Asia Pacific Journal of Information Systems
Vol. 32 No. 3 (September 2022), 564-579

ISSN 2288-5404 (Print) / ISSN 2288-6818 (Online)
https://doi.org/10.14329/apjis.2022.32.3.564

Preemptive or Catch Up? Performance Differences under Enterprise Digital Transformation

Peinan Ji[a,*], Guang Yu[b]

[a] *Senior Research Fellow, School of Management, Lanzhou University, Lanzhou, China*
[b] *Professor, School of Management, Harbin Institute of Technology (HIT), Harbin, China*

ABSTRACT

The use of on-premises technology in the business environment to create a competitive advantage is ushering in a new era known as digital transformation. As the foundation of digital transformation of enterprises, information technology still has a paradoxical effect on enterprises. This paper documents the effect of investments in IT on a firm's long-term profitability performance measures as return on assets (ROA), as well as tests whether the earlier entrant and the later entrant are different in IT investment performance. Using a sample of China's public firms IT investment data between 2016 and 2019, the result indicates that IT investment in firms have a positive effect on firm performance in full sample, but not in the financial industry firms. When it comes to the different investment time, the result shows no significant difference between the earlier entrant firm and the later entrant firm in the full sample, but not in the case of software industry sample. This should help alleviate the concerns that some have expressed about the viability of digital transformation given the highly publicized IT investment and implementation problems at some firms.

Keywords: IT Investment, Digital Transformation, Firm Performance, Investment Decision

Ⅰ. Introduction

With the rapid development of computer and information technology, more and more attention has been paid to the intelligent and digital reform of the country and enterprises. The digital economy based on information technology and data has developed rapidly. From the current business environment, data resources based on information technology have increasingly become the most important resources of enterprises and the basis for innovation, competition, development and survival in the future (Khuntia et al., 2018). On one hand, enterprises are continuously undertaking digital transformation by implementing, maintaining, and integrating digital technologies for their information systems (Wang and Wang, 2022).

*Corresponding Author. E-mail: jipn@lzu.edu.cn

On the other hand, the digital economy positively enhances enterprise digital transformation, and enterprise digital transformation has an impact on enterprise performance (Li et al., 2022). This mutually reinforcing relationship supports the development of the digital transformation of enterprises.

In the process of digital transformation of enterprises, in order to obtain the data resources, enterprises need to make a lot of investment and construction in information technology (Gökalp and Martinez, 2020), such as Enterprise Resource Planning (ERP), 5G, cloud services, Internet of Things (IoT) and so on. The investment and implementation of these information technologies often consume a lot of resources such as time, manpower and money. According to the survey conducted by Society for Information Management (SIM) of U.S. in 2020, investment and use of enterprise cloud services continues to increase, doubling in the past five years and showing an accelerating growth trend amid a sharp drop in corporate revenue due to the COVID-19 pandemic (Kappelman et al., 2021). At the same time, the China Statistical Yearbook released in 2021 by the National Bureau of Statistics of China shows that in 2020, the software business revenue will exceed 8.1 trillion yuan, an increase of more than 12.5% from 7.2 trillion yuan in 2019. In short, a large amount of IT investment by enterprises is the basis for the digital transformation of enterprises.

The reasons of firms to allocate significant parts of their capital budgets toward IT are execute digital strategies and digital transformation (Xue et al., 2021). These digital strategies and digital transformations are considered to be important methods for companies to face future competition and development. However, academia is still arguing about whether enterprise IT investment has brought corresponding performance to the enterprise (Acar et al., 2017; Khuntia et al., 2018; Liu et al., 2021). Many studies have found that corporate IT investment and implementation have not brought corresponding corporate benefits to the company, and even have a negative impact on normal production and operation. Using panel data on IT investment of Jordanian banks, Gangopadhyay and Nilakantan find that a bank's IT investment does not respond to other banks' lagged profitability, which consistent with the presence of the IT productivity paradox (Gangopadhyay and Nilakantan, 2021). Based on data envelopment analysis (DEA), Liu et al.'s research shows that IT performance shows little regional difference, but significant industrial diversity (Liu et al., 2021). For the surface of the debate on IT investment performance, it is necessary to in-depth study the causes and solutions of this "productivity paradox".

In the process of digital transformation of enterprises, they also face competition from enterprises in the same industry, which means that the implementation timing of enterprises is very important. On one hand, the technical and informational characteristics of information technology make the enterprises that use it in the early stage have the advantage of switching cost, that is, it is easier to obtain customer accumulation and thus have the first-mover advantage (Otim et al., 2012). On the other hand, falling IT costs over time provide cost advantages for later entrants, making investment decisions more challenging for early entrants (Dos Santos and Sussman, 2000). For example, Demirhan and Jacob's research show that declining IT cost intensifies or relaxes competition between firms depending on whether they are serving quality- or price-sensitive markets. And in both cases, the average price per unit quality decreases when the IT cost declines, which benefits consumers (Demirhan et al., 2005).

This research aims at deepening the understanding

of the effects of IT investment on firm performance in the context of enterprise digital transformation, and to find the level and direction of the relationship between IT investment and firm financial performance. Many researchers argued that the changes brought about by IT investment are crucial for organizations that face dynamic market requirements and also that the criticized procedures and constraints actually support process reengineering. However, few studies have paid attention to the impact of early-stage IT investment and late-stage IT investment on enterprise IT productivity in the time dimension. This study will fill this gap and extend the scope of the established literature in IS by examining the influence of IT investment using Chinese public firms' data to see if such spending has had an influence on corporate performance in the investment time-line.

Through the research on IT investment performance under the different enterprise IT investment time, this research has certain theoretical and practical significance. First, it extends the scope of the established literature by examining the influence of IT investment using Chinese public firms' data and IT investment to see if investment time has an impact on IT investment performance. Second, as far as we are aware, there is a lack of research on impact of enterprise competition in the horizontal time dimension on enterprise performance in the digital transformation of enterprises. Third, for business practice, this research could help make reasonable IT investment decisions, and help enterprises improve the success rate of digital transformation, and promote enterprises to reduce losses.

Ⅱ. Literature Review

2.1. Firm Digital Transformation, IT Investment and IT Productivity

With the advancement of the new economy, the digital transformation of enterprises based on data and information technology is the trend (Zhai et al., 2022). Firm Digital transformation (DT) is to achieve major business improvements by using of new digital technologies or information technologies (Fitzgerald et al., 2014). The literature also refers DT as applying digital technology in operation, business model innovation, or digital strategy to create values for a firm (Kane et al., 2015; Schallmo et al., 2020; Selimović et al., 2021). DT affects all sectors of society, which makes governments and enterprises pay more and more attention to digital transformation, in particular economies. At the same time, DT opens new networking possibilities and enables cooperation between different actors, who, for example, exchange data and thus initiate processes (Selimović et al., 2021). According to an annual report by the Shanghai Academy of Social Science,[1] the top five countries are the US, Singapore, China, South Korea and UK in the economy-wide digitalization. Especially, China showed obvious advantages in digital industry competitiveness, ranking first in the world by a large margin ahead of the United States. However, the country still had certain room for improvement in digital innovation, governance capability and infrastructure construction.

Different scholars have given different definitions of enterprise IT investment (Alghorbany et al., 2022; Huang et al., 2006). In this research, IT investment

1) Report source: https://www.ciie.org/zbh/en/news/exhibition/News/20210107/25218.html

is considered as resources related to IT such as software, hardware, communications, and smartphones, which other studies have adopted in the digital transformation of enterprises. In the process of enterprise digital transformation, Internet and information technology (IT) are important foundations. On the one hand, the investment and implementation of information technology provides technical support for the digital transformation of enterprises; on the other hand, the digital transformation and application of enterprises can improve the efficiency of enterprise information technology. Therefore, the IT investment and digital transformation of enterprises are complementary and mutually reinforcing. With the development and popularization of computer technology and the wide application of various information systems, a large amount of original data has been accumulated in various systems, and the demand for data analysis in all walks of life is becoming more and more urgent. In addition to predicting the operation trend of related systems, there are increasingly higher requirements for the breadth and speed of data analysis. These demands have prompted IT and Internet manufacturers to continue to accelerate the research and development of data analysis technology. On the one hand, big data analysis is no longer limited to structured historical data, but is more inclined to analyze unstructured data collected from social networks and various sensors; on the other hand, fierce market competition has prompted big data solution manufacturers to increase larger investment in research and development of fast, real-time data analysis, and intelligent decision-making technologies.

The improvement of enterprise productivity is the result of technological progress on the one hand, and the improvement of enterprise efficiency on the other hand (Banker et al., 2005). Advances in technology can shift the possibility frontier of firm production outward, which can be achieved by adopting new technologies or introducing product and process innovations (Chang and Gurbaxani, 2013). An example of technological advancement leading to an increase in business productivity is the migration of a business to a more advanced business model or the use of redesigned business processes based on the support of new technologies such as cloud technology. An increase in firm efficiency can also lead to an increase in firm productivity, as a firm shifts its production possibilities forward by extracting more output from any given input and existing technology. improve. For example, companies can improve the performance of operational processes such as supply chain or customer acquisition by using business intelligence software that enables sophisticated analysis of existing data to improve the quality of decision-making. Ultimately, it brings about an increase in enterprise productivity.

2.2. IT Productivity Paradox and Explanations

Research on the impact of enterprise IT investment on enterprise productivity has always been a hot issue in information system (IS) research (Khuntia et al., 2018). On the one hand, in enterprise practice, IT investment has always been faced with large investment amounts, long implementation cycles, and failure risks. On the other hand, it is because of the long-term existence of the phenomenon of "IT productivity paradox" in academic research, even in the current business environment (Ilmudeen, 2021). Researchers from different countries have used enterprise data from different countries and adopted different research methods to study the IT productivity of enterprises under different evaluation indicators, but the conclusions are still inconsistent. For example, Gangopadhyay and Nilakantan used the panel data

of the Jordanian banking industry to verify the phenomenon of "IT productivity paradox" in the IT investment of Jordanian banks (Gangopadhyay and Nilakantan, 2021). Karhade and Dong used European enterprise data to study the relationship between IT investment and business innovation performance, and the results show that there is an inverted U-shaped relationship between them as a whole (Karhade and Dong, 2020). <Table 1> is the research about IT investment on firm performance in the past 5 years. From these latest research conclusions, the paradox of IT investment performance still exists, and the number of negative results is almost the same as that of positive results.

As the phenomenon of "IT productivity paradox" appears more and more in the research, the causes of this paradox have also attracted the attention of more and more researchers. At present, the reasons for the "IT productivity paradox" mainly include the following four explanations (Hajli et al., 2015): 1) Measurement errors caused by research methods; 2) The lag due to the learning and adjustment process after IT investment; 3) Income distribution and 4) Ambiguity of findings. On one hand, lots of research proved that firm IT investment have a positive influence on firm performance. At the same time, a handful of studies (Beccalli, 2007; Thakurta and Deb, 2018) on the impact of IT investments in firms show weak or non-existent links between IT spending and firm performance. This difference in the results shows that there are still controversies in the research on IT investment performance, and there is no unified convincing conclusion.

<Table 1> Research about IT Investment on Firm Performance Recently

Authors	Performance Indicator	Data Source	Method	Result
(Gangopadhyay and Nilakantan, 2021)	Financial	Jordan	Linear in Means Model	Negative
(Thakurta and Deb, 2018)	Stock Market	India	Multivariate Analysis	
(Han et al., 2019)	Financial	United States	Post-Hoc Analysis	
(Boban and Susak, 2017)	Financial	Croatia	Regression Model	
(Kohli et al., 2012)	Stock Market	United States	Regression Model	
(Takeda et al., 2021)	Stock Market	Japan	Event Study	
(Mohamad et al., 2017)	Financial	Malaysia	Hierarchical Regression Analysis	Mixed
(Stores et al., 2018)	Stock Market	Malaysia	Regression Model	
(Liu et al., 2021)	Financial	Asia, Europe and US	Network Dea Models	
(Qi and Han, 2020)	Financial	United States	Generalized Method of Moments	
(Shea et al., 2019)	Stock Market	United States	Discontinuity Regression	
(Karhade and Dong, 2021)	Innovation	Europe	Regression Model	
(Khuntia et al., 2018)	Organizational	India	Regression Model	Positive
(Lee and Choi, 2019)	Financial	United States	Linear Model	
(Fernandes et al., 2017)	Organizational	Portugal	Case Study	
(Mohamad et al., 2017)	Organizational	Malaysia	Structural Equation Model	
(Shea et al., 2019)	Financial	United States	General Linear Model	

2.3. IT Investment Competition in the Process of Digital Transformation

The improvement of enterprise productivity stems from technological progress or the improvement of enterprise efficiency, and competition is the driving factor of efficiency. That is to say, in the digital transformation competition environment, the efficiency at the enterprise level may show considerable heterogeneity, which has an important impact on the productivity of the enterprise. The current research confirms that the intensity of competition has a positive impact on the productivity of enterprises, that is, the higher the degree of competition faced by enterprises, the higher the productivity of enterprises (Xin and Choudhary, 2019). There are two main reasons for this: 1) in the highly competitive external environment, enterprise managers have more pressure and motivation to manage effectively and reduce management slack; 2) At the same time, in the highly competitive external environment, enterprises use resources more efficiently and can enhance and optimize the rational allocation of resources (Chang and Gurbaxani, 2013).

At present, there is very little research on the timing of IT investment under the background of digital transformation. In the competition research of enterprise IT investment, there are many researches on investment intensity and investment focus, but there are very few researches on investment time, that is, the pioneer in adopting IT or the late investment compared with competitors (Arora and Rahman, 2016). Therefore, there are relatively few studies on the interaction and game relationship between investors before and after. In the rapidly developing IT industry, the threat of new entrants from start-ups has an important impact on corporate decision-making (Pan et al., 2019). Research by Demirhan and Jacob et al. shows that falling IT costs always hurt the profits of early entrants. At the same time, early IT adopters may adopt aggressive investment strategies or defensive investment strategies to cope with falling IT costs, depending on the relationship between switching costs and falling IT costs (Demirhan et al., 2007).

Ⅲ. Data and Method

3.1. Data

Data Selection: The purpose of our research is to introduce the difference of IT investment on firm financial performance between the earlier entrant and the later entrant. To accomplish this objective, we searched the Wind database, which is a leading financial company providing financial data, information, and software services, over the four-year period from 2016 to 2019 for news articles about firms planning to make investments in IT in their own company. We take IT investment as the keyword to search for the full text of announcements. Next, we checked the title of the announcements and excluded those that were obviously not enterprise IT investment announcements. Then, the specific contents of these announcements were reviewed to determine whether they were shown to invest in IT, including purchases, agreements to purchase, or plans to buy equipment, software, or services. After reading, we excluded the sample that was not related to a company's own IT investment. If a company announced the same IT investment more than once, e.g., one firm's plan to buy some computer software, the earliest title was retained. Finally, 325 IT investment samples were kept. Every announcement was also carefully examined to determine whether the

<Table 2> Distribution of IT Investment Announcements Over Time

Year	Manufacturing Industry	Software Industry	Financial Industry	Other Industries	Full Sample
2016	14	12	7	10	43
2017	37	20	11	29	97
2018	29	27	8	25	89
2019	41	23	20	12	96
Total	121	82	46	76	325

proposed IT investment was innovative IT investment in the company.

Data Classification: After obtaining the final enterprise IT investment data, we classify IT investment data according to the type of IT investment and the industry in which the enterprise is located. The industry classification of this paper is based on the industry classification results of the listed companies of the China Securities Regulatory Commission (CSRC) at the announcement day of the enterprise IT investment. As shown in the <Table 2>, there are 325 IT investment samples in four years between 2016 and 2019, including 121 manufacturing industry firms, 82 software industry firms, 46 financial industry firms, and 76 other industries sample. At the same time, we further categorize enterprise IT investments in each industry by IT type, including Enterprise Resource Planning (ERP) system, Supply Chain Management (SCM) system, Customer Relationship Management (CRM) system, 5G upgrade, Artificial Intelligence (AI), Virtual Reality (VR), and so on. Other IT investments in <Table 3> are mainly composed of a smaller number of types, including office computer, software upgrade, cyber security, data storage and analysis software. The distribution of IT investment by IT type is shown in the <Table 3>.

Data Grouping: Based on the classification rules above, we classified the 325 enterprise IT investment data by industry and IT category. After that, we divide the IT investment samples in each category into two groups equally, namely the earlier entrant group (E) and the later entrant group (L), according to the investment time. That is to say, based on the IT investment announcement date, we evenly divide the IT investment sample into two groups: the earlier entrant group (E) and the later entrant group (L).

<Table 3> Distribution of Firm IT Investment by IT Type

Year	Manufacturing Industry	Software Industry	Financial Industry	Other Industries	Full Sample
ERP	21	9	12	14	56
SCM	20	4	3	10	37
CRM	18	7	10	12	47
5G	15	4	5	7	31
AI	13	8	7	16	44
VR	9	13	4	8	34
Others	25	37	5	9	76
Total	121	82	46	76	325

For example, there are 82 IT investment firms in software industry between 2016 and 2019. The earlier entrant group (E) in software industry is 41 firms, which is half of the full 82 samples, and the later entrant group (L) is the last 41 firms, which investment year between 2018 and 2019. If the number of data is singular, the sample of enterprises with intermediate investment is deleted, in order to make the classification of IT investment clearer. Moreover, we obtained the firm financial data for the selected 325 sample in the year of IT investment and the following two years in CSMAR database.

3.2. Method

In the context of enterprise digital transformation, enterprises have made a lot of IT investment and implementation. However, in the presence of the "IT Productivity Paradox" and the competitive environment, it remains unclear whether firm early-stage IT investment and firm late-stage IT investment have an effect on corporate performance. In order to solve this problem, we use a Difference-in-Difference-in-Difference (DDD) model to examine the effects of the earlier entrant of IT and the later entrant of IT on firm financial performance. This study was carried out according to the following steps.

(1) **The control group**; We choose a control enterprise for each sample enterprise in the following four steps (Barber and Lyon, 1996; Ji et al., 2020):

① For each company in the sample, we search all the companies with the same standard industrial classification (SIC) code in the Wind database as a possible comparison group. Afterward, we choose the firms, whose firm size in the starting year of the measurement period is within 90-110 percent in the possible comparison group. According to Barber and Lyon, the 90-110 percent range filter has well-specified test statistics (Barber and Lyon, 1996).

② If we do not find any firms in Step 1, then we attempt to match performance within the 90-110 percent filter using all firms in the same one-digit SIC code.

③ If we do not find any firms in Step 2, then we attempt to match performance within the 90-110 percent filter without regard to SIC code.

④ If we do not find any firms in step 3, then we chose the firm that is closest in performance without regard to SIC code.

(2) **One-fold Difference**; After matching the control group for each sample firm, we performed the one-fold difference. The time window period in our research is 2 years after the IT investment announcement. Even though, the evidence on the time required to implement the IT systems is limited. Raman and Singh's case study on i2 Technologies indicated that implementation of SCM systems can take about 6-12 months (Raman and Singh, 1998). Sambrani and Pol reports a 1.5-year implementation period for SCM systems (Sambrani and Pol, 2016). According to previous research (An, 2005; Hendricks et al., 2007), we selected a two-year time window for this research. For example, if a sample company announced ERP investment in the year 2019, we will observe the changes of the financial performance of the sample company from 2019 to 2021. The formula of one-fold difference for all sample group and control group firms is as follows:

$$OD_{i,t} = FP_{i,t+2} - FP_{i,t}$$

Where, $OD_{i,t}$ is the result of One-fold difference for firm i in year t, $FP_{i,t}$ is the financial performance

for firm *i* in year *t* and $FP_{i,t+2}$ is the financial performance for firm *i* in year *t+2*. In our study, we selected Return on asset (ROA), which is equal to a fiscal year's earnings divided by its total assets and expressed as a percentage, as the firm financial performance.

(3) **Double Difference**; After we obtain the results of one-fold difference of sample group and control group firms, we calculate the double difference (DD) between sample group firms and control group firms as financial performance of IT investment. The formula of double difference for firms invest in IT is as follows:

$$DD_t = SOD_{i,t} - COD_{j,t}$$

Where, DD_t is the result of double difference in year *t*, $SOD_{i,t}$ is the result of one-fold difference for sample group firm *i* in year *t*, $COD_{j,t}$ is the result of one-fold difference for control group firm *j* in year *t*. In this study, the result of double difference (DD) is the net benefit of an enterprise's IT investment. Through statistical analysis to DD value, we will know the impact of IT investment on firm financial performance in the following two years.

(4) **Triple Difference**; After we obtain the results of double difference between sample group firms and control group firms, we calculate the triple difference (TD) between the earlier entrant group (E) and the later entrant group (L). The formula of triple difference for firms invest in IT is as follows:

$$TD_t = EDD_{i,t} - LDD_{j,t}$$

Where, TD_t is the result of triple difference in year *t*, $EDD_{i,t}$ is the result of double difference for the earlier entrant group firm *i* in year *t*, $LDD_{j,t}$ is the result of double difference for the later entrant group (L) firm *j* in year *t*. In this research, the result of triple difference (TD) can be considered the time effect of enterprise IT investment performance. Through statistical analysis to TD value, we will know the financial performance difference after firm IT investment for the earlier entrant firm and the later entrant firm, even in the same firm industry and IT type.

Ⅳ. Results

What this section shows is the results of the influence of IT investment on the firm's financial performance with different types of firm industry, including full sample, manufacturing industry sample, software industry sample and financial industry sample. In addition, the financial performance differences after firm IT investment for the earlier entrant firm and the later entrant firm are also illustrated, even in the same firm industry and IT type. We illustrate the four types of sample results with T-statistics analysis respectively.

4.1. Results for the Impact of IT Investment on Firm Financial Performance

<Table 4> presents results of the firm financial performance for the full sample, manufacturing industry sample, software industry sample and financial industry sample of firms that invested in IT after a two-year investment announcement time window. During the two-year time window after firm IT announcement, we use t statistical test method to observe the changes of financial performance, namely ROA, of enterprises. The results on abnormal return

<Table 4> The Impact of Firm IT Investment on Financial Performance

DD value[a]	Observation	Mean	Median	Percent Positive
Full Sample	325	0.87 (1.99**)	0.79 1.354	68.08 (1.791*)
Manufacturing Sample	121	0.50 (1.72*)	0.54 (1.90*)	53.47 (1.41)
Software Sample	82	0.93 (2.81***)	1.03 (1.77*)	72.14 (1.81*)
Financial Sample	46	0.71 (1.06)	0.77 (1.66)	67.89 (0.84)

Note: [a] Results on abnormal return on assets (ROA) based on DD value. T-statistics for the mean, the median, and the percent positive (binomial sign test) are reported in parentheses.

* Significantly different from zero (50% in the case of percent positive) at the 10% level for one-tailed test.

** Significantly different from zero (50% in the case of percent positive) at the 5% level for one-tailed test.

*** Significantly different from zero (50% in the case of percent positive) at the 1% level for one-tailed test.

on assets (ROA) based on DD value, namely the double difference in the DDD model. We can see in <Table 3>, notice that the abnormal return on assets for the 325 full sample is significantly different from zero, and the two-year average cumulative ROA is 0.87%. There is a positive impact of IT investment on firm financial performance and companies that invest in IT have an average ROA that is 0.87% higher than companies that do not invest in IT. At the same time, the percentage of DD value that greater than zero in all categories is 68.08%, at the 10% level for one-tailed test.

When it comes to different industry samples, notice that the mean of DD values for the manufacturing sample and software sample are significantly different from zero, and the two-year average cumulative ROA return are 0.5% and 0.95%, respectively. However, this does not apply in case of IT investment in financial sample, even though the total average DD value in this group is 0.71%. Specifically, the median value of DD for the full sample, manufacturing sample, software sample and financial sample is 0.79%, 0.54%, 1.03% and 0.77%, respectively. But only manufacturing sample and software sample passed the significance test at the 10% level. The biggest source of income for enterprises in the financial industry is loan interest income, which accounts for a large proportion of enterprise income. Therefore, it is difficult for enterprises in the financial industry to change their profitability and profit structure through IT investment. This may be the reason why companies in the financial industry are not able to achieve higher corporate performance from IT investments. At the same time, for all types of industry firms, more than half of firms have positive ROA financial performance in IT investments, even though only the software sample firms passed the significance test at the 10% level.

4.2. Results for the Firm Financial Performance Under Different It Investment Time

Many event studies have used firm size (e.g., small group, middle group, and large group (Im, Dow, and Grover, 2001)), industry character (e.g., high information-intensive industry and low information-intensive industry (Lee and Kim, 2006)), and company categories (e.g., health-care firm (Menon and Lee, 2000)) to research the impact of different proper-

<Table 5> The Performance Differences under Different IT Investment Time

TD value[a]	Observation	Mean	Median	Percent positive
Full Sample	160	0.12 (1.54)	0.09 (1.07)	55.17 (1.85*)
Manufacturing Sample	58	-0.08 (0.95)	0.05 (0.57)	43.87 (1.09)
Software Sample	40	0.30 (1.72*)	0.37 (1.55)	61.24 (2.03**)
Financial Sample	21	0.15 (1.62)	0.11 (0.79)	59.08 (1.27)

Note: [a] Results on firm return on assets (ROA) difference based on TD value. T-statistics for the mean, the median, and the percent positive (binomial sign test) are reported in parentheses.

* Significantly different from zero (50% in the case of percent positive) at the 10% level for one-tailed test.

** Significantly different from zero (50% in the case of percent positive) at the 5% level for one-tailed test.

*** Significantly different from zero (50% in the case of percent positive) at the 1% level for one-tailed test.

ties of IT investment on firms. In this section, we want to know whether the different IT investment time, namely the earlier entrant firm and the later entrant firm, have an impact on the companies. To solve this problem, this research divide in half to the earlier and later entrance group about the data set to examine the impact of IT investment time. Due to the lack of relevant data classification reference, our research results are to divide the research data simply in half by investment time.

As seen in <Table 5>, there is no significant difference between the earlier entrant firm and the later entrant firm from the TD value for full sample. That is to say, using t statistical test method, the time that enterprises choose to invest in IT will not have a significant impact on the financial performance of enterprises for the full sample. However, compared with the later entrant firm, 55.17% the earlier entrant firm achieved higher abnormal financial returns of ROA at the 10% level for one-tailed test.

Another interesting aspect of our research is to study whether the IT investment time have an influence on firm financial performance in different industries. We can see form the <Table 5>, over the two-year research window, we do not find the positive effect for the full sample, the manufacturing sample and the financial sample, but not in the case of the software sample. At the 10% significance level, the earlier entrant firm have a greater financial performance that the later entrant firm from the mean TD value in software industry firms. In other words, it is better for enterprises to invest in IT in the early stage than in the late stage. The reason may be due to the greater competition among companies and the higher importance of IT in the software industry. At the same time, compared with the later entrant firm, 61.24% the earlier entrant firm achieved higher abnormal financial returns of ROA at the 5% level in the software industry firms.

Ⅴ. Conclusions

This study examined the cumulative abnormal financial performance after firms invested in IT under the background of enterprise digital transformation. We also investigated whether, in addition to the types of IT investment time and the types of listed compa-

nies, IT investments increase the ROA value of the firm and the effect changes in the two-year investment window. In analyzing the full sample of 325 IT investment announcements, the results indicate positive effects of firm financial performance with 0.87% average excess ROA earnings in the two-year time window, which means that IT investment will have a positive effect on firm performance. When it comes to types of listed company industries, the IT investments of manufacturing sample and software sample have a significant impact on firm financial performance.

Compared with previous studies, which only pay attention to the longitudinal position of firms, our research also examined the impact of IT investment on firms' horizontal position, namely the changes of firm performance after IT investment in different IT investment time. Our research shows there is no significant difference between the earlier entrant firm and the later entrant firm from the TD value for full sample. That is to say, the time that enterprises choose to invest in IT will not have a significant impact on the financial performance of enterprises for the full sample, but not in the case of software sample firms. For software industry firms, it is better to invest in IT in the early stage than in the late stage, and the earlier entrant could obtain more firm performance from IT investment.

Ⅵ. Limitations

There are several limitations in this research. First, the data set of this study is simply divided in half by the earlier or later entrance group; hence, this could lead to errors of research results cannot be generalized. Second, the firms in the sample are all in China listed companies, so this may not accurately reflect the entire environment of developing countries, and could possibly. Thirdly, as proposed by a reviewer, this study uses the enterprise's IT investment as an alternative variable for the enterprise's digital transformation. However, the IT investments of enterprises are not all digital transformation investments. Forth, because of the different types of IT investments, choosing a uniform 2-year lag period as the time window in this research is too generalization. Despite these limitations, this study empirically reveals the impact of enterprise IT investment on enterprise financial performance comprehensively, and finds the impact of different IT investment time on enterprise financial performance under the background of enterprise digital transformation.

Acknowledgements

This work was supported by the National Natural Science Foundation of China under Grant No.72201117.

<References>

[1] Acar, M. F., Zaim, S., Isik, M., and Calisir, F. (2017). Relationships among ERP, supply chain orientation and operational performance: An analysis of structural equation modeling. *Benchmarking: An International Journal*, *24*(5), 1291-1308. https://doi.org/10.1108/BIJ-11-2015-0116

[2] Alghorbany, A., Che-Ahmad, A., and Abdulmalik, S. O. (2022). IT investment and corporate performance: Evidence from Malaysia. *Cogent Business and Management, 9*(1). doi:10.1080/23311975.2022.2055906.

[3] An, C. (2005). *Supply Chain Management On Demand.* Berlin: Supply Chain Management On

Demand.

[4] Arora, B., and Rahman, Z. (2016). Information technology investment strategies: A review and synthesis of the literature. *Technology Analysis* and *Strategic Management, 28*(9), 1073-1094. https://doi.org/10.1080/09537 325.2016.1181742

[5] Banker, R. D., Chang, H., and Natarajan, R. (2005). Productivity change, technical progress, and relative efficiency change in the public accounting industry. *Management Science, 51*(2), 291-304. https://doi. org/10.1287/mnsc.1040. 0324

[6] Barber, B. M., and Lyon, J. D. (1996). Detecting abnormal operating performance: The empirical power and specification of test statistics. *Journal of Financial Economics, 41*(3), 359-399 https://doi.org/ 10.1016/0304-405X (96)84701-5

[7] Beccalli, E. (2007). Does IT investment improve bank performance? Evidence from Europe. *Journal of banking finance, 31*(7), 2205-2230. https://doi.org/ 10.1016/j.jbankfin.2006.10.022

[8] Boban, M., and Susak, T. (2017, May 22-26). *The interconnection between investment in software and financial performance - The case of Republic of Croatia.* Paper presented at the 40th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), Opatija, CROATIA.

[9] Chang, Y. B., and Gurbaxani, V. (2013). An empirical analysis of technical efficiency: The role of IT intensity and competition. *Information Systems Research, 24*(3), 561-578. https://doi.org/10.1287/isre.1120.0438

[10] Demirhan, D., Jacob, V. S., and Raghunathan, S. (2005). Information technology investment strategies under declining technology cost. *Journal of Management Information Systems, 22*(3), 321-350. http://doi.org/10.2753/mis0742- 1222220311.

[11] Demirhan, D., Jacob, V. S., and Raghunathan, S. (2007). Strategic IT investments: The impact of switching cost and declining IT cost. *Management Science, 53*(2), 208-226. https://doi.org/10.1287/ mnsc.1060.0629

[12] Dos Santos, B., and Sussman, L. (2000). Improving the return on IT investment: the productivity paradox. *International Journal of Information Management, 20*(6), 429-440. http://doi.org/ 10.1016/s0268- 4012(00)00037-2.

[13] Fernandes, T. M., Gomes, J., and Romão, M. (2017). Investments in E-Government: A benefit management case study. *International Journal of Electronic Government Research, 13*(3), 1-17. http://doi.org/ 10.4018/IJEGR.2017070101

[14] Fitzgerald, M., Kruschwitz, N., Bonnet, D., and Welch, M. (2014). Embracing digital technology: A new strategic imperative. *MIT Sloan Management Review, 55*(2), 1.

[15] Gangopadhyay, P., and Nilakantan, R. (2021). Peer effects and social learning in banks' investments in information technology. *International Review of Economics* and *Finance, 75*, 456-463. http://doi. org/10.1016/ j.iref.2021. 03.024.

[16] Gangopadhyay, P., and Nilakantan, R. (2021). Peer effects and social learning in banks' investments in information technology. *International Review of Economics* and *Finance, 75*, 456-463. https://doi.org/ 10.1016/j.iref. 2021.03.024

[17] Gökalp, E., and Martinez, V. (2020) Digital transformation maturity assessment: development of the digital transformation capability maturity model. *International Journal of Production Research.* http://doi.org/10.1080/ 00207543.2021.1991020.

[18] Hajli, M., Sims, J. M., and Ibragimov, V. (2015). Information technology (IT) productivity paradox in the 21st century. *International Journal of Productivity and Performance Management, 64*(4), 457-478. https://doi.org/10.1108/IJPPM-12-2012-0129

[19] Han, S., Hasan, S., and Tucci, C. (2019, Jan 08-11). *Information Technology and the Cost of Bank Loans: An Empirical Investigation.* Paper presented at the 52ndHawaii International Conference on System Sciences (HICSS), Hi.

[20] Hendricks, K. B., Singhal, V. R., and Stratman, J. K. (2007). The impact of enterprise systems on corporate performance: A study of ERP, SCM, and CRM system implementations. *Journal of Operations*

Management, 25(1). https://doi.org/10.1016/j.jom.2006.02.002

[21] Huang, S. M., Ou, C. S., Chen, C. M., and Lin, B. (2006). An empirical study of relationship between IT investment and firm performance: A resource-based perspective. *European Journal of Operational Research, 173*(3), 984-999. http://doi.org/10.1016/j.ejor.2005 .06.013.

[22] Ilmudeen, A. (2021). The impact of managing IT on business-IT alignment and firm performance: an empirical study. *Foresight, 23*(6), 679-697. https://doi.org/10.1108/FS -11-2020-0116

[23] Im, K. S., Dow, K. E., and Grover, V. (2001). Research report: A reexamination of IT investment and the market value of the firm—an event study methodology. *Information Systems Research, 12*(1), 103-117. http:// doi.org/10.1287/isre.12.1.103.9718

[24] Ji, P. N., Yan, X. B., and Yu, G. (2020). The impact of information technology investment on enterprise financial performance in China. *Chinese Management Studies, 14*(3), 529-542. http://doi.org/10.1108/ cms-04-2019-0123.

[25] Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., and Buckley, N. (2015). Strategy, not technology, drives digital transformation. *MIT Sloan Management Review, 14*, 1-25.

[26] Kappelman, L., Maurer, C., McLean, E. R., Kim, K., Johnson, V. L., Guerra, K., and Snyder, M. (2021). The 2020 SIM IT Issues and Trends Study. *MIS Quarterly Executive, 20*(1), 69-107. http://doi.org/ 10.17705/ 2msqe.000XX.

[27] Karhade, P., and Dong, J. Q. (2020). Information technology investment and commercialized innovation performance: Dynamic adjustment costs and curvilinear impacts. *MIS Quarterly, 45*(3), 1007-1024. https://doi.org/10.25300/MISQ/2021/14368

[28] Karhade, P. P., and Dong, J. Q. (2021). Information technology investment and commercialized innovation performance: Dynamic adjustment costs and curvilinear impacts. *Mis Quarterly, 45*(3), 1007-1024. http://doi.org/10.25300/misq/2021/14368.

[29] Khuntia, J., Saldanha, T. J. V., Mithas, S., and Sambamurthy, V. (2018). Information Technology and Sustainability: Evidence from an Emerging Economy. *Production and Operations Management, 27*(4), 756-773. http://doi.org /10.1111/poms.12822.

[30] Kohli, R., Devaraj, S., and Ow, T. T. (2012). Does information technology investment influence a firm's market value? A case of non-publicly traded healthcare firms. *Mis Quarterly, 36*(4), 1145-1163. https://doi.org/ 10.2307/41703502

[31] Lee, J., and Choi, J. Y. (2019). Increased health information technology investment decreases uncompensated care cost: A study of Texas hospitals. *Technology and Health Care, 27*(1), 13-21. http://doi.org/10.3233/thc-181399.

[32] Lee, S., and Kim, S. H. (2006). A lag effect of IT investment on firm performance. *Information Resources Management Journal, 19*(1), 43-69. http://doi.org/10.4018/irmj.200601 0103

[33] Li, R., Rao, J., and Wan, L. Y. (2022). The digital economy, enterprise digital transformation, and enterprise innovation. *Managerial and Decision Economics*. http://doi.org/10.1002/mde.3569.

[34] Liu, J. W., Gong, Y. M., Zhu, J., and Titah, R. (2021). Information technology and performance: Integrating data envelopment analysis and configurational approach. *Journal of the Operational Research Society, 73*(6), 1278-1293. http://doi.org/10.1080/01605682.2021. 1907238.

[35] Menon, N. M., and Lee, B. (2000). Cost control and production performance enhancement by IT investment and regulation changes: evidence from the healthcare industry. *Decision Support Systems, 30*(2), 153-169. https://doi.org/10.1016/S0167-9236(00)00095-6

[36] Mohamad, A., Zainuddin, Y., Alam, N., and Kendall, G. (2017). Does decentralized decision making increase company performance through its Information Technology infrastructure investment? *International Journal of Accounting Information Systems, 27*, 1-15. http://doi.org/10.1016/j.accinf. 2017.09.001.

[37] Otim, S., Dow, K. E., Grover, V., and Wong, J. A. (2012). The Impact of Information Technology

Investments on Downside Risk of the Firm: Alternative Measurement of the Business Value of IT. *Journal of Management Information Systems, 29*(1), 159-193. http://doi.org/10.2753/mis0742-1222290105.

[38] Pan, Y., Huang, P., and Gopal, A. (2019). Storm clouds on the horizon? New entry threats and R&D investments in the US IT industry. *Information Systems Research, 30*(2), 540-562. https://doi.org/10.1287/isre.2018.0816

[39] Qi, K. K., and Han, S. M. (2020). Does IT Improve Revenue Management in Hospitals? *Journal of the Association for Information Systems, 21*(6), 1486-1506. http://doi.org/10.17705/ 1jais.00644.

[40] Raman, A., and Singh, J. (1998). i2 Technologies, Inc. *Harvard Business School*.

[41] Sambrani, V. N., and Pol, N. B. (2016). Supply chain management impact of distributor ROI towards sales enhancement in FMCG Sector. *Social Science Electronic Publishing*. http://dx.doi.org/10.2139/ssrn.2770481

[42] Schallmo, D., Williams, C. A., and Boardman, L. (2020). Digital transformation of business models—best practice, enablers, and roadmap. *Digital Disruptive Innovation* (pp. 119-138). World Scientific.

[43] Selimović, J., Pilav-Velić, A., and Krndžija, L. (2021). Digital workplace transformation in the financial service sector: Investigating the relationship between employees' expectations and intentions. *Technology in Society, 66*, 101640. https://doi.org/10.1016/j.techsoc.2021.101640

[44] Shea, V. J., Dow, K. E., Chong, A. Y. L., and Ngai, E. W. T. (2019). An examination of the long-term business value of investments in information technology. *Information Systems Frontiers, 21*(1), 213-227. http://doi.org/10.1007/ s10796-017-9735-5.

[45] Stores, F., Diah, M. L. M., Abdullah, N. H., and Kadir, Z. A. (2018). The impact of information technology investment on firms performance. *International Journal Of Entrepreneurship Business Development, 2*(1), 43-55. https://doi.org/10.29138/ijebd.v2i1.648

[46] Takeda, F., Takeda, K., Takemura, T., and Ueda, R. (2021). The impact of information technology investment announcements on the market value of the Japanese regional banks. *Finance Research Letters, 41*. http://doi.org/10.1016/j.frl.2020. 101811.

[47] Thakurta, R., and Deb, S. G. (2018). IS/IT investments and firm performance: Indian evidence. *Journal of Global Information Technology Management, 21*(3), 188-207. http://doi.org/10.1080/1097198x.2018.1498274.

[48] Wang, H., and Wang, S. H. (2022) A Semantic Model for Enterprise Digital Transformation Analysis. *Journal of Computer Information Systems*. http://doi.org/10.1080/08874417. 2022.2037476.

[49] Xin, M., and Choudhary, V. (2019). IT investment under competition: The role of implementation failure. *Management Science, 65*(4), 1909-1925. https://doi.org/10.1287/mnsc. 2017.3005

[50] Xue, L., Mithas, S., and Ray, G. (2021). Commitment to it investment plans: The interplay of real earnings, management, it decentralization, and corporate governance. *Mis Quarterly, 45*(1), 193-224. http://doi. org/10.25300/misq/2021/ 14970.

[51] Zhai, H., Yang, M., and Chan, K. C. (2022). Does digital transformation enhance a firm's performance? Evidence from China. *Technology in Society, 68,* 101841. doi: https://doi.org/10.1016/j.techsoc.2021.101841.

◆ About the Authors ◆

Peinan Ji

Peinan Ji is a Senior Research Fellow at School of Management, Lanzhou University, Lanzhou, China. He holds Ph.D from the School of Management, Harbin Institute of Technology (HIT), Harbin, China. His research interests are IT investment, enterprise informatization and firm performance. His research has been published in international journals such as Journal of Global Information Technology Management, Information Technology and Management, Chinese Management Studies, Technology in Society, Journal of Asia Business Studies and other peer reviewed journals.

Guang Yu

Guang Yu is a professor at School of Management, Harbin Institute of Technology (HIT), Harbin, China. She received her Ph.D in Department of Management Science and Engineering, School of Management, from Harbin Institute of Technology in 2007. Her research interests are information management, information metrology and informatics.

Submitted: April 21, 2022; 1st Revision: May 28, 2022; 2nd Revision: August 28, 2022;
Accepted: September 7, 2022