importance of AI applications. According to the Global AI Adoption Index 2021 report by the International Business Machines (IBM) Corporation ([IBM 2021](#)), nearly 43% of surveyed businesses report their companies accelerated the rollout of AI because of the COVID-19 pandemic. The term AI was first mentioned in 1955 ([McCarthy et al. 1955](#)) and gained substantial interest in commercial applications and investments ([Babina et al. 2021](#)). In a broad sense, AI refers to the ability of machines to study from experience, adapt to new inputs, and carry out human-like tasks ([Duan et al. 2019](#)).

The increasing attention on AI in businesses is due to the technological maturity in terms of both computing power and the ability to perform rapid and real-time analysis of large amounts of data. Data analysis and AI enable individuals to systematize disaggregated information, and transform data into business decisions, thereby facilitating decision-making processes within an enterprise ([Sestino and De Mauro 2022](#)). From stock management, business model selection, workforce optimization, and supply chain management, AI gradually penetrates many business processes and revolutionizes how enterprises will be organized and controlled in the future ([Chen and Biswas 2021](#); [Jarrahi 2018](#)). AI in businesses uses enormous amounts of data and complex computing algorithms for analysis and prediction, thereby giving solutions in a timely manner ([Agrawal et al. 2019](#)). A recent online survey by [McKinsey \(2021\)](#) shows considerable earnings boost and cost savings through AI adoption. The findings demonstrate that up to 56% of respondents report adopting at least one function of AI in their organization, ranging from product development to service optimization.

Several studies investigate the impact of AI adoption on business performance in terms of reducing prediction costs and improving forecasting ([Agrawal et al. 2019](#)), offering productivity growth by replacing traditional human tasks with automation ([Acemoglu and Restrepo 2018](#)), and improving product innovation ([Babina et al. 2021](#); [Rock 2019](#)) and firm growth ([Alekseeva et al. 2020](#)). AI is regarded as playing a key role in improving business productivity, delivering high-quality products and services, and achieving better disruption management brought on by the COVID-19 crisis ([McKendrick 2021](#)). However, some studies reveal that the application of AI may be overhyped in terms of its effectiveness, accuracy, reliability, and scale because of the complex nature of AI, and its disregard for human

involvement ([Davenport and Dasgupta 2019](#); [Sipior 2020](#)). A recent study by [Lui et al. \(2022\)](#) indicates that announcements of AI adoption led to negative abnormal market returns and significant adverse impacts on the market value of firms. Further, assessing the economic impact of implementing AI technologies is challenging due to the lack of comprehensive firm-level data on the AI adoption of firms ([Seamans and Raj 2018](#)).

2. Performance of Artificial Intelligence Adopted Firms

[IBM \(2020\)](#) defines AI as a field that leverages computer science with robust datasets to enhance firms' problem-solving and decision-making. According to [Jain \(2019\)](#) and [Mamela et al. \(2020\)](#), natural language processing, machine learning, data mining, and decision-making are the major topics under the umbrella of AI. These fields comprised AI algorithms that can be used to create expert systems to facilitate predictions or classifications based on input data ([IBM 2020](#)). Therefore, AI in businesses can be defined as the theory and advancement of computer systems that are capable of carrying out tasks that typically require human intelligence ([Deloitte 2017](#)). AI can be deployed across various value chains of firms, including inventory tracking, financial recording keeping, workforce management, and customer segmentation ([Enholm et al. 2021](#)). Measuring AI adoption in firms is challenging because of the lack of standardized concepts and the dynamic aspects of AI practices and applications. Prior studies use multiple ways to measure AI adoption in firms. Some qualitative measurements are the demand for AI-skilled human capital ([Rock 2019](#); [Alekseeva et al. 2020](#); [Babina et al. 2021](#)), the business perceptions towards AI ([Jain 2019](#)), the introduction of specific AI-based technology such as machine translation ([Brynjolfsson et al. 2019](#)), and the integration of AI applications into core businesses ([Drydakis 2022](#); [Kinkel et al. 2022](#)). Other measurements are quantitative, such as the data of AI product announcements ([Xu et al. 2021](#)), AI investments or research and development (R&D) expenditure ([Biswas 2021](#); [Lui et al. 2022](#)), and AI patent applications ([Damioli et al. 2021](#)).

AI-adopted firms are defined as the companies that are involved in the adoption of AI or are expected to benefit from products or services that incorporate machine learning or AI technologies. The literature shows that the exponential growth of AI adoption has significant benefits for firm performance; however, prior studies mainly focused on the theoretical front of the benefits of AI implementation on business processes. For example, adopting AI in businesses maintains market share and competitiveness ([Lakshmi and Bahli 2020](#)), enhances work performance and productivity ([Casalino et al. 2020](#); [Ernst et al. 2019](#); [Mamela et al. 2020](#); [Kopsacheilis et al. 2021](#)), maximizes profit through cost reduction and operating efficiency ([Lakshmi and Bahli 2020](#)), and optimizes the customer experience and products and services ([PwC 2019](#)).

Specifically, the primary impact of AI implementation is at the processing level because AI involves replacing repetitive routine tasks with machine automation. Therefore, AI-adopted firms are likely to benefit from economies of scale because it results in better decision-making and cost efficiency ([Brynjolfsson and McElheran 2016](#)). The replacement of human work helps firms increase output and productivity and reduce human errors and cognitive limitations, which leads to better-informed decision-making and faster responses to market dynamics ([Makridakis 2017](#); [Enholm et al. 2021](#)). In addition, AI allows more precise customer segmentation and dynamic pricing by tailoring product offerings based on customer preferences; these can be achieved through collecting and processing existing customer data, which enables firms to adapt to changes in customer behaviors more effectively ([Mihet and Philippon 2019](#)). Aligning advanced technologies unleashes product innovation opportunities by finding patterns through massive amounts of data analysis, resulting in improved customer satisfaction and competitive advantages ([Aghion et al. 2018](#)).

Several studies explore the empirical evidence of AI adoption and firm performance; however, empirical research on the impact of AI adoption on the performance of listed firms and security markets is underexplored, which mainly focuses on the United States (US), and the results remain mixed. For instance, using an online survey in India, [Jain \(2019\)](#) found the adoption of AI helps firms manage technology-related challenges, enhance business operations, and boost business growth. [Alekseeva et al. \(2020\)](#) examine the relationship between AI adoption (measured by demand for AI-related skills) and firm performance from 2010 to 2018 in the US. The researchers reveal a positive relationship between AI adoption and firms' sales growth, capital expenditure, EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortization) margin, and R&D investments; however, there is no significant association between AI adoption and total factor productivity.

[Babina et al. \(2021\)](#) reveal that AI-investing firms have better economic outcomes in terms of sales growth, employment, and market valuations through product innovation; however, the effects are pronounced in large firms because they accumulate considerable amounts of data. There is no significant impact of AI technology on cost-cutting. A recent empirical analysis of AI capability's effect on firm performance by [Mikalef and Gupta \(2021\)](#) shows that the use and deployment of AI in organizations results in positive outcomes in organizational performance and creativity. [Damioli et al.](#)

(2021) find that AI-related patent applications have an extra positive effect on firms' labor productivity. On the other hand, [Lui et al. \(2022\)](#) estimate the impact of AI investment on firm value based on the AI investment announcements of 62 US-listed firms. The researchers' results indicate that the stock prices decrease by 1.77% on the announcement date. Firms with lower information technology capability and credit ratings and firms in non-manufacturing sectors experience more adverse influence compared to others; however, a recent study by [Fotheringham and Wiles \(2022\)](#) shows that AI investment announcements in terms of customer service such as chatbots lead to a 0.22% abnormal stock return.

3. The Impact of COVID-19 Pandemic on Firm Performance

Because of the highly contagious and fatal nature of the coronavirus, strict measures by governments and legal authorities to prevent transmission resulted in the suspension of most economic activity. The stock market experienced a massive crash in early March 2020, as measured by the Dow Jones Industrial Average (DJIA), which plunged 26% (6400 points) because of government precautions against the COVID-19 pandemic ([Mazur et al. 2021](#)). [Baker et al. \(2020\)](#) indicate that no other infectious disease outbreak, including the Spanish Flu, has had such a significant impact on the stock market as the COVID-19 pandemic. Several studies have examined the stock market response to the pandemic worldwide, such as [Khatatbeh et al. \(2020\)](#), [Ozili and Arun \(2020\)](#), and [Chowdhury et al. \(2022\)](#). [Ramelli and Wagner \(2020\)](#) reveal that the COVID-19 pandemic led to extraordinarily volatile, negative aggregate market reactions. Internationally-orientated firms with high exposure to China were found to be underperforming, which led to substantially lower cumulative returns during the incubation and outbreak period.

[Liu et al. \(2020\)](#) highlight that COVID-19 had a severe negative impact on stock market indices' performance of 21 economies, especially Asian countries. [Al-Awadhi et al. \(2020\)](#) show that daily growth in the total number of confirmed cases and deaths significantly affects stock returns in China. In addition, [Mazur et al. \(2021\)](#) investigated the stock price volatility of Standard and Poor's (S&P) 1500 firms and found a March 2020 stock price collapse. Roughly 90% of the S&P 1500 stock prices generated asymmetrically distributed negative returns. [Khan et al. \(2020\)](#) examine the performance of stock market indices of 16 economies and the S&P Global 1200 Index representing the global equity market. The researchers conclude that the stock market indices negatively reacted to the news in both the short and long term after the virus was announced in 2020 as transmissible among humans. [Ashraf \(2020\)](#) demonstrates that stock markets had a quick, negative reaction to the number of COVID-19 confirmed cases. Though the responses of stock markets varied over time, negative market response was strong during the initial stage of the outbreak. The US, Japan and European stock markets did not react significantly to the initial outbreak in China until the virus spread globally around 20 February 2020 ([Gormsen and Koijen 2020](#)).

A series of studies quantified the magnitude of the effect of COVID-19 across various industries and firms (see, for example, [Ali et al. 2020](#); [Cai and Luo 2020](#); [Maneenop and Kotcharin 2020](#); [Sansa 2020](#); [Narayan et al. 2021](#)). These studies demonstrate that financial markets and firms reacted to the pandemic heterogeneously and highlight the importance of multiple factors such as region, industry, and firm characteristics when analyzing the impact of COVID-19 on firm performance. For instance, [Hu and Zhang \(2021\)](#) indicate that firms' return on assets (ROA), on average, is adversely affected by the severity of COVID-19 cases based on firm-level accounting data across 107 countries. [Fahlenbrach et al. \(2021\)](#) conclude that firms with greater financial flexibility could better fill the needs for cash flow shortfall and are relatively less affected by COVID-19 shocks than those with less financial flexibility. In addition, [Xiong et al. \(2020\)](#) analyze the reaction of the Chinese listed companies to the pandemic. Firms with a larger size, greater profitability and growth opportunity, and higher combined leverage positively impact cumulative abnormal return.

In the same vein, [Ding et al. \(2021\)](#) find that firms with higher exposure to the pandemic through international supply chains, or customers, suffered greater stock price drops; however, firms with high liquidity and profitability experienced better stock price performance than other similar firms. According to [Lyke \(2020\)](#), the pandemic influence varies from negative to positive on the US oil and gas sector, and the stock reaction is firm-specific. [Rababah et al. \(2020\)](#) elaborate that small- and medium-sized enterprises are most hit by the pandemic in China, leading to a decrease in profit margins, especially in tourism and transport. Similarly, [Hassan et al. \(2020\)](#) and [Mazur et al. \(2021\)](#) conclude that industries including transport, hospitality, electricity, and the environment are the worst-hit sectors during the pandemic, whereas manufacturing, medicine and health care, and information technology (IT) sectors show remarkable resilience.

With regard to the performance of AI-based companies, few studies focused on the use of AI by businesses induced by COVID-19. For example, [Xu et al. \(2021\)](#) examine and compare the competitiveness of AI-adopted firms with non-AI firms based on product announcements using multinational data under COVID-19. Their findings reveal that the revenues of firms engaged in AI products ex-ante were less negatively affected during the COVID-19 outbreak. In addition, firms in developing countries with higher GDP growth, benefit more from AI adoption. [Chen and Biswas \(2021\)](#) analyze how the

adoption of AI and big data could smooth business operations during the pandemic based on eight business scenarios. The outcomes suggest that AI and big data are critical drivers for operating efficiency in challenging environments. In addition, [Kumar and Kalse \(2021\)](#) conclude that adopting AI could be beneficial for small and medium-sized enterprises (SMEs) in all fields in confronting the challenges caused by COVID-19, including marketing, financial performance, employee engagement, and data management. Accordingly, [Drydakis \(2022\)](#) indicates that AI application is associated with mitigating business risks for SMEs; this is because leveraging AI technology enables SMEs to improve their dynamic capabilities and efficiency in predicting market trends.

Overall, existing studies document the severe impact of COVID-19 on firm performance at the market, industry, and firm levels. These studies demonstrate that firms in various sectors were affected differently in response to the COVID-19 outbreak. Previous research highlights factors such as geographical region, industry, and corporate characteristics can affect the stock reactions in different ways; however, because of the broad conceptual and multifaceted nature of AI, studies on AI adoption and its impact on firm performance remain embryonic and are predominantly confined to theoretical analysis. The empirical analysis of the impact of AI on firm performance in terms of different measures is lacking and the results are mixed. Most importantly, the effect of COVID-19 on the performance of AI-adopted listed firms is still underexplored. Given the importance of advanced technology in reshaping business operations, additional empirical research is needed to demonstrate whether AI adoption by firms can translate into business performance and how they can be impacted by exogenous shocks and extreme events. It is important to understand whether corporate characteristics, such as AI-based companies can better shape their stock price reactions to the COVID-19 pandemic.

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