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Investigating the impact AI on Corporate financial and operating flexibility of Retail Enterprises in China

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Abstract: Using panel data of 373 retail firms listed on Shenzhen and Shanghai Stock Exchange from 2011 to 2022, this study examines the transformative impact of artificial intelligence on the operating and financial flexibility of retail enterprises of China. We employ two-way fixed effects regression model to demonstrate how AI influences corporate operating and financial flexibility. The findings of this study show that AI positively influence corporate operating and financial flexibility, however, the influence is more pronounced and greater on operating flexibility of retail firms. The heterogeneity analysis results show that retail firms with high innovation capabilities and those in developed regions benefit most from AI adoption, optimizing their adaptability and stability via improving operating and financial flexibility. Moreover, AI fosters operating flexibility of small-sized retail enterprises while enhances financial flexibility of large-sized retail enterprises. These findings highlight the crucial role of AI to navigate uncertainties and driver resilience in the evolving economic landscape. Policymakers are suggested to foster AI infrastructure, make innovation-driven policies, and promote digital inclusion to ensure sustainable growth and equitable benefits for China's retail industry.

Keywords: *Artificial Intelligence; Corporate Operating flexibility; Corporate Financial flexibility; Retail enterprises.*

1. Introduction

The rapid development of artificial intelligence (AI) transformed numerous industries worldwide, enabling them to follow automated processes in planning, implementing, monitoring, and controlling operations. China, as the world's second largest economy, is emerged as a leader in AI adoption, with its AI investments of $17 billion in 2022 [1]. The integration of AI in business processes has become an urgent need for all sectors of China to become competitive, efficient, and transparent to manage the operations systematically [2]. The retail sector, with its direct interaction with customers, is on forefront to adopt AI technologies and controlling its operations in an organized way. Most of the retail giants such as Alibaba, JD.com, Taobao, and others have heavily invested in AI technologies and they are using machine learning and data analytics to optimize

their supply chains and improve customer experiences [3, 4]. Also, they are adopting AI-based end-to-end learning methods, significantly enhancing network intrusion detection and providing strong support for critical data protection [5]. Consumer psychology plays a crucial role in marketing strategies [6]. AI technology can precisely analyze consumer behavior and psychology, enabling retail businesses to develop personalized branding strategies that enhance customer experience and boost sales [7, 8]. Rashidin, et al. [9] state that shifting of retail sector toward AI technologies has reshaped consumer behavior, as now 60% of the Chinese customers have to interact with AI-driven platforms during their shopping journeys. Additionally, Chinese government's strong emphasis on AI innovations, coupled with heavy investments from private enterprises, highlighted the crucial role of AI in modern economy to make it highly competitive and efficient [10].

The industrial robot penetration trend is found positive and growing across the retail enterprises of China over the period of 2011-2022. The retail enterprises leverage AI technologies to foster their efficiency and effectiveness of operations [11]. AI technologies are deployed by these enterprises to have operational improvements in inventory management, demand forecasting, customer relationship, and personalized marketing strategies [4, 12]. Cao [13] shows that AI-driven platforms offer precise demand analytics, and thus help retail enterprises to understand the product needs. Using AI tools help companies to reduce inventory management costs and to inspect quality patterns. Additionally, AI algorithms tailored marketing strategies could help firms in focusing individual customer preferences, and thus achieving higher customer satisfaction scores [6, 14]. AI tool of automate customer service system helps retail managers in gaining operational efficiency and reducing the response time to counteract the operational challenges in customer service delivery cycle [15]. The transformative role of AI streamlines business processes and enhances consumer engagement to optimize operational and financial flexibility of retail enterprises[16]. In customer churn prediction, the use of domain adaptation algorithms enables more accurate detection of changes in customer needs, helping businesses develop retention strategies and enhance customer loyalty [17]. AI-driven tools help retail enterprises to directly and closely monitor the supply chain cycle and thus having the enhanced control over the product development and delivery processes.

Corporate operating flexibility is referred to a firm's ability of being adaptive to change the market conditions, consumers' preferences, and other external disruptions in market while sustaining its efficiency and competitiveness in their relative industries [18]. In practical terms, operating flexibility encompasses the elements of capacity management, inventory management, supply chain management, and reconfiguring services in response to real-time demand. Artificial intelligence may help retail enterprises in improving their operating flexibility through responding quickly to the change customers' needs and following external disruptions in industry [19]. The predictive analytics, driven by AI technologies, could be utilized by retail enterprises to avoid the situations of overstocking or stockouts [20]. The robotic process automation (RPA) allows retail enterprises to regulate routine tasks, enable provision of resources, and to accelerate the systematic efficiency [21]. In addition to this, AI may help retail enterprises to use flexibility logistics systems that could enable AI optimized delivery schedules and routes, and thus ensure a timely product delivery and availability [22, 23]. By these all channels, AI can help retail enterprises to foster their operating flexibility.

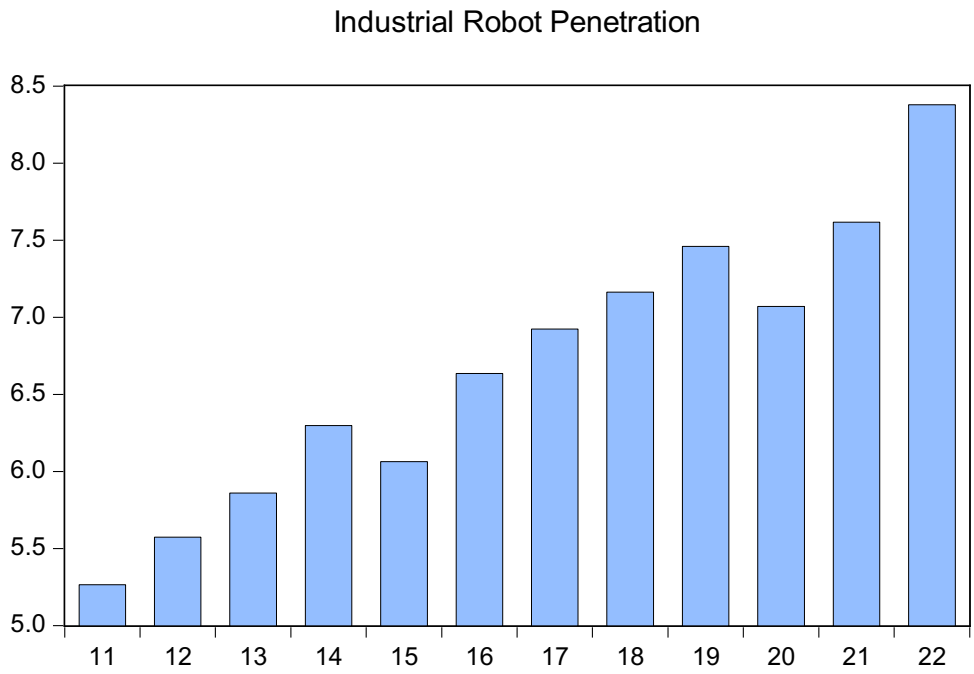

Figure 1: Industrial robot penetration across retail enterprises over 2011-2022

In addition to optimizing operational flexibility, AI can also help enterprises to gain financial flexibility which is the firm's ability to effectively manage and allocate financial resources to adapt various challenges, seize growth opportunities, and ensure long-term sustainability [24]. Financial flexibility involves maintaining adequate liquidity, optimizing cost structures, and securing access to investment or credit under favorable terms so firms could not be out of funds or having high volume of unusable funds in hands. AI-driven financial analytics streamline decision-making process by offering accurate forecasts and identifying changing financial market trends [25]. AI technologies could help retail enterprises to gain cost optimization and thus gain high profit margins. AI-driven technologies can allow retail enterprises in financial planning to forecast cash flows and allocate resources efficiently, and thus gaining a better financial flexibility [26, 27]. Using AI technologies can help retail enterprises in implementing cost optimization strategies to improve profit margins and reduce operational costs [28]. There can be advanced credit risk assessment tools to help retail firms in enhancing borrowing capacity and thus mitigating overall default or bankruptcy risks [29]. All these benefits underscore AI's strategic importance to strengthen economic resilience of retail enterprises in China.

This paper contributes to the existing literature by examining the dual impact of AI on operational and financial flexibility of retail enterprises of China. Prior research has mainly focused on AI's role to enhance corporate financial performance, improve customer experience, and enhance total factory productivity [9, 13, 24, 29]. As per best of our knowledge, this is the first study to examine the influence of AI on corporate operating and financial flexibility. This study offers a nuanced understanding of how AI drives flexibility in retail operations and financial management, offering valuable insights for academics and practitioners alike. Current research will show that how innovation firms are different than those with low innovation level to adopt AI technologies to drive corporate operating and financial flexibility. We will explain the heterogeneity effects of AI on corporate operating and financial flexibility of retail enterprises by considering the firm size and regional development of provinces.

Remaining of this paper is structured as follow: Section (2) presents literature review and develops hypotheses current study; Section (3) discusses data, methodology, variables, and econometric model of study; Section (4) encompasses empirical results including descriptive statistics, correlation matrix, baseline regression results, robustness results, and heterogeneity analysis; Section (5) concludes the paper and presents policy implications.

2. **Literature review and hypotheses development**

2.1 AI and operating flexibility

Corporate operating flexibility is referred to a firm's ability of adapting the market changes and consumer demands and it is crucial for today's competitive and dynamic retail environment to gain operating flexibility to make right decisions at right time [30]. Adopting AI technologies by retail enterprises could help them in enhancing operating flexibility via improving real-time decision making, predictive analytics, and automation. Kitzmann [31] demonstrate that AI-powered demand forecasting tools allow firms in optimizing inventory management, and thus reducing overstocking and stockouts. For retail enterprises, it is crucial to avoid inventory overstock or stockout as both conditions may erode their profitability. Menz, et al. [32] show that AI could improve supply chain process by making automatic adjustments in supplier and customer connections, and thus allows retail enterprises to use leverage predictive analytics systematically. Using AI-driven tools in supply chain processes enables firms in closely monitoring their connections with customers and suppliers, and thus being fully informed about consumers' changing product needs, and suppliers' capacity of meeting the company needs.

Leveraging AI-driven analytics could help retail firms to gain better understanding of consumers' changing behaviors, and thus being adaptive to the real-time market trends [33]. This adaptability is crucial for those industries where trends change immediately, such as fashion retail [34]. Retail enterprises with full information of stock in hand and stock production, could be more efficient to manage their capacity of sales and achieve operational excellence. Dhamija and Bag [35] demonstrate that AI systems could help firms to enhance operational decision-making by integrating data from multiple sources, such as social media trends and purchasing patterns. In other words, AI accesses different data sources and combine the trends on a single platform to provide a better understanding of changing conditions.

AI could also help retail enterprises to improve their customer service experience, a crucial element of operational flexibility. AI-powered chatbots and virtual assistant could provide 24/7 support, address customers' different queries and complaints with minimal human intervention [36]. Tarafdar, et al. [37] argue that AI-driven tools have the efficiency to reduce the response time by almost 50%, and thus there could be significant improvement in customer satisfaction and freeing human resources for more complex tasks. The customer relationship management (CRM) through AI becomes more efficient and effective to address customers' issues, and thus enabling a more advanced platform to attract and retain customer base [38]. In addition to this, AI-enabled sentiment analysis platform could help retail enterprises to gauge consumer sentiments and address negative feedback in a proactive manner [39].

The integration of AI in logistics and supply chain operations has revolutionized retail industry. The connections of retailers with suppliers and customers have been strengthened through using AI tools that enable a more directive pattern. Predictive maintenance powered by AI significantly minimize equipment downtime, and ensures continuous operational flow in a systematic manner

to achieve strategic and operational goals of retail enterprises [40]. AI systems optimize delivery routes, reduce transportation costs, and improve delivery times, and thus directly contribute to overall transparency and efficiency of operations of retail industry [41]. In simple terms, the advancements brought by AI tools contribute to a more agile and efficient supply chain, and thereby offering firms with a competitive edge in the marketplace.

Despite the benefits brought by AI, the implementation of AI may also create some operational challenges, that are crucial to address for being able to efficiently optimize operating flexibility of retail enterprises. Dubey, et al. [42] state that the integration of AI systems with legacy infrastructure could require significant investments in technology upgrades and workforce training. Any discrepancy in these both areas may not only create cost burdens but also mitigate the operational flexibility. Additionally, resistance to change among employees could hinder the successful adoption of AI technologies in retail enterprises [43]. Addressing these challenges would require retail enterprises to foster a culture of innovation and provide adequate training facilities for being able to achieve operational outcomes. Based on above discussion, we can develop this hypothesis: H1: Adopting AI could optimize operational flexibility of retail enterprises of China.

2.2 AI and Financial flexibility

Financial flexibility, referred to an enterprise's ability of efficiently allocating and managing financial resources, could be critical aspect for retail enterprises to navigate uncertainties and seize growth opportunities [44]. Artificial intelligence (AI) optimizes financial flexibility by improving risk assessment capabilities, cost management, and enhancing the financial decision making. Ahmed, et al. [45] demonstrate that AI-driven financial planning systems can help firms in forecasting cash flows more accurately, allowing them to anticipate liquidity shortages, and optimizing their resource allocation. Buckley, et al. [46] argue that AI-based cost optimization tools could reduce operational expenses by up to 25% in leading retail firms, enhance their ability of reinvesting in growth opportunities, and thus optimizing the overall corporate financial flexibility.

AI-driven financial risk management can diagnose financial risks and offer appropriate solutions on time. Machine learning algorithms could provide superior accuracy to assess credit risks, enable firms in securing loans in more favorable terms, and also providing them crucial information about the future fund requirements. [47] explain that firms leveraging AI technologies for credit risk assessment could reduce loan default rate by 15%, and improve overall financial stability as well [48]. In addition to this, AI could help firms to gain real-time monitoring of financial metrics, allow firms to identify and address potential financial risks before they hike [49]. In other words, AI tools can facilitate firms in developing the potential through which they can identify and rectify the financial risks immediately.

Making investment decisions is another crucial area of financial planning and it requires financial flexibility to make more appropriate investment decisions. AI-driven portfolio optimization tools could help firms in analyzing the market trends and project returns, helping firms to allocation of capital to high-performing investments, and thus gaining overall investment efficiency. Wang, et al. [50] state that firms employing AI tools could improve information transparency in investment decision making, and thus gaining the higher returns. AI tools could lead firms in diversifying their portfolios, mitigating the risks associated with market volatility, and achieving better control over their portfolio allocation [51].

AI-driven financial transparency, adopted by retail enterprises, could enable them in achieving their financial and economic returns more significantly. Blockchain-based AI systems could improve accountability by offering immutable records of financial transactions and strengthening the audit processes to avoid corporate financial frauds [52]. The transparency, brough by AI tools, fosters investor confidence and simplifies compliance with regulatory requirements to enable an environment where all stakeholders could feel safe and secure [53]. By identifying anomalies in financial data, AI can facilitate in fraud detection and making the processes more transparent and effective to achieve potential goals.

To implement AI for optimizing financial flexibility, there might be need of substantial cost that may deter small and medium-sized enterprises to adopt AI technologies [54]. The data privacy concerns could pose significant risks, as the financial data may be really sensitive and there could be need of making significant emphasis on robust cybersecurity measures to mitigate these risks. Using AI technologies can create the strategic paradigm through which there can be better financial planning to manage costs, make appropriate investment decisions, predict risks and address them, and counteract frauds. Based on these views, we can posit this hypothesis: H2: Artificial intelligence can optimize corporate financial flexibility of Chinese retail enterprises.

3. **Data, Variables, and Empirical modelling**

3.1 Data

This paper uses unbalanced panel data of 373 retail enterprises listed on Shenzhen and Shanghai Stock Exchanges of China. The sample firms are mainly from retail sector, and firm level data is mainly sourced from CSMAR. The sample period of this study is 2011-2022, and the sample of this paper is constructed as: first, we drop the enterprises with special or partial treatment in any of the sample year; second, we exclude those firms with missing values of any variables; last, we have the final sample of 373 retail enterprises. The industrial robot penetration data is used to measure the AI development of retail enterprises. Due to unavailability of data for some of the sample years, we have unbalanced panel data for current study.

3.2 Variables of study

3.2.1 Independent variables:

Artificial Intelligence (AI): The firm's AI development is measured using the industrial robot penetration data.

3.2.2 Dependent variable:

Operating flexibility (Op_{Fx}): We use the ratio of net sales to net fixed assets, to measure the operating flexibility for assessing how efficiently a retail enterprise utilize its fixed assets to generate revenue, and thus reflects its operational adaptability.

Financial flexibility (F_{Fx}): Cash to Total assets ratio is used as the measure of financial flexibility, which assesses a firm's liquidity relative to its total assets, indicating its ability of responding to financial needs.

3.2.3 Control variables

Following [9, 12, 36, 54], we use the control variables of Firm liquidity (Liq) measured as current assets to current liabilities, Debt to Equity (D/E) ratio measure as total liabilities divided by total equity, Asset Turnover ratio (Ast_{TO}) measured as total sales divided by total assets, Working Capital ratio (WC) measured as the proportion of working capital in total assets, and Return on Assets (ROA) measured as the net income divided by the total assets of retail enterprises.

3.2.4 Empirical Modelling

We use two-way fixed-effects regression approach to explain the potential influence of AI on Op_{Fx} and F_{Fx}. For both, we have constructed the econometric models:

$$Op_{Fx_{i,t}} = \beta_0 + \beta_1 AI_{i,t} + \beta_2 Liq_{i,t} + \beta_3 \frac{\mathrm{D}}{\mathrm{E}_{i,t}} + \beta_4 Ast_{TO_{i,t}} + \beta_5 \mathrm{WC}_{i,t} + \beta_6 \mathrm{ROA}_{i,t} + \epsilon \quad (1)$$

$$F_{Fx_{i,t}} = \beta_0 + \beta_1 AI_{i,t} + \beta_2 Liq_{i,t} + \beta_3 \frac{\mathrm{D}}{\mathrm{E}_{i,t}} + \beta_4 Ast_{TO_{i,t}} + \beta_5 \mathrm{WC}_{i,t} + \beta_6 \mathrm{ROA}_{i,t} + \epsilon \quad (2)$$

where $Op_{Fx_{i,t}}$ and $F_{Fx_{i,t}}$ reflect operating and financial flexibility of firm i in year t, respectively. $\mathrm{AI}_{\mathrm{i,t}}$ denotes AI development, $\mathrm{Liq}_{\mathrm{i,t}}$ is the firm liquidity, $\frac{\mathrm{D}}{\mathrm{E}_{i,t}}$ represents firm debt to equity ratio, $Ast_{TO_{i,t}}$ measures Asset Turnover ratio, $\mathrm{WC}_{\mathrm{i,t}}$ indicates working capital, $\mathrm{ROA}_{\mathrm{i,t}}$ reflects return on asset ratio, β_0 to β_5 denote regression coefficients in both models, and ϵ is the error term.

4. **Empirical results and discussion**

4.1 Descriptive statistics

The descriptive statistics of all variables including dependent, independent, and control variables are reported in Table 1. As per the descriptive statistics, Op_{Fx} has mean value of 13.03361 with standard deviation of 19.74311, and thus showing the existence of significant dispersion in operating flexibility of retail enterprises of China. The mean value for F_{Fx} is shown as 0.1879346, which is within range of 0.0002805 and 0.9359065, suggesting that financial flexibility of retail enterprises of China is normally distributed. As per the descriptive statistics, mean value of AI is 6.74414 with standard deviation of 4.001815, that suggests the existence of significant robot penetration across Chinese A-share retail enterprises. In addition to this, the descriptive statistics of all control variables are within acceptable range and showing the normal range of data.

Table 1: Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Op_{Fx}	2,809	13.03361	19.74311	0.0085657	132.662
F_{Fx}	2,809	0.1879346	0.1266653	0.0002805	0.9359065
AI	2,809	6.74414	4.001815	0.0028	15.92
Liq	2,809	1.879318	1.945122	0.01604	44.54991
D/E	2,809	1.897586	10.14982	-54.08443	416.2532
Ast_{TO}	2,809	1.02309	0.8177326	0.001846	9.379897
WC	2,809	0.1527398	0.2660902	-2.073264	0.95118
ROA	2,809	0.0399134	0.1404698	-4.803333	0.99711

4.2 Pairwise correlation matrix

We examine the correlation between variables of study to know the strength and extent of relationship across all variables. As per the pairwise correlation results, reported in Table 2, there is a positive relationship exists between Op_{Fx} and F_{Fx}, suggesting that increasing operating flexibility leads to increase the financial flexibility of retail enterprises. The nexus of AI with OP_{Fx} and F_{Fx} is reported positive as denoted by the correlation coefficients of 0.0387 and 0.0145 respectively. Based on these results, it can be claimed that AI development improves the corporate operating and financial flexibility of retail enterprises of China. In addition to this, AI possess positive relationship with Liq and WC, whereas negative relationship with D/E, Ast_{TO}, and ROA. Based on pairwise correlation results, the nexus of Op_{Fx} and F_{Fx} is mainly significant with all variables of study and thus core explanatory variable and control variables would have the significant influence on the dependent variable.

Table 2: Pairwise correlation results.

Variable	Op_{Fx}	F_{Fx}	AI	Liq	D/E	Ast_{TO}	WC	ROA
Op_{Fx}	1.0000							
F_{Fx}	0.0382*	1.0000						
AI	0.0387**	0.0145***	1.0000					
Liq	-0.0002	0.3171***	0.0241*	1.0000				
D/E	0.0353*	-0.0649***	-0.0206**	-0.0799***	1.0000			
Ast_{TO}	0.5235***	0.0696***	-0.0090**	-0.1479***	-0.0025	1.0000		
WC	0.1540***	0.3806***	0.0240***	0.6056***	-0.1456***	0.0070	1.0000	
ROA	-0.0118	0.1175***	-0.0101	0.0840***	-0.0840***	0.0473**	0.2693***	1.0000

Note: *, **, *** denote the significance level at 10%, 5%, and 1%.

4.3 Benchmark regression results

We estimate model 1 and model 2, and report the regression results in Table 3. As per the regression results of Model 1, AI has regression coefficient of 0.111556, that suggests a positive influence of artificial intelligence on operating flexibility of retail enterprises. These results indicate that increased industrial robot penetration of retail enterprises lead them to achieve improved operating flexibility. These results confirm the positive role of AI development to foster operating flexibility through providing operational space to the retail enterprises. It can be argued that when retail enterprises are using AI-driven platforms to manage their operations, they are more empowered with those tools that help them in achieving their operational goals. Using AI

technologies help retail enterprises to become more efficient toward their operational processes, and thereby gain the operational efficiency. In other words, when retail enterprises are using AI tools, they are able to manage their product development, product design, product delivery, and customer service processes more efficiently, and thus achieving the operational efficiency.

The regression results of F_{Fx} are reported in model 2 of Table 3. As per these estimates, there is also a positive influence posited by AI on F_{Fx} as denoted by the regression coefficient of 0.06319. However, the regression coefficient is not strongly significant, but still, we can discuss AI's influence on F_{Fx}, and thus leading the retail enterprises to achieve financial flexibility. These results claim that retail enterprises are leveraging the benefits of AI develop to counteract their financial challenges and being able to make better financial planning. By using AI-driven platforms, retail enterprises become more efficient in their investment decision making processes, credit risk assessment, and financial budgeting. With the integration of AI in their business processes, these enterprises become fully informed about their budgeting needs and allocation requirements. They use their financial resources more transparently and thus mitigate the corporate financial frauds as well.

As per the benchmark regression results, we can accept both hypotheses of this study, that claim the positive role of AI development in fostering corporate operating and financial flexibility of retail enterprises. We may argue that AI development could help retail enterprises to efficiently manage their operations of customer service, supply chain, quality control, financial planning, credit risk assessment, and inventory control [2, 9, 14]. The industrial robot penetration of retail enterprises helps them to be well-informed about strategic and financial decision making. Based on these views, we can claim that AI offers significant benefits to retail enterprises for allowing them to achieve higher operating and financial flexibility.

Table 3: Benchmark regression results.

Variable:	Model 1 (Op_{Fx})	Model 2 (F_{Fx})
AI	0.111556**	0.06319*
	(2.21)	(1.86)
Liq	-0.0963956	0.0096105***
	(-0.53)	(7.28)
D/E	0.0443368**	-0.0003974**
	(2.16)	(-2.55)
Ast_{TO}	11.71986***	0.0065327**
	(26.84)	(2.04)
WC	11.34786***	0.1670406***
	(7.66)	(15.29)
ROA	-5.880365***	0.0107765
	(-3.56)	(0.87)
Cons.	0.0828821	0.1400482***
	(0.08)	(19.79)
N	2,809	2,809
R^2	0.3055	0.1624

Note: *, **, *** denote the significance level at 10%, 5%, and 1%. T-statistics are reported in parentheses.

5. **Heterogeneity analysis**

5.1 Firm innovation heterogeneity

To further confirm the heterogeneity effects of AI on Op_{Fx} and F_{Fx}, we have segregated the enterprises based on their research and development expenditures [55]. The firms with high research and development expenditures are classified as Inov = 1, and firms with low research and development expenditures are categorized as Inov = 0. As per the regression results, reported in Table 4, we find that AI has greater influence on Op_{Fx}, as denoted by regression coefficient of 0.218841, for those firms which have high volume of research and development expenditures. In addition to this, AI has shown its positive influence on financial flexibility with the regression coefficient of 0.0004705. Based on these results, we can argue that retail firms with high volume of research and development expenditures are more efficient to leverage the benefits of AI to improve operating flexibility and financial flexibility. These results show that AI development could enable retail enterprises to leverage AI technologies for gaining the operational efficiency and better financial results.

Table 4: Heterogeneity analysis: Highly innovative vs Less-innovative firms

Variable	Operating Flexibility		Financial Flexibility	
	Inov = 1	Inov = 0	Inov = 1	Inov = 0
AI	0.218841**	0.1190932*	0.0004705*	0.0009096
	(2.34)	(1.86)	(1.91)	(0.91)
Liq	-0.1322266	0.0410705	0.0069228***	0.0105769***
	(-0.37)	(0.20)	(3.10)	(6.91)
D/E	0.0135662	0.1120264***	-0.0005861***	-0.0002269
	(0.80)	(3.00)	(-4.31)	(-0.82)
Ast_{TO}	13.53607***	12.48558***	-0.0055017	0.0036279
	(12.99)	(24.55)	(-0.79)	(0.98)
WC	5.187124**	13.97129***	0.1614333***	0.1610808***
	(2.31)	(7.74)	(9.74)	(12.20)
ROA	-1.96134	-11.99405***	-0.0081297	0.0347895
	(-1.28)	(-3.73)	(-0.68)	(1.47)
Cons.	-0.8102602	-1.442562	0.1324261***	0.1483432***
	(-0.47)	(-1.25)	(12.22)	(18.49)
N	731	2,078	731	2,078
R^2	0.2602	0.3234	0.1919	0.1650

Note: *, **, *** denote the significance level at 10%, 5%, and 1%. T-statistics are reported in parentheses.

5.2 Firm size heterogeneity

Firm size could be a significant factor to influence the retail enterprises' ability to leverage AI technologies to achieve operating and financial flexibility [42]. By considering the firm size effects, we re-estimate both models and report the results for large and small size enterprises. As per the results, small-sized enterprises are significantly leveraging AI technologies to improve corporate operating flexibility. We can argue that small sized enterprises would have the greater operational space to improve their flexibility by leveraging the AI technologies in their business processes. As per the regression results of financial flexibility, we found that large enterprises are major beneficiary of AI technologies to achieve financial flexibility. By using AI technologies, small-sized enterprises are more efficient to manage their operations and thus improving their operating flexibility. On the other side, large size enterprises are able to make better financial plans, and thus tends to have higher financial flexibility.

Table 5: Heterogeneity analysis: Large size vs Small Size Enterprises

Variable	Operating Flexibility		Financial Flexibility	
	Large	Small	Large	Small
AI	-0.0211443	0.1871509**	0.0008117*	0.0001353
	(-0.30)	(2.78)	(1.67)	(0.23)
Liq	-2.059639**	-0.0456061	0.0141835**	0.0085957***
	(-2.28)	(-0.26)	(2.40)	(5.87)
D/E	0.0059315	0.087266***	0.0001003	-0.0000799
	(0.19)	(2.73)	(0.49)	(-0.29)
Ast_{TO}	10.92201***	9.766868***	0.0167401***	0.004564
	(18.31)	(13.07)	(4.57)	(0.75)
WC	20.62398***	12.1804***	0.1375093***	0.1671649***
	(5.18)	(7.50)	(5.29)	(12.30)
ROA	-19.93886***	-5.37208***	0.0748741*	0.0025542
	(-3.38)	(-3.36)	(1.90)	(0.19)
Cons.	6.235529***	-0.8846821	0.1110828***	0.145997***
	(3.33)	(-0.69)	(10.25)	(14.42)
N	1,357	1,452	1,357	1,452
R^2	0.3857	0.1840	0.0704	0.2078

Note: *, **, *** denote the significance level at 10%, 5%, and 1%. T-statistics are reported in parentheses.

5.3 Regional development heterogeneity

The regional development varies across the provinces of China as the central and eastern provinces are more developed than western provinces. The retail enterprises within developed regions could have better digital infrastructure to deploy digital technologies in their processes and having the trained and skillful staff to use it. In under-developed regions, retail enterprises are mainly short of funds and infrastructure to invest in AI technologies. It can be seemed that operating flexibility is positively and significantly influenced by the AI development in those retail enterprises, that are based in developed regions. On the other side, retail enterprises based in developed and under-developed regions are able to leverage the benefits of AI technologies to improve their financial flexibility. We can claim that AI development fosters financial flexibility of retail enterprises more in developed regions, when compared to the under-developed regions. It can be claimed that regional development has significant influence of AI on operational and financial flexibility of retail enterprises in China.

Table 6: Heterogeneity analysis: Developed vs Under-developed regions

Variable	Operating Flexibility		Financial Flexibility	
	Developed	Un_Develop	Developed	Un_Develop
AI	0.1581108***	0.0961444	0.02455***	0.006999***
	(2.63)	(1.28)	(2.45)	(2.46)
Liq	0.0542204	-3.248257***	0.0108885***	0.0035106
	(0.37)	(-4.18)	(7.69)	(0.75)
D/E	0.0295974*	0.6408841***	-0.0002795*	-0.002066*
	(1.72)	(3.82)	(-1.80)	(-1.95)
Ast_{TO}	3.478814**	11.7198***	0.0493139***	0.0018791
	(2.22)	(20.99)	(3.28)	(0.54)
WC	7.742607***	30.93523***	0.1588149***	0.1590781***
	(5.40)	(9.09)	(11.60)	(7.65)
ROA	-7.670242***	-6.081165***	0.0689153**	-0.0069274
	(-2.59)	(-2.97)	(2.54)	(-0.53)
Cons.	2.674675**	1.83892	0.1130913***	0.172298***
	(2.47)	(0.94)	(10.16)	(15.57)
N	1,404	1,405	1,404	1,405
R^2	0.0402	0.3393	0.2597	0.0608

Note: *, **, *** denote the significance level at 10%, 5%, and 1%. T-statistics are reported in parentheses.

6. **Conclusion and policy implications**

The integration of artificial intelligence (AI) has revolutionized current business world, with retail enterprises in China at forefront of this transformation. As per the dynamic and competitive nature of retail sector, understanding the role of AI to enhance corporate operating and financial flexibility is crucial to maintain resilience and adaptability. So, this study aims to examine that how AI adoption empowers retail sector to navigate uncertainties, optimize decision making, and strengthen financial stability in evolving economic landscape. Using unbalanced panel data of 373 retail enterprises listed on Shenzhen and Shanghai Stock Exchange for the period of 2011-2022, we show the influence of AI on operating and financial flexibility of retail enterprises. We use two-way fixed effects regression model to show that whether AI has any significant influence on operating or financial flexibility. The benchmark results of this study show that AI penetration across retail enterprises significantly fosters operating and financial flexibility. In addition to this, we perform heterogeneity analysis by considering firm innovation, firm size, and regional development. The heterogeneity analysis results show that firms with high innovation capability and firms based in developed regions are more exposed to the benefits of AI to optimize their operating and financial flexibility. The firm size has shown mixed results, as AI penetration fosters operating flexibility of small sized retail enterprises, whereas improves financial flexibility of large retail enterprises.

Based on the findings of paper, there can be several policy implications followed by stakeholders to leverage AI for retail sector's growth and resilience. First, policymakers are required to make investments in developing AI infrastructure and digital transformation tools, particularly for retail sector, to optimize their operating and financial flexibility. Second, there should be targeted support for the small-medium size enterprises to facilitate their AI adoption, so these firms could demonstrate improved operating flexibility through AI penetration in their processes. Third, it is recommended to have the innovation-driven policies by government, such as R&D tax incentives and subsidies for AI-focused projects, to enable firms for having high innovation capabilities to maximize their benefits associated with AI. Fourth, regional governments in China are required to

focus on addressing the digital gaps by promoting AI adoption in underdeveloped regions, so there can be equitable benefits across all retail enterprises of China. Last, it is suggest to extend collaboration between public and private sectors to create industry-specific AI solutions, to foster sustainable growth and resilience within China competitive and dynamic retail landscape.

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Chi Li conceptualized the research framework and contributed to the methodology development and data analysis. Yingda Tang conducted the formal analysis, implemented the computational models, and contributed to the validation of results. Kaixian Xu supervised the research, reviewed and edited the manuscript, and provided critical insights into the study. All authors contributed to writing the manuscript, discussed the results, and approved the final version.

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Conflict of Interest
The authors declare no conflict of interest.

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