Information Systems and Firm Competence: Evidence from Chinese Listed Companies

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Information Systems and Firm Competence: Evidence from Chinese Listed Companies

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Abstract: By using unbalanced panel data set for 76 firms in Chinese listed companies, this paper empirically study the relationship between information systems and firm competence under Chinese context with GLS regression method. This study draws such conclusions: (1) in the short term, the use of information systems has statistically significant negative impact on firm competence; in the relative long term, as year by year, such negative influence decreases gradually, and shows U shape relationship. In the long term, the use of information systems has statistically positive impact on firm competence.

Keywords: Information technology, Information systems, Competence, Empirical research, GLS

1.  INTRODUCTION

In 2010, The Chinese government determines to promote seven new strategic industries during the “12th five-year-planning”, which are new generation IT industry, high-tech equipment manufacturing industry, energy-saving and environmental protection industry, new energy industry, new material industry, new energy car industry, and biology industry. The great development of new generation IT, internet, and e-business will bring great potential applications for management information systems, which will definitely generate profound influence for future business model and management.

Since mid 1990s, the economy of USA begins to revive, firms in USA begin to invest IT rush. Empirical studies made by American researchers found that IT (IS) can significantly improve operational performance. While on the relationship between IT (IS) and firm profitability, on whether IT (IS) can improve firm competence and bring competitive advantages, there are controversy both in theories and empirical studies [1]. Since 2005, by using corporate financial data and statistical and econometric techniques, some Chinese researchers conducted empirical study on such controversial problems. While research methods of those related literatures are not rigorous, and research conclusions are not identical, so there are many problems left to be further researched and tested. Based on such above reasons, by using Chinese listed company data, by using econometric techniques and controlling year, industry, ownership, capital and labor, this paper try to empirically study this problem under Chinese context.

2.  LITERATURE REVIEW AND RESEARCH HYPOTHESIS

On the relationship between IT (IS) and competence and profitability, there are controversy both in theories and empirical studies. Some competitive theories, such as bad management theory, time lag theory, profit reallocation theory, and IT resource theory, try to explain the relationship of IT (IS) and competence and profitability. In empirical studies, research conclusions made by early and recent empirical literatures are not consistent. Before the mid 1990s, some empirical studies by western scholars found that there is negative relationship between IT (IS) and profitability. For example, empirical study by Brynjolfsson and Hitt (1996)
found that IT investment can not improve firm profitability significantly \(^2\). By using data set from American banking industry, Prasad and Patrick (1997)’s empirical study found that IT investment does not improve firm competence (measure by ROA and ROE) significantly \(^1\).

Many Chinese scholars and institutions argue that IT application level of most Chinese native enterprises is at a lower stage of development and fall behind western firms, so Chinese native enterprises may experience IT investment return dilemma at an early stage of IT (IS) application. We think that IT application level of most Chinese native enterprises is at a lower stage of development, and these enterprises lack relative IT application experience and knowledge, in a short term, competence of Chinese listed companies probably become weak since use of IS. Because large IS project is high risk, not only require large investment capital, but also require excellent project management abilities. In a word, we propose the first research hypothesis:

**H1:** In the short term, the use of information systems has statistically significant negative impact on firm competence (measured by ROA and ROE).

Since mid 1990s, the economy of USA begins to revive, firms in USA spend lots of money in investing IT (IS) about the same period, and empirical studies made by American scholars found that there is significantly positive relationship between IT (IS) and firm competence. For instance, Hitt, Wu and Zhou (2002)’s empirical study found that ERP investment significantly increase corporation’s ROA and ROE \(^4\). An empirical study by Brynjolfsson and Hitt (2003) also found that IT investment significantly enhance list companies’ ROA and ROE \(^5\).

Since 2005, some Chinese researchers conducted empirical study on IT (IS) and firm profitability (competence), but research conclusions are not identical. By using statistical match method and one year data of 70 firms, WANG and ZHANG (2007) found that ROA and ROI of those companies implemented ERP are significantly improved \(^6\). By using OLS technique and five years of unbalanced panel data from Chinese listed companies, LIN et al (2007) found that IT investment can significantly increase main operation margins \(^7\). By using GLS method and five years of balanced data from Chinese listed companies, LI and WU found that IT investment does not significantly enhance ROA and ROE \(^8\). By using four years of data for 92 firms in Chinese listed companies, ZHAO, HUANG, and PU found that there is no significant improvement in rate of return on invested capital for those companies that have implemented ERP \(^9\).

For the above mentioned controversy in theories and empirical studies, we try to propose a theoretical explanation based on Nolan (1976)’s IT stage theory, bad management theory, and time lag theory: IT stage theory by Nolan (1976) insists that IT (IS) application is an organizational learning process and gradual development process from primary stage to advanced stage, in order to sufficiently realize IT investment return, organizations should effectively control every stage it is in. At the early stage of IT (IS) development, because the lack of related IT experience and IT knowledge, generally speaking, it need a long time for firms to learn to use IT improving competence and profitability. While with the accumulation of IT knowledge, the deepening of IT application, and the learning curve effect, in the long term information systems use will increase firm competence and profitability.

Based on such mentioned above analysis, we propose the following second research hypothesis:

**H2:** in the short term, the use of information systems has statistically significant negative impact on firm competence; in the relative long term, as year by year, such negative influence decreases gradually, and shows U shape relationship. In the long term, the use of information systems has statistically positive impact on firm competence.

### 3. RESEARCH MODEL
3.1 Econometric model for testing H1

Based on referring related literatures, we design such blow econometric model to test H1:

\[ \text{competence} = \beta_0 + \beta_1 \text{use} + \beta_2 \ln K + \beta_3 \ln L + \beta_4 \text{state} + \beta_5 \text{industry} + \beta_6 \text{year} + \varepsilon \]  

(I)

In econometric model (I), \( \beta_0 \) is intercept term, \( \varepsilon \) is error term, \( \text{use} \), \( K \), and \( L \) are explanatory variables; \( \text{state, industry, and year} \) are control variables, \( \text{competence} \) are explained variable. In empirical study literatures ROA and ROE are always used to measure firm competence and profitability. We follow this study tradition. Both ROA and ROE are the same kind indicator, which means resource profitability. Assets in ROA are from company’s own resource and other people’s resource, while equity capital in ROE is from stockers’ investment resource, which belongs to company’s own resource. If financial leverage is reasonable, firms care ROE generally, otherwise ROA. Both ROA and ROE is financial ratio, which is positive or negative.

The definitions and details of each variable in the econometric model (I) are as below:

- \( \text{use} \): Dummy variable, \( \text{use}_j \) means a firm had used information systems for \( j \) year, \( j=0,1,\ldots,5 \). We set five dummy variable for the variable \( \text{use} \), and we set \( \text{use}0=0 \). We predict those coefficients of \( \text{use} \) are negative.

- \( K \): Material capital, fix asset is used to measure \( K \). We predict the coefficient of \( \ln K \) is negative.

- \( L \): Labor capital, (accrued wages + accrued welfare) is used to measure \( L \). We predict the coefficient of \( \ln L \) is positive.

- \( \text{state} \): Dummy variable, \( \text{state}=1 \), private company=0.

- \( \text{industry} \): Dummy variable, we use the class industry classification of China Securities Regulatory Commission (CSRC). We totally set 11 \( \text{industry} \) dummy variables, which are oil, chemistry, plastics, and plastic material (C4), electronics (C5), metal and none metal (C6), food and drink (C0), medicine and biological products (C8), mining and digging (B), electric power, gas, and water (D), transportation and storage (F), IT (G), wholesale and retail (H), real estate (J), mechanics, equipment, and instrument (C7). We set C7 as reference industry.[10]

- \( \text{year} \): Dummy variable, the data set of our sample is from 1995 to 2007, totally span 13 years, we set 1995 as reference year, totally including 12 \( \text{year} \) dummy variable[10].

3.2 Econometric model for testing H2

Based on referring related literatures, we design such blow econometric model to test H2:

\[ \text{competence} = \beta_0 + \beta_1 \text{use} + \beta_2 \text{use}^2 + \beta_3 \ln K + \beta_4 \ln L + \beta_5 \text{state} + \beta_6 \text{industry} + \beta_7 \text{year} + \varepsilon \]  

(II)

In the econometric model (II), the variables \( \text{use, use}^2, \ln K, \) and \( \ln L \) are explanatory variables. We especially focus on the coefficient \( \beta_1 \) of \( \text{use} \) and the coefficient \( \beta_2 \) of \( \text{use}^2 \). The marginal effect of information systems use on firm competence is \( \beta_1 + 2\beta_2 \text{use} \), three cases will arise in the regressions: ① if both \( \beta_1 \) and \( \beta_2 \) is significant, and \( \beta_1 + 2\beta_2 \ln K \geq 0 \), then it shows that information systems use is positively and significantly associated with firm competence, otherwise it is negatively and significantly associated with firm competence; ② if only one of \( \beta_1 \) and \( \beta_2 \) is significant, then whatever \( \beta_1 + 2\beta_2 \ln K \geq 0 \) or \( \beta_1 + 2\beta_2 \ln K \leq 0 \), we can not confirm that information systems use is positively or negatively and significantly associated with firm competence; ③ if both \( \beta_1 \) and \( \beta_2 \) is not significant, then information systems use is not significantly associated with firm competence.

The definitions and details of each variable in the econometric model (II) are as below:

- \( \text{use} \): The variable \( \text{use} \) is 0 and natural number, \( \text{use}=0,1,2,\ldots,12; \text{use}=0 \) means a firm had used information systems for 0 year, \( \text{use}=1 \) means a firm had used information systems for 1 year, \( \text{use}=3 \) means a firm had used information systems for 3 year, and so on; in our research sample, \( \text{use} \in [0,12] \). We predict the coefficient of \( \text{use} \)
is negative.

$use^2$: This variable means the square of the variable $use$; it measures U shape or inverse U shape relationship between information systems and firm competence. We predict the coefficient of $use^2$ is positive.

The definition of $K, L, state, industry,$ and $year$ is the same as in the econometric model (I), i.e. identical to the definition of the paragraph 3.1. We predict the coefficient of $\ln K$ is negative, and the coefficient of $\ln L$ is positive.

4. RESEARCH DESIGN

4.1 Sample selection

For sample selection, we refer to the reference literature [10].

4.2 Data source

We download related financial data (such as balance sheet, income statement, corporate governance) of Chinese listed companies from RESSET Finance Research Database. Our data set period from RESSET is up to 2008-12-31. For data period limitations, we totally collect related data of 76 listed companies. In those 76 listed companies, the shortest data period is only 2 years magnitude, the longest is 13 year magnitude, only two companies’ data period beyond 10 years, most data period are among 4~6 years magnitude and from 1999 to 2005 year. The data set is unbalanced panel data, totally about 400 observations [10].

4.3 Research method

Our data set is unbalanced panel data of 76 firms from Chinese listed companies; most data period are 4~6 years, totally forming about 400 observations. In panel data, not only maybe exist heteroscedasticity, but also maybe exist autocorrelation, whichever situation exists, using OLS will be bias. So we will use GLS to regress the data set for testing H1 and H2. We use STATA10.1 to execute regression.

5. EMPIRICAL ANALYSIS

5.1 The descriptive statistics

<table>
<thead>
<tr>
<th>statistics</th>
<th>use</th>
<th>use1</th>
<th>use2</th>
<th>use3</th>
<th>use4</th>
<th>use5</th>
<th>lnK</th>
<th>lnL</th>
<th>ROA</th>
<th>ROE</th>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.609</td>
<td>2.454</td>
<td>-.369</td>
<td>-2.045</td>
</tr>
<tr>
<td>max</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>17.667</td>
<td>13.289</td>
<td>.358</td>
<td>1.281</td>
</tr>
<tr>
<td>median</td>
<td>2</td>
<td>.204</td>
<td>.191</td>
<td>.163</td>
<td>.138</td>
<td>.108</td>
<td>11.445</td>
<td>7.912</td>
<td>.046</td>
<td>.134</td>
</tr>
<tr>
<td>mean</td>
<td>2.525</td>
<td>.403</td>
<td>.394</td>
<td>.370</td>
<td>.346</td>
<td>.311</td>
<td>1.551</td>
<td>1.614</td>
<td>.060</td>
<td>.186</td>
</tr>
</tbody>
</table>

The below Table 1 is about the descriptive statistics of related key variables. The variable $ownership, year,$ and $industry$ are control variables. For simple, it is not necessary to list them.

5.2 The correlation matrix

In the Table 2, as we can see, $\ln K$ is significantly and positively correlated with $\ln L$, $use_4$ and $use_5$ is significantly and positively correlated with $\ln L$. The result shows that information systems use is significantly associated with increase in human capital investment. In the Table 3, $use$ is significantly and positively
correlative with \( \text{use}^2 \); \( \text{use} \) is significantly and positively correlative with \( \ln L \). The result also indicates that IT (IS) use is significantly associated with increase in human capital investment, and accordingly causing human resource skills improvement.

An exploratory study by Hitt and Brynjolfsson (1997) also found that IT investment is significantly and positively associated with organizational behavior (such as decision, incentives, and human capital) \(^{[11]}\). The correlation matrix results of the Table 2 and the Table 3 provide preliminary evidence for the complementarities of information systems use and human capital investment.

### Table 2. The correlation coefficients matrix of explanatory variables

<table>
<thead>
<tr>
<th></th>
<th>use1</th>
<th>use2</th>
<th>use3</th>
<th>use4</th>
<th>use5</th>
<th>lnK</th>
<th>lnL</th>
</tr>
</thead>
<tbody>
<tr>
<td>use1</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use2</td>
<td>0.2456***</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use3</td>
<td>-0.2233***</td>
<td>-0.2146***</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use4</td>
<td>-0.2024***</td>
<td>-0.1945***</td>
<td>-0.1769***</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use5</td>
<td>-0.1759**</td>
<td>-0.1691**</td>
<td>-0.1538**</td>
<td>-0.1394*</td>
<td>1.0000</td>
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<td></td>
</tr>
<tr>
<td>lnK</td>
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<td>0.0321</td>
<td>0.0532</td>
<td>0.0553</td>
<td>0.0132</td>
<td>1.0000</td>
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<tr>
<td>lnL</td>
<td>-0.0545</td>
<td>-0.0052</td>
<td>0.0429</td>
<td>0.0984*</td>
<td>0.0883*</td>
<td>0.5784***</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Note: ***p<1%; **p<5%; *p<10%.

### Table 3. The correlation coefficients matrix of explanatory variables

<table>
<thead>
<tr>
<th></th>
<th>use</th>
<th>use^2</th>
<th>lnK</th>
<th>lnL</th>
</tr>
</thead>
<tbody>
<tr>
<td>use</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>use^2</td>
<td>0.9052***</td>
<td>1.0000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lnK</td>
<td>0.0474</td>
<td>0.0128</td>
<td>1.0000</td>
<td></td>
</tr>
<tr>
<td>lnL</td>
<td>0.1117***</td>
<td>0.0602</td>
<td>0.5784***</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Note: ***p<1%; **p<5%; *p<10%.

### 5.3 The regression results and analysis

Firstly, we execute Hausman test (the test results are listed in the last row of the Table 4 and Table 5). Secondly, we choose RE or FE model according to the Hausman test result. Finally, we use GLS method to regress ROA and ROE respectively. The correlation coefficient of ROA and ROE is 0.8575, \( P=0.0000 \), so both ROA and ROE can be substituted for each for robust test. The regression results are summarized in the Table 4 and Table 5. The following is a brief analysis.

As we can see in the Table 4, the regression results for ROA and ROE is similar. In the Table 4, for ROA and ROE, the coefficients of \( \text{use1} \sim \text{use5} \) is significantly negative, the significance level of Wald \( \chi^2 \) is less than 1%; so we can conclude that from the 1st year to the fifth year since information systems use, the ROA and ROE of the sample companies decrease significantly and statistically. For ROA in the Table 4, the coefficients of \( \text{use1} \sim \text{use5} \) is among \([-0.017, -0.057]\), that is to say, in the case of other conditions remain unchanged, from the 1st year to the 5th year since information systems use, the decrease scope of ROA is from 1.7% to 5.7%. For ROE in the Table 4, the coefficients of \( \text{use1} \sim \text{use5} \) is among \([-0.059, -0.105]\), that is to say, in the case of other conditions remain unchanged, from the first year to the fifth year since information systems use, the decrease
The marginal revenue.

In the case of other conditions remain unchanged, the marginal effect of information systems use on ROA is\( \beta_2+2\beta_3\times use=-0.0125+2\times 0.0014\times use=-0.0125+0.0028\times use\), if\( use=1, 2, 3, 4, 5\), then the marginal effect number is\(-0.0097, -0.0069, -0.0041, -0.0013, 0.0015\), that is to say, when using information systems for 1, 2, 3, 4, and 5 year, the change scope of ROA respectively is\(-0.97\%, -0.69\%, -0.15\%, -0.13\%, 0.15\%\), which displays increasing marginal revenue. From the first year to the fourth year since information systems use, ROA of the 76 listed companies significantly decreases. The infection point begins at\( use=5\), i.e. to begin at the fifth year, information systems use have significantly positive influence on ROA. So in the long term, information systems use is significantly and positively associated with ROA. In the samples constitution,\( use \in [2,12]\). For most samples\( use \in [4,6]\), therefore we can be optimistic for such above regression results.

We would like to point out that the numerical numbers of ROA and ROE based the Table 4 are different from the Table 5, this is because for the variable information systems, we use different measure approach in the econometric (I) and (II), yet the regression results are similar. We only focus the positive and negative direction and significance level of the coefficients of the key variable\( use\), instead of detail regression figures.

## 6. EMPIRICAL RESULTS DISCUSSION

By using Chinese listed companies, this paper empirically prove the two hypotheses we propose. Our empirical study find that in the short term, the use of information systems has statistically significant negative
impact on firm competence, while in the long term information systems use has statistically significant positive impact on firm competence. Based on time lag theory, bad management theory, and Nolan’s IT stage theory, and considering Chinese context, we propose such below theoretical explanations:

At the introductory stage and growth stage of enterprise informatization, the IT capital stock of the whole economy is still small, firms lack relevant experience and knowledge, so firms can not implement and manage IT project effectively; and because of learning curve, time lag may happen more possibly. For the above reasons, in the short term, firm may not obtain significant IT investment return since the use of information systems. At the maturation stage of enterprise informatization, the IT capital stock of the whole economy enlarges, and with the increase of experience, the accumulation of knowledge, and the deepening of IT application, firms will be able to manage IT investment more effectively, to reduce the influence of time lag, and thus to realize IT investment more rapidly.

Our empirical study suggests that IT investment return experience of Chinese firms is similar to those firms in western developed countries: at the early stage of informatization, firms realize IT investment hardly; at the later stage of informatization, firms can gain significant IT investment return. While IT payback period of Chinese listed companies obviously shorten, which indicates that with the rapid spread and diffuse of IT application and IT knowledge around the globe, firms in underdeveloped countries can utilize IT experience and IT knowledge of developed countries to achieve IT investment return rapidly, and finally gain potential competitive edges.

By using data of over 800 firms in Zhejiang province, WANG, ZHANG, and ZHOU found that enterprise informatization can significantly improve firm competence (measured by ROA) \cite{12}. By using data set of Chinese listed companies, our empirical study also finds that in the long term information systems can significantly improve firm competence (measured by ROA and ROE). Such above empirical results demonstrate that for Chinese firm at the primary stage of informatization, information systems can improve firm competence and profitability.

We put forward the above theoretical explanations for the relationship between information systems and firm competence under Chinese context. As for the more convincing theory, we need further investigation and research.

7. CONTRIBUTIONS AND CONCLUSIONS

This paper's contributions are as follow: (1) By using data set from Chinese listed companies and controlling the influence of capital, labor, industry, year, and ownership, this article conduct empirical study on the relationship between information systems and firm competence under Chinese context; (2) By now as for the IT (IS) measurement, existing empirical studies either use real investment magnitude, or use dummy variable, while this paper use another new measurement approach in econometric model (II), which may provide helpful reference for future empirical research.

This empirical study draws such two conclusions: (1) in the short term, the use of information systems has statistically significant negative impact on firm competence (measured by ROA and ROE). (2) In the short term, the use of information systems has statistically significant negative impact on firm competence; in the relative long term, as year by year, such negative influence decreases gradually, and shows U shape relationship. In the long term, the use of information systems has statistically positive impact on firm competence.

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REFERENCE