The Association of Structure to Performance in the IoT Industry: Comparison between Taiwan and China

柯瓊鳳
（東呉大学准教授）

林志芳
（シニアスペシャリスト EDOM テクノロジー株式会社）

Chiung-Feng KO
Associate Professor, Soochow University

Chih-Fang Lin
Senior Specialist, Edom Technology Co., Ltd.

This research uses the Multiple Linear Regression method on the IoT sectors of Taiwan and China to determine which category and what financial ratios have the strongest association to IoT industrial performance. Across IoT companies in Taiwan, companies producing T2T products have higher performance than that of those producing H2H products. The result is similar in China, with T2T and T2H having better operational results than H2H. These companies are increasing operational efficiency by adding digital services and innovations to their product mix. China can generate enormous economies of scale as the urban population grows and the middle class expands, this gives Chinese companies a distinct advantage in the development and deployment of IoT applications.

I. Introduction

1. The Development of the IoT Industry

The term Internet of Things (Hereinafter referred to as IoT) was first used by Kevin Ashton during a presentation at Procter & Gamble (P&G) in 1999. Dobbs, et al. (2015) contend IoT is a digitizing of the physical world. They define the IoT as sensors and actuators connected by networks to computing systems, allowing these systems to monitor or manage the health and actions of connected objects and machines. Connected sensors can also monitor the natural world, people, and animals. Tarng (2015) defines the IoT as service systems which consist of embedded intelligence networking sensors. After receive messages via a communication network, the systems can manage and analyze, and then respond, giving feedback and services automatically.

According to McKinsey, the economic value of IoT could be anywhere between USD 3.9 trillion to 11.2 trillion by 2025. In the IoT environment, all objects are instrumented, interconnected and interacted with each other intelligently. Three communication patterns co-exist : namely human-to-human (H2H), human-to-thing (H2T), and thing-to-thing (T2T) (Lu et al., 2014)

In essence, the Internet of Things (IoT) is designed to track, monitor, and intelligently manage an item by embedding an identifier that can store object information on the item. The ultimate goal of the IoT is to facilitate the communication of information between people and things, thereby enhancing the welfare of a society.

2. Key Technology in the Development of IoT

The industrial networking infrastructure of IoT can be broadly divided into three layers : the perception layer, the network layer, and the application layer. Ko and Chang (2017) investigated the industrial links of IoT in Taiwan and China. They found that with regard to industry supply chain, the IoT in upstream enterprises in Taiwan has a significant effect, while the upstream and midstream segments achieve significant results in China. Driven by nation policy, China has accelerated the development of the IoT industry, and this has resulted in positive outcomes of utilizing IoT technology.

The IoT era emphasizes highly integrated and diversified applications. Its industrial operation mode is a horizontal division of labor and vertical integration in parallel. Here, the “things” of IoT include not only immobile devices, but also mobile devices (e.g., mobile phones and tablets).

There are many examples of this. China’s Sogou search engine has online voice input method and voice error correction, using search technology and information. Using the Jingdong super app, Jingdong Weilian allows the harmonization and unified control of data from different smart systems, facilitating the voice control of smart products and smart shopping. Microsoft China uses the cloud-developed BotFrameWork to help users connect robots to other systems (50cnnet, 2016).

Zhan (2015) describes that there are four Network Layers of IoT Architectures, sensor-connected IoT devices : (e.g., Hardware, OS, sensor), network transmission (e.g., 4G, 5G, DSL, NFC), information collection, and application services, mainly in value-added services.

Lin (2011) stated that among IoT industry applications in general, the interaction between people and things can be divided into four communication patterns : thing-to-human (T2H) ; human-to-human (H2H) ; thing-to-thing (T2T) ; and human-to-thing (H2T) (Figure 1). T2H means information collected by the object will be transmitted to humans, H2H refers to conversations or file transfers between people, T2T refers to the direct transmission of information between objects, H2T refers to the transmission of information from people to a machine (or object). The developed flow of the IoT can be traced from T2H, started by using contents and e-commerce through communication between people and Web servers, then SNS appeared on

H2H, after that, applications and solutions of the intelligent sensors used for M2M increased substantially.

In the case of T2T, POS terminals may be used to manage the inventory and sales of vending machines, environmental observation cameras may be used for remote monitoring, and environmental sensors installed in 4G modules may be used to collect weather information in the cloud. In the case of H2T, for instance, e-Health is the use of ICT (Information and Communication Technology, ICT) for health. By the definition of WHO, e-Health encompasses multiple interventions, including telehealth, telemedicine, mobile health (mHealth), electronic medical or health records (eMR/eHR), big data, wearables, and even artificial intelligence (AI). Pasha and Shah (2018) showed that interoperability between different IoT devices, standards, and protocols in a smart health system could be attained by a specialized gateway device among different web technologies.

In China thing-to-thing (T2T) is often referred to as Machine to Machine (M2M). The Chinese government has played a pivotal role in IoT, especially in M2M related fields. Telecom operators are engaging with smart-city projects, enlarging their M2M and IoT businesses. Mobile operators have advanced sophisticated M2M service propositions with devoted vertical platforms for specific application areas, such as the automotive sector or health care. China leads the world in the adoption of M2M services, with 74 million connections at the end of 2014, representing almost a third of the global base (Bouverot, 2015).

FIGURE 1. Four Communication Patterns of IoT

The interactions between humans and things

(Human)

(Things)	H2T Transmission of information from people to a machine	H2H Direct communication between people	(Human)
	T2T Direct transmission of information between Things	T2H Machines gather information and transmit to humans	

(Things)

Source : Lin (2011.10.28), Department of Industrial Technology (DoIT), Ministry of Economy Affairs (MOEA)

3. Motivation

Dobbs et al. (2015) outlined nine major areas of IoT applications, and noted they are expected to constitute $3.9 trillion to $11.1 trillion per year by 2025. In order to join this massive market, many companies have begun to invest in IoT related industries. However, there is still a lack of relevant data with which to assess the performance of the IoT industry.

In addition, the development strategy for the IoT in Taiwan is less ambitious than China. This poses the question : do IoT enterprises in Taiwan have any differences with Chinese enterprises?

IoT deployments are costly to install, manage and maintain, and need to provide a very clear value to justify the investment to investors and creditors. Although large scale enterprises continue investing in IoT applications, can they show more effectiveness that other forms of enterprise in terms of scale and operational efficiency? (Silva and Maló, 2014).

In recent years, due to different R&D technologies and applications, the four fields of IoT industires discussed above have not developed evenly. In which of these fields has the application of IoT shown the best results? All of the above issues still require data to validate, and it is hoped this research will help provide such data.

In this study, we use multiple regression analysis to determine the performance of the IoT industry and discuss with what financial variables can explain the performance of the IoT industry. In addition, with ambitious government plans for IoT, China is poised to take a leading role in global M2M (i.e., T2T) development. Is there any variance between the four areas of IoT that justify this emphasis? Also, this study compares the developing performance of the IoT on both sides of the Straits of Taiwan, and examines whether the size of the enterprise is an influence on performance factors.

4. Purpose

By the statistics data of MOEA, the global export of ICT products accounted for 11.9% of the total export in 2015, of which Taiwan accounted for the highest proportion at 39.5%. In addition, China, South Korea, and Japan are 26.6%, 21.7%, 8.5%, respectively. The ICT industry is the leading industry in Taiwan's economy and has a large presence worldwide. In order to enhance the competitiveness of IT technology, China vigorously supports its IT industry. Given the uncertainty about the initial investment performance of ICT, the valuation factors such as financial structure, operational capabilities and supply chain management are critical.

Based on the issues raised in the motivations, this research investigates financial variables that affect the performance of IoT industries by multiple regression analysis of the IoT sectors of Taiwan and China. In this study, IoT related companies are divided into three types : H2H, T2H, and T2T, according to the proportion of major products of their enterprise[1]. The purpose of this study is to answer the following questions : (1) What financial variables will affect the performance of enterprises in the development of IoT? (2) Does the type of IoT application have an influence on a company's performance? and (3) Is IoT industry performance better the larger the scale of the company?

2. Literature Review

1. Industrial Structure and Performance

Industrial structure refers to the characteristics and distribution of firms in the industry. The main variables include the scale of the firms, the differentiation of commodities, the vertical division of labor, capital intensity, etc. (Shepherd and Shepherd, 2004 ; Kranenburg and Hogenbirk, 2006)

Bain (1956) argues that the "Structure-conduct-performance (SCP)" theory assumes that the industrial structure will affect the market and thus the performance of the business. However, other scholars believe that business performance and market behavior will also affect the industrial structure (Baumol et al., 1982 ; Wirth and Bloch, 1995).

In addition, some scholars (Wernerfelt, 1984 ; Barney, 1991) put forward the Resource-Based Theory. They conduct that the main cause of influence on firm's performance is the attribution of the manufacturer itself. Some firms offer certain unique products or services to create performance. Because the resources owned by the manufacturer are valuable, scarce, irreplaceable, and difficult to be imitated, the manufacturer can enhance its competitiveness (Short et al., 2006).

2. Indicators of performance

Scholars have proposed a number of different indicators that can be used to measure performance, both for companies in general, and specifically for IoT industries. Venkatraman and Ramanujam (1986) proposed three measures of business performance : Financial Performance, Business Performance, and Organization Performance. Comiskey (1982) and Levitske (1994) both argue that from the perspective of creditors, indicators such as liquidity and solvency focus on the expression of operating cash flows, and are important indicators of performance. From the investor's standpoint, financial information can be used as an indicator of the company's future operating conditions.

Tomaz and Danijel (2005) measured the operating performance separately from the financial and non-financial indicators. The financial performance used ROE, ROA, and the net profit rate. The non-financial performance was based on the turnover rate of employees and the ratio of employee education and training expenses to total expenses.

In IoT industry supply chain, Ko and Chang (2017) divided the IoT industry into upper, middle and lower streams and studied the profitability of the IoT industry. The empirical results showed that the IoT industrial chain has produced significant results in upper and middle stream industries. Afzhan (2016) proposed the number of patents relating to IoT as one of the observable factors in assessing performance.

To sum up, most scholars focus on financial indicators (Table 1). Therefore, this study only considers the most commonly cited financial indicators such as return on assets (ROA), return on equity (ROE), and Tobin's Q.

Table 1 : Summary of Performance measures

Author	Year	Performance Measurement Indicators
Tomaz and Danijel	2005	ROA, ROE, net income ratio
Short et al.	2006	ROA
Shepherd and Shepherd ; Kranenburg and Hogenbirk,	2004 2006	Scale, labor, capital intensity, et al.
Afzhan	2016	number of patents
Ko and Chang	2017	ROE, ROA

Source : Made by authors based on the above cited literatures.

3. Research Methods

1. Scope of Study

(1) Study Period and Subjects

Based on the concepts of the SCP model, this paper investigates the companies listed in the base category of IoT set by the MONEY DJ financial website for Chinese and Taiwanese companies on 31 March 2016. The research includes 109 listed companies in Taiwan and 138 listed companies in China. The study period is from September 2010 to September 2015 and quarterly data is used. All of the basic information and financial information of Taiwanese, and Chinese companies was obtained from the Taiwan Economic Journal (TEJ) financial data base.

(2) Study variable definitions and indicators

First, all companies on the Money DJ website Internet of Things company list were chosen as samples for this research. The enterprises were then classified into 3 different types, based on the highest proportion of their major products : H2H, T2H, and T2T. As existing applications of H2T are still in the startup stage, no observable samples were found. H2T applications are primarily related to medical equipment, and there are at present no medical institutions on either side of the Taiwan straits operating as OTC traded companies.

Accordingly there were no H2T samples found for this study. As mentioned above, H2T is to collect human information and send it back to the machine (object), while there are many different IoT technology frameworks that can be implemented in smart health systems, most are in the experimental stage and not yet developed well enough for mass production.

We then analyze the company's performance based on the company's management ability, financial structure, solvency and industrial structure.

Table 2 : IoT Companies Type and Region

Unit : number of companies

Type \ Territory	Taiwan	China	Total
H2H	21	6	27
H2T	0	0	0
T2H	20	36	56
T2T	68	96	164
Subtotal	109	138	247

Note : H2H - Communication between people using devices, for example mobile phones, computer communications software etc.

H2T - The information collected from people and then sent to a device, for example medical equipment.

T2H - Items collect information, and transmit it to people, for example smart appliances.

T2T - identical to the M2M concept. Information transmitted between items, for example mobile logistics management, safety monitoring.

The variables discussed in this study are shown in Table 3.

Table 3 : Definitions of Variables

Aspect	Variable	Code	Measurement method/formula
Profitability	ROA	ROA	EBITDA/Total assets
Financial Structure	Debt ratio	LA	Total debts/Total assets
Management Ability	Accounts receivable turnover	RT	Net sales /Accounts receivable
	Total assets turnover	AT	Net sales /Total assets
	% of Cost of Goods Sold	RC	COGS / Net sales
	Inventory turnover	IT	Cost of Goods Sold /Inventory
Solvency	Current ratio	CL	Current assets / Current liabilities
	Cash flow ratio	CR	Net Cash Flow from Operating /Current liabilities
Industrial Structure	size	Log(S)	Logarithm of Net sales
	Capital intensity	CI	PPE / Net sales
	Internet of Things industry type	D1	Dummy variable. D1 = 1 indicates T2T company.
		D2	Dummy variable. D2=1 indicates T2H company.

EBITDA : Earnings before Interest, Taxes, Depreciation, and Amortization

COGS : Cost of Goods Sold
PPE : Property, Plant, and Equipment ; Fixed Assets

2. Research Hypothesis

The Internet of Things is based on the connection of things, and has led to the development of smart technology devices such as smart homes. The development of T2H has been slower than that of T2T due to concerns over data collected from people and its possible misuse to damage the personal rights and interests of individuals.

The focus of government support for IoT has put China at the forefront of global M2M/T2T communications. To attract investment, local government authorities have granted enterprises financial subsidies based on the tax contributions of an enterprise, though such subsidies has been restricted since May 2015 (Ernst & Young, 2016). Because of this, the development of T2T can be expected to be more effective and visible in China.

This study establishes the following first hypothesis.

H1 : In the development performance of IoT industry, the T2T category is better than T2H, and is better than H2H.

At present, smart phones are widely used to integrate with a wide variety of smart devices such as smart homes. Therefore, most of the IoT industry samples in this study are in the electronics industry. Moreover, transnational companies such as Apple, Microsoft, Google, Sony, Samsung, Nike, and Adidas have all produced smart wearable devices, as Murphy-Hoye (2016) and Bennett (2016) point out, and are attempting to vertically integrate into the value chain from top to bottom.

It can be observed in practice that one of the characteristics of the Internet of Things is economies of scale. This study establishes the second hypothesis below.

H2 : In the IoT industry, the larger the scale of the company, the higher the performance.

3. Research Model

Refer to the empirical research conclusions of Levitske (1994), Short et al. (2006) and Tomaz and Danijel (2005) in the existing literature, this study uses a multiple regression model to measure the impact on financial performance of IoT-related enterprises in Taiwan and China. The performance measurement model is as follows :

$$ROA_{it} = \beta_0 + \beta_1 LA_{it} + \beta_2 RT_{it} + \beta_3 AT_{it} + \beta_4 RC_{it} + \beta_5 IT_{it} + \beta_6 CL_{it} + \beta_7 CR_{it} + \beta_8 Log(S)_{it} + \beta_9 CI_{it} + \beta_{10} D_1 + \beta_{11} D_2 + \varepsilon_{it} \quad (1)$$

4. Empirical results and analysis

1. Sample description and descriptive statistics

(1) Sample data analysis

This study uses data from 278 IoT enterprises on both sides of the Taiwan Strait to carry out the empirical study. The study period is from the third quarter of 2010 to the third quarter of 2015 with 5,187 observation data points (Table 4). Due to considerations concerning the comprehensiveness of company financial information, data for OTC companies listed after the third quarter of 2010 was excluded, as they would not produce a full data set for the entire period.

Table 4 : Empirical Sample of IoT Companies

Sample \ Territory	Taiwan		China		Composite	
	No. of companies	No. of observations	No. of companies	No. of observations	No. of companies	No. of observations
No. of original samples	119	2, 499	159	3, 339	278	5, 838
Less : Listed after Q3 in 2010	10	210	21	441	31	651
No. of empirical samples	109	2, 289	138	2, 898	247	5, 187

Due to the different currency measurement units used across the Straits, for the sake of consistency, the selling price of the CNY exchange rate of Taiwan banks at the end of each quarter was used as the basis of comparison.

(2) Statistical analysis

Table 5 provides descriptive statistics for the financial variables that were used in the empirical studies of the IoT industry in Taiwan and China. The return on total assets (ROA) for Taiwan ranges from -0.284 to 0.17. In contrast that of China ranges from -0.09 to 0.611. The mean is 0.027 for Taiwanese companies and 0.013 for those firms in China. This shows Taiwan's profitability is relatively good.

In order to compare the means of two IoT industries across the Straits to see if there is a significant difference, we test the dependent variable on ROA. After t-tests to determine whether there was a difference between the two groups of the means, the result shows that there is a clear difference at the 95% confidence interval (Table 6). It is speculated that the environment and developmental progress of China's IoT industry may lead that of Taiwan, and thus make it more expensive to invest in research and development in IoT. Therefore, the average ROA of Chinese companies is lower than that of Taiwan.

In terms of the financial structure, the mean of debt ratio (LA) is 0.398 for Taiwanese companies and 0.444 for those firms in China, slightly higher than that of Taiwan companies, indicating a higher degree of debt. The mean of inventory turnover (IT) is 2.698 in Taiwan while the average number for Chinese companies is 3.751, which means that Chinese companies have better sales capabilities.

Secondly, in terms of the cash flow ratio (CR), Taiwan's is 0.105 and China's is 0.040, suggesting that Taiwanese companies are more able to pay their current liabilities via cash flows from operating activities. The sample companies with the lowest value in Taiwan were electronic component manufacturers ; those in China with the lowest values provided e-commerce platform development and related promotional activities.

In addition, in terms of capital intensity (CI), Taiwan is 1.437, lower than China's 2.402. It is speculated that Chinese companies rely relatively more on technical and intellectual factors of production. China has a large population and thus a large market and access to key resources, and with the strong support of government policy, its capital input is relatively large.

Table 5 : Descriptive Statistics for Financial Variables

Territory	**Taiwan**				**China**			
Variable	Mean	Minimum	Maximum	Standard Deviation	Mean	Minimum	Maximum	Standard Deviation
ROA	0.027	−0.284	0.170	0.026	0.013	−0.090	0.611	0.022
LA	0.398	0.047	0.871	0.169	0.444	0.010	1.597	0.234

RT	1.952	0.080	88.870	2.872	1.552	0.040	142.010	3.379
AT	0.272	0.020	1.490	0.178	0.163	0.010	2.170	0.124
RC	0.758	0.220	1.619	0.146	0.715	0.021	1.775	0.191
IT	2.698	0.000	114.700	7.635	3.751	0.000	172.370	12.578
CL	2.556	0.432	22.475	2.058	3.248	0.086	190.668	7.580
CR	0.105	−0.759	1.166	0.180	0.040	−2.250	5.043	0.324
LOG(S)	6.4973	4.5056	9.1761	0.8924	6.3342	4.4064	8.5886	0.6316
CI	1.4367	0.0027	17.7821	1.5392	2.4015	0.0000	41.7099	3.6994

Variable Description :

ROA= return on total assets ; LA= debt ratio ; RT= accounts receivable turnover ; AT= total assets turnover ; RC=% of Cost of Goods Sold ; IT= inventory turnover ; CL= current ratio ; CR= cash flow ratio ; LOG(S)=size ; CI= capital intensity.

Table 6 : t-test Result for Mean of ROA between Taiwan and China

Variable	Territory	No. of Observations	Mean	Standard Deviation	Standard Error of the Mean, SEM	*t* Distribution	P Value	Degree of Freedom. (DOF)
ROA	CN	2, 898	0.0127	0.022	0.000	−21.725	0.000	5185.00
	TW	2, 289	0.0274	0.026	0.001			

Before the multiple regression analysis, the samples were analyzed by Pearson’s correlation coefficient. The correlation coefficients between the variables were all less than 0.7, indicating that the variables were not highly collinear and the results were reasonable. In addition, the VIFs of all the variables in this study were less than 10, indicate that there is no collinearity problem in the model. Finally, the DW value of the empirical results is between 1.589 and 1.977, indicating that there is no self-correlation between the residuals.

2. The empirical results

(1) Taiwanese Companies

In terms of overall statistics, debt ratio (LA), accounts receivable turnover (RT), total assets turnover (AT), % of Cost of Goods Sold (RC), inventory turnover (IT), current ratio (CL), cash flow ratio (CR), size (Log(S)), capital intensity (CI) are significantly at the 1% statistical level. However, debt ratio (LA) and % of Cost of Goods Sold (RC) are negatively correlated with the return on total assets (ROA). Table 7 shows Taiwan enterprises are using IoT in digital innovation and to improve operational efficiency, resulting in lower sales costs.

In addition, accounts receivable turnover (RT), total assets turnover (AT), inventory turnover (IT), cash flow ratio (CR), size (Log(S)), capital intensity (CI) are positive correlated with the return on total assets (ROA) in line with the expectations. Corporations with higher profitability have accumulated a high level of earnings, their financial structure is relatively stable, and operational risk is relatively low.

The current ratio (CL) is negatively correlated with the return on assets (ROA). This is contrary to expectations. It is presumed that the R&D expenditure and capital expenditure may have been relatively large, and have not yet recouped the investment they required in the short term. It will take time for this expenditure to come to fruition and produce results.

$$ROA_{it} = 0.051 - 0.034LA_{it} + 0.001RT_{it} + 0.031AT_{it} - 0.094RC_{it} + 0IT_{it}$$
$$-0.004CL_{it} + 0.043CR_{it} + 0.008Log(S)_{it} + 0.002CI_{it} + \varepsilon_{it}$$

Table 7 : Regression Results of IoT Industry in Taiwan

Variable	Expected Correlation	Coefficient	t statistic	P value	VIF
(constant)		0.051	12.397	<0.001***	
LA	−	− 0.034	− 8.907	<0.001***	2.753
RT	+	0.001	3.925	<0.001***	1.099
AT	+	0.031	9.407	<0.001***	2.280
RC	−	− 0.094	− 26.153	<0.001***	1.796
IT	+	0.000	7.029	<0.001***	1.159
CL	+	− 0.004	− 16.897	<0.001***	1.911
CR	+	0.043	16.416	<0.001***	1.454
LOG(S)	+	0.008	14.305	<0.001***	1.799
CI	+	0.002	5.317	<0.001***	1.762
N=2,289	F value= 260.949	Adjusted-R^2=0.508	DW=1.969		

1. Variable Description :

ROA= return on assets ; LA=debt ratio ; RT=accounts receivable turnover ; AT=total assets turnover ; RC=% of Cost of Goods Sold ; IT=inventory turnover ; CL= current ratio ; CR= cash flow ratio ; LOG(S)=size ; CI= capital intensity.

2 . ***/**/* : *indicate significance at the 1%/5%/10% level.*

The empirical results with dummy variables T2T (D1) and T2H (D2) added are shown in Table 8. The D1 and D2 coefficients are both positive. There is a significant positive relationship between T2T (D1) and Asset Return Ratio (ROA), in line with expectations. As can be seen from the empirical results, Taiwan has seen remarkable achievements in the application of direct transmission of information between things in the development of T2T, and the results have increased operating performance.

$$ROA_{it} = 0.05 - 0.034LA_{it} + 0.001RT_{it} + 0.031AT_{it} - 0.093RC_{it} + 0IT_{it}$$
$$-0.004CL_{it} + 0.043CR_{it} + 0.008Log(S)_{it} + 0.002CI_{it}$$
$$+0.002D_1 + 0.002D_2 + \varepsilon_{it}$$

Table 8 : Regression Results of IoT Industry in Taiwan with T2T (D1) and T2H (D2) Dummy Variables Added

Variable	Expected Direction	Coefficient	t statistic	P value	VIF
(Constant)		0.050	12.110	<0.001***	
LA	−	− 0.034	− 8.650	<0.001***	2.851
RT	+	0.001	4.024	<0.001***	1.103
AT	+	0.031	9.326	<0.001***	2.299
RC	−	− 0.093	− 25.629	<0.001***	1.832
IT	+	0.000	7.079	<0.001***	1.162
CL	+	− 0.004	− 17.019	<0.001***	1.930
CR	+	0.043	16.448	<0.001***	1.457
LOG(S)	+	0.008	13.623	<0.001***	1.873
CI	+	0.002	5.036	<0.001***	1.792
D1		0.002	1.953	0.051*	1.778

D2		0.002	1.586	0.113	1.694
Num.obs=2,289 F value= 214.071 Adjusted-R^2=0.506 DW=1.977					

1. Variable Description :
ROA= return on assets ; LA=debt ratio ; RT=accounts receivable turnover ; AT=total assets turnover ; RC=% of Cost of Goods Sold ; IT=inventory turnover ; CL= current ratio ; CR= cash flow ratio ; LOG(S)=size ; CI= capital intensity ; D1=T2T ; D2=T2H。
2 . ***/**/* : *indicate significance at the 1%/5%/10% level.*

(2) Chinese Companies

As can be seen in Table 9, debt ratio (LA), total assets turnover (AT), % of Cost of Goods Sold (RC), cash flow ratio (CR), size (Log(S)) are significantly at the 1% level. The empirical coefficients of each variable are also consistent with the expected directions. This shows that the larger the scale of a business, the lower the cost of sales, the better operating margins, and the better the profitability.

$$ROA_{it} = 0.013 - 0.018LA_{it} - 0RT_{it} + 0.057AT_{it} - 0.04RC_{it} - 0IT_{it} + 0CL_{it}$$
$$+0.022CR_{it} + 0.004Log(S)_{it} + 0CI_{it} + \varepsilon_{it}$$

Table 9 : Regression Results of IoT Industry in China

Variable	Expected Correlation	Coefficient	t statistic	P value	VIF
(Constant)		0.013	3.219	0.001***	
LA	−	− 0.018	− 8.949	<0.001***	2.020
RT	+	− 0.000	− 1.622	0.105	1.099
AT	+	0.057	17.023	<0.001***	1.634
RC	−	− 0.040	− 19.080	<0.001***	1.491
IT	+	− 0.000	− 1.380	0.168	1.072
CL	+	0.000	0.187	0.852	1.247
CR	+	0.022	21.059	<0.001***	1.063
LOG(S)	+	0.004	6.095	<0.001***	1.695
CI	+	0.000	0.642	0.521	1.358
N=2,898 F value= 196.411 Adjusted-R^2=0.378 DW=1.589					

1. Variable Description : ROA= return on assets ; LA=debt ratio ; RT=accounts receivable turnover ; AT=total assets turnover ; RC=% of Cost of Goods Sold ; IT=inventory turnover ; CL= current ratio ; CR= cash flow ratio ; LOG(S)=size ; CI= capital intensity
2 . ***/**/* : *indicate significance at the 1%/5%/10% level.*

The empirical results with dummy variables T2T (D1) and T2H (D2) added are shown in Table 10. The D1 and D2 coefficients are both positive and significantly at the 1% level. This shows that China is effectively developing both T2T and T2H IoT industries, possibly indicating Chinese enterprises are at a more mature stage of IoT commercial development.

$$ROA_{it} = 0.007 - 0.017LA_{it} - 0RT_{it} + 0.062AT_{it} - 0.043RC_{it} - 0IT_{it} + 0CL_{it}$$
$$+ 0.021CR_{it} + 0.004Log(S)_{it} - 0CI_{it} + 0.01D_1 + 0.005D_2 + \varepsilon_{it}$$

Table 10 : Regression Results of IoT Industry in China with T2T (D1) and T2H (D2) Dummy Variables Added

Variable	Expected Correlation	Coefficient	t statistic	P value	VIF
(Constant)		0.007	1.553	0.121	
LA	−	− 0.017	− 8.679	<0.001***	2.025
RT	+	− 0.000	− 1.417	0.157	1.102
AT	+	0.062	17.889	<0.001***	1.736
RC	−	− 0.043	− 20.321	<0.001***	1.583
IT	+	− 0.000	− 0.948	0.343	1.078
CL	+	0.000	0.894	0.372	1.297
CR	+	0.021	20.766	<0.001***	1.067
LOG(S)	+	0.004	5.750	<0.001***	1.802
CI	+	− 0.000	− 0.348	0.728	1.382
D1		0.010	5.991	<0.001***	5.538
D2		0.005	3.012	0.003***	5.621
N=2,898	F value= 169.418	Adjusted-R^2=0.390	DW=1.602		

1. Variable Description :

ROA= return on assets ; LA=debt ratio ; RT=accounts receivable turnover ; AT=total assets turnover ; RC=% of Cost of Goods Sold ; IT=inventory turnover ; CL= current ratio ; CR= cash flow ratio ; LOG(S)=size ; CI= capital intensity ; D1=T2T ; D2=T2H。

2 . ***/**/* : *indicate significance at the 1%/5%/10% level.*

5. Conclusions

1. Analysis conclusions

The development of the Internet of Things has drawn the attention of governments and enterprises from all over the world. However, despite its vigorous development, there is a lack of relevant research on industrial structure and performance. To help address this problem, this study examined the IoT industry in Taiwan and China as a research sample to see which financial variables have an impact on business performance.

The empirical analysis showed that : debt ratio (LA), total assets turnover (AT), % of Cost of Goods Sold (RC), cash flow ratio (CR), and size (Log(S)) are significant factors related to ROA both in Taiwan and China. The other significant factors in Taiwan are accounts receivable turnover (RT), inventory turnover (IT), current ratio (CL), and capital intensity. The other significant factor in China is cash flow ratio (CR).

The empirical results also showed that the greater the scale of IoT companies in Taiwan and China, the higher the positive impact on business performance, which is in line with expectations.

In addition, for the four major development types of IoT vendors, the empirical results show that in the Taiwan IoT industry, T2T is better than the other types. However, in China’s IoT industry, both T2T and T2H are significant. The emergence of business opportunities in the IoT industry has developed from the performance of upstream component manufacturers, midstream equipment manufacturers and system integrators as well as platform operators. Through this process the applications of T2T have begun to take shape, these applications are being effectively deployed by companies on both sides of the Taiwan Straits.

2. Research originality

We use a rigid theoretical and empirical framework to examine the association among the patterns of Iot and firm performance. China is developing its own distinctive and vibrant IoT, combining its enviable economies of scale with innovative new devices and services that meet the specific needs of Chinese consumers and companies (Bouverot, 2015). China can also generate enormous economies of scale, while the country's rapid economic growth and development is driving adoption of new technologies, as the urban population grows and the middle class expands (Bouverot, 2015). This gives Chinese companies a distinct advantage in the development and deployment of IoT applications.

In addition, results show that the application of T2H by mainland enterprises is relatively advanced. The development of smart cities and New Retail in China has meant the opening of many new possibilities for Chinese companies with regard to T2H (Ministry of Industry and Information Technology, 2012 ; State Council of China, 2013). It is expected that Taiwanese manufacturers will develop products and services in this area in the future.

Daugherty et al.(2015) conduct that the IIoT (Industrial Internet of Things) companies are classifying new growth opportunities by adding digital services and innovations to their intelligent industrial product mix. To gain the full benefits of the IIoT, companies will need to leverage three technology capabilities : sensor-driven computing, industrial analytics and intelligent machine applications.

IoT is still in its infancy. Most of the information currently collected via IoT devices has not yet been effectively utilized, and the data collected is not sufficient. Especially, with the spread of the COVID-19 pandemic, social and economic status is changing drastically. As measures to prevent infection with the pandemic, telework and distance learning are being adapted, and new non-contact and non-face-to-face lifestyles are being promoted. It can be said that the use of IoT has also been promoted in order to respond to this change in lifestyle. In the new normal era the ever-deepening application of the IoT in a new business model for H2T that can be found in areas such as public safety, healthcare and smart homes. As of 2020, the number of IoT devices grows rapidly in medical, consumer, industrial use, automobile and aerospace (Ministry of Internal Affairs and Communications, 2021). In conclusion, informatization and digitization are the core competitiveness of industry, IoT is one of key drivers of economic growth.

Annotation

1 As H2T is still in its early stage of development, there were no samples producing H2T products, so it was excluded from this research.

Reference

1. 50cnnet, [2016], Analyze the Market Status and Ecosystem of China's Smart Home, Available from http :// www.50cnnet.com/zonghe/106661.html
2. Afzhan : CPS.COM.CN, [2016], 2016 China Internet of Things Market Scale and Industry Development Trends. Available from http ://www.afzhan.com/news/detail/48186.html
3. Bain J.S. [1956], *Barriers to New Competition : Their Character and Consequences in Manufacturing Industry*, Cambridge : Harvard University Press.
4. Barney, J. B., [1991], "Firm Resources and Sustained Competitive Advantage," *Journal of Management*, 17(1), pp. 99-120.
5. Baumol, W.J., Panzar, J. C., and Willig, R.D. [1982], *Contestable Markets and the Theory of Industry Structure*, New York : Harcount Brace Jovanovich.
6. Bennett, Jo, [2016], "Why Integration is Critical to IoT Success," Available from http ://www.gartner.com/ smarterwithgartner/iot-integration-questions
7. Bouverot, Anne, [2015], "How China is Scaling the Internet of Things," GSMA.

8. Comiskey, Eugene E. [1982], “Assessing Financial Qua1ity : An Organizing Theme for Credit Analysts,” *Journa1 of Commercial Bank Lending*, 65(4), pp. 32-47.
9. Daugherty, Paul, Prith Banerjee, Walid Negm and Allan E. Alter, [2015], “Driving Unconventional Growth through the Industrial Internet of Things,” Available from https ://www.accenture.com/us-en/_acnmedia/Accenture/next-gen/reassembling-industry/pdf/Accenture-Driving-Unconventional-Growth-through-IIoT.pdf, Accenture Technology.
10. Dobbs, Richard, James Manyika, and Jonathan Woetzel, [June 2015], “The Internet of Things : Mapping the Value beyond the Hype,” McKinsey Global Institute.
11. Ernst & Young, [2016], “M2M in China : Opportunities to Build on Global Leadership,” EY Publication.
12. Ko, Chiung-Feng, and Chang Chia-Hao, [December 2017], “Assessing the Value of the Firms on Internet of Things Industry : A Comparative Study of across Taiwan Strait,” *Soochow Journal of Economics and Business*, No.95 : pp. 57-90.
13. Kranenburg, H. V., and Hogenbirk, A., [2006], Issues in Market Structure. In A. B. Albarran, S. M. Chan-olmsted & M. O. Wirth (Eds.), Handbook of Media Management and Economics (pp. 325-344). Mahwah, N.J. : L. Erlbaum Associates.
14. Levitske, J., [1994], ESOP Valuation : ”The Quality of all Earnings is not the Same,” *Journal of Pension Planning and Compliance*, 77(2), pp. 76-85.
15. Lin, Chuan-Neng, [2011], Wisdom Networking Industry Technology Development Layout, 2011 Executive Yuan Smart Networking Industry Development Strategy Meeting, Taipei.
16. Lu, Xinjiang, Zhiwen Yu, Bin Guo, Xingshe Zhou, [June 2014], “Predicting the Content Dissemination Trends by Repost Behavior Modeling in Mobile Social Networks,” *Journal of Network and Computer Applications*, 42, pp. 197-207.
17. Ministry of Industry and Information Technology, [2012], The “Twelfth Five-Year” Development Plan for the Internet of Things. Central Government Portal www.gov.cn. Available from http ://big5.gov.cn/gate/big5/www.gov.cn/zwgk/2012-02/14/content_2065999.htm
18. Ministry of Internal Affairs and Communications, [2021], Information and Communication in Japan 2021 white paper, Economic Research Office, ICT Strategy Policy Division, Information and communications Bureau, Ministry of Internal Affairs and Communications, Japan.
19. Murphy-Hoye, Mary, [2016], “From strategy to action : Driving IoT to Industrial Scale,” *Cognizant*, 9(1), pp. 1-8.
20. Pasha, Maruf, and Syed Muhammad Waqas Shah, [2018], “Framework for E-Health Systems in IoT-Based Environments,” Wireless Communications and Mobile Computing, vol. 2018, Article ID 6183732, 11 pages. Available from https ://doi.org/10.1155/2018/6183732.
21. Shepherd, William G., and Shepherd, J. M., [2004], *The Economics of Industrial Organization*, 4E. Long Grove : Waveland Press, Inc.
22. Short, Jeremy C ; Ketchen, David J, Jr ; Bennett, Nathan ; Mathilda du Toit., [2006], “An Examination of Firm, Industry, and Time Effects on Performance using Random Coefficients Modeling,” *Organizational Research Methods*, 9(3), pp. 259-284.
23. Silva, Edgar M. and Maló1, Pedro, [2014], “IoT Testbed Business Model,” *Advances in Internet of Things*, 4, pp. 37-45.
24. State Council of China, [2013], “Guiding Opinions of the State Council on Promoting the Orderly and Healthy Development of the Internet of Things,” Central Government Portal www.gov.cn. Available from http ://www.gov.cn/zwgk/2013-02/17/content_2333141.htm
25. Tarng, J.H., [2015], “Internet of Things-Big Wave Taiwan ICT New Growth Curve,” *Industrial Technology,* 285, pp. 16-21.
26. Tomaz, Cater and Pucko Danijel, [2005], “How Competitive Advantage Influences Firm Performance : The Case of Slovenian Firms,” *Economic and Business Review*, 7(2), pp. 119-135.
27. Venkatraman, N. and Ramanujan, Vasudevan, [1986], “Measurement of Business Performance in Strategy Research : A Comparison of Approaches”, *Academy of Management Review*, 11(4), pp. 801-814.
28. Wernerfelt, B., [1984], “A Resource-based View of the Firm,” *Strategic Management Journal*, 5 (2), pp. 171-180.
29. Wirth, M. O., and Bloch, H., [1995], “Industrial Organization Theory and Media Industry Analysis,” *Journal of Media Economics*, 8(2), pp. 15-26.

30. Zhan Wennan, [2015], “Taiwanese Vendors’ Business Opportunities and Challenges in the Internet of Things,” Institute of Information Industry, Industrial Intelligence Research Institute (MIC), Available from http ://mic.iii.org.tw.

（審査受付　　　2022 年 2 月 4 日）
（最終校正受理　2022 年 7 月 28 日）