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資通訊科技與企業競爭力管理：台灣金融產業實證

Information and Communication Technology and Corporate Competitiveness Management: Empirical Evidence of the Financial Industry in Taiwan

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摘 要

在當前激烈競爭市場上，資通訊科技已成為企業不可或缺的一項必要投入。資通訊科技的應用可提升決策者資訊管理能力，藉此強化企業競爭力管理。資訊化也促使台灣金融產業進步，帶動組織升級，使得金融產品與服務進入新紀元。因此衡量資通訊科技對於台灣金融產業競爭力管理之影響即為本文之目的，透過 KLEMI 模型探討資通訊科技與組織競爭力所呈現的互動關係。

實證結果顯示，資通訊科技的投資對於台灣金融產業的產值有正向影響，資通訊科技的投入可使金融產業產生規模報酬遞增之現象，尤其投入資通訊科技軟體的正面影響超過資通訊科技硬體，為提升金融業產值的重要因素，有助於企業競爭力管理。本文在結論中對此實證結果引申其管理意涵。

【關鍵字】資通訊科技、企業競爭力管理、金融產業

Abstract

Aided by information and communication technology (ICT), decision-makers can enhance their management capabilities and strengthen corporate competitiveness. The primary purpose of this study is to examine whether ICT investment in Taiwan's financial industry positively promotes industrial output value. Specifically, this study evaluates whether the impact of ICT investment in the financial industry in Taiwan also increases returns to scale, as it has in the US.

Empirical results derived utilizing the KLEMI model reveal that ICT generally has a positive effect on production in Taiwan's industries; however, the financial industry in Taiwan experienced increasing returns to scale (IRS) after investing in ICT. This study divided ICT investment in the financial industry into hardware (ICTH) and software (ICTS) investments. This is an early attempt in the literature in this field. The analytical results show that the contribution of ICTS investment to Taiwan's financial industry is greater than that of ICTH. Additionally, the increasing returns to scale (IRS) contributed to by ICT in Taiwan's financial industry (1.37-1.39%) is greater than that of the ICT in financial industry of the US. (1.13%). These are the major contributions of this study.

【Keywords】information and communication technology, corporate competitiveness management, financial industry

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1. Introduction

With the aid of ICT, such as computer, telecommunication and electronic appliances, decision makers can enhance their decision capability and strengthen their competitiveness. Many literatures such as Wu (1991), Kelley (1994), Harberger (1998), Ho, Jorgenson, and Stiroh (1999), Schreyer (2000) and Jorgenson (2001), show that there is a positive effect of the ICT on the achievement of the production objectives of an organization.

Similar to the above literature, Brynjolfsson and Hitt (1996) indicated that information system spending had made a substantial and statistically significant contribution to firm output. Brynjolfsson and Hitt (1998) also pointed out that many firms in addition to getting more total benefits from IT, related organizations of those firms also appear to be adopting IT at a faster rate. In 1994 this amounted to only about a 50% difference in overall IT investment intensity, however, this gap is growing by 10% per year. Over the following decade, these decentralized and empowered organizations might begin to pull away from their industrial age counterparts in performance as they are better able to exploit increasingly inexpensive information technology. These results suggest that it is becoming increasingly important to organize in ways that leverage the value of IT. Brynjolfsson and Hitt (2000) further surveyed micro-studies into the effects of ICT on productivity. They found that investment in ICT goods leads to higher productivity, especially if the investment in capital goods is accompanied by investments in organizational change, like reorganizing the supply chain and introducing new workplace methods. Dedrick, Gurbaxani, and Kraemer (2003) critically reviewed more than 50 articles on computers and productivity. They indicated that many studies in the 1980s found no connection between IT investment and productivity in the U.S. economy, a situation referred to as the *productivity paradox*. They developed a scientific framework and concluded that the productivity paradox as first formulated has been effectively refuted. At both the firm and the country level, greater investment in IT is associated with greater productivity growth. Brynjolfsson and Yang (1996) conducted a comprehensive survey and categorized relevant studies into four groups, identified remaining productivity puzzles, and reviewed four possible explanations for them: mismeasurement, lags, redistribution and mismanagement. They concluded with recommendations for investigating each of these explanations, including more careful applications of traditional methodologies, as well as employment of alternative, broader metrics of welfare to assess and enhance the benefits of IT.

Oliner and Sichel (2000, 2003) identified that one of the major sources of the U.S. economic growth is caused by adopting ICT since 1995. Jorgenson (2001) also pointed out

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that the semiconductor industry was the main driving force of productivity growth. Crafts (2002, 2003) further proves that ICT contributes significantly to the U.S. economic growth from 1996 to 2000. However, to what extent the ICT has influenced on the productivity, there are not many literatures dealing with this subject.

Klein and Kumasaka (2000) pointed out that the ICT revolution appears to have contributed to accelerating merger and acquisition (M&A), because the ICT has been utilized to promote globalization of the economy and it may bring the organization with increasing returns to scale (IRS)[1]. Klein, Saltzman, and Duggal (2003) indicated that the financial industry in U.S. became increasing returns to scale by using ICT. While the above-mentioned literature have shown that ICT does possess a positive contribution to the productivity and corporate competitiveness of various sectors, it would be quite interesting to see if the *newly industrialized countries (NICs)* such as Taiwan also possesses this kind of empirical evidence, considering that the NICs normally lag behind U.S., E.U. or Japan for about ten years or so. Since Zhang and Lee (2007) examined a time series analysis of international ICT spillover of Korea, Singapore and Hong Kong, lacking Taiwan as one of the Four Asian Tigers. Accordingly, it has become the motivation of this study to investigate if ICT investment in Taiwan's industries has a positive effect on corporate competitiveness management or economic growth. Specifically, if the impact of ICT investment on the financial industry in Taiwan also possesses the phenomena of increasing returns to scale, as it has been shown in the U.S.

In 2007, the output value of Taiwan's financial industry is equivalent to U.S. $ 55,000 million. In contrast to the figures of 2001, it means a 15.2% growth. Therefore, computing and data processing of the computer system is the key to enhance the productivity and corporate competitiveness of financial industry. In 2004, the output value of ICT service of Taiwan's financial industry reached U.S. $55 million. Accordingly, the main purpose of the present study is to examine the economic impact of ICT on corporate competitiveness management of Taiwan's financial industry. In particular, for the first objective of this study, we are interested in knowing if ICT investment in the financial industry also exist the phenomena of increasing returns to scale as it has been shown in the U.S.A.

Generally speaking, the investment of ICT could be divided into software technology

[1] In microeconomic theorem, the production function or the economic activity of a corporation is termed as increasing returns to scale (IRS), when each of all input factors/variables is increases by 1%, the output value will increase a magnitude of greater than 1%. This means there is an existed phenomenon of decreasing average production cost, i.e., economy of scale. With IRS, the production activity of introducing those input variables is deemed as a positive contribution to the corporate competitiveness.

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and hardware technology, both leading to different effect on different industries. Therefore, the second objective of the study is to explore the contribution of different ICT technology, i.e., software and hardware, on the productivity and corporate competitiveness of the financial industry, which is also the uniqueness of this paper different from previously mentioned literature.

In order to achieve the above two objectives, we first review the current situation of Taiwan's ICT application in service industries. Then, we demonstrate the empirical model employed in this study. Next, we illustrate data sources and empirical results. Finally, the conclusion and recommendations of this study are presented.

2. Overview of Taiwan's ICT Application in Service Industries

To the whole economy, Taiwan's industries possess a relatively high percentage of computer system application, i.e., the average rate is about 55.6%. To account by individual industry, the public administration service, the educational service industry, finance and insurance industry, professional and technical service industry, possess the highest rates of ICT and computer application, i.e., 100%, 95.84%, 94.38% and 92.8% respectively (see appendix table 1).

To compare the percentage of ICT and computer expenditure in major industries in Taiwan, the average expenditure was U.S. $23.3 million in 2004. If ranking the total expenditure amount, the highest one is public utility industries (i.e., electricity, gas and water); totaling amount is U.S. $92 million dollars, followed by finance, insurance and real-estate, which is U.S. $55 million dollars (see appendix table 2). One should note that the public utility industry is mainly considered for providing social benefits and they are all monopolized industries, not purely focus on the corporate competitiveness management. Therefore, the financial industry though ranks as number two in all sectors, it is actually considered ranks as the top industry in terms of exploring enterprise competitiveness management enhancement. Accordingly, it would be worthy to examine the impact of the ICT investment on the corporate competitiveness management of the financial industry.

From figure 1, the trend of output value of ICT software services could be divided into two stages. The first stage covers the period of 1981 to 1989, which is relatively steady with a minor growth in output value. While the second stage from 1990 to 2004, the output value surging sharply from U.S. $125 million dollars in 1990 to U.S. $565 million dollars in 2004, shows the ever-increasing importance of the role of ICT and computer systems.

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3. The KLEMI Model

One of the effective methodologies to investigate the relationship between ICT and corporate competitiveness management is the KLEMI (capital-labor-energy-material-information) model, which is an inter-industry type of models. Inter-industry model was firstly advocated by Leontief (1936), the Nobel laureate in Economics of 1973. The main purpose of the model is to describe the inter-dependent relationship among all industries within a framework of a set of explicit matrix numbers of the Leontief production functions. It is most useful to investigate the input-output relation (meaning the relationship between the input factors and output value) based on the industrial level of an economy, and is also termed as input-output (I-O) model. While this I-O model proved to be very applicable to study general input-output relation between the production factors of capital and labor, it was then modified into the KLEM (capital-labor-energy-materials) model in 1976 by Klein, who is also a Nobel laureate in Economics of 1980. The KLEM (capital-labor-energy-materials) model contains a more detailed production function framework, in which the role of materials and energy are explicitly recognized. Furthermore, Klein et al. (2003) argued in their paper that "IT is especially relevant in the financial industry in that it was one of the first sectors to use computer services on a large scale-taking off by about 1980 in using electronic transfer, ATM machines, automatic accounting systems and other automated "back office" services to keep abreast of global markets and provide almost instantaneous services to customers. Yet, industry studies to date have not been able to measure any meaningful productivity impacts from IT in the finance sector." Accordingly, they constructed the KLEMI (capital- labor-energy-materials-information) model by including the "IT capital" as an independent input. Following their approach, we replicated the KLEMI model and applied to the case in Taiwan. It would be worthy to note that in our paper we utilize the term "ICT" rather than "IT" as in Klein et al. (2003).

Following Klein et al. (2003) including ICT hardware and software as separate factor inputs, we adopted their definition and the context of ICT within the framework of a generalized KLEM production function. To be more specific, they measured directly the impact of the information services input (defining as ICT software and the remaining capital expenditure on information technology are defined as ICT hardware) in the form of the service activity that has surged in the past decade.

The production functional form is assumed as Cobb-Douglas type, shown in equation 1. Then the standard KLEM production function is extended as linear with the parameter coefficients in its natural log functional form shown in equation 2:

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$$Y=AK^{\alpha 0} L^{\alpha 1} E^{\alpha 2} M^{\alpha 3} \quad (1)$$

$$\ln Y= \alpha_0 \ln K + \alpha_1 \ln L + \alpha_2 \ln E + \alpha_3 \ln M+ \varepsilon_t \quad (2)$$

Where K is non-ICT capital; L is labor; E is energy; M is intermediate; Y is gross output.

Now we can input ICT capital, therefore the production function is rearranged as equation 3 and equation 4.

$$Y=AK^{\alpha 0} L^{\alpha 1} E^{\alpha 2} M^{\alpha 3} I^{\alpha 4} \quad (3)$$

$$\ln Y= \alpha_0 \ln K + \alpha_1 \ln L + \alpha_2 \ln E + \alpha_3 \ln M + \alpha_4 \ln IT + \varepsilon_t \quad (4)$$

Where ICT represents ICT capital investment.

To further separate ICT capital into hardware and software, we obtain equation 5 as follows:

$$\ln Y= \alpha_0 \ln K + \alpha_1 \ln L + \alpha_2 \ln E + \alpha_3 \ln M + \alpha_4 \ln ITH + \alpha_5 \ln IHS + \varepsilon_t \quad (5)$$

Where ICTH is ICT hardware and ICTS is ICT software service.

4. Data Source and Empirical Results

4.1 Data Source

The empirical data for this paper are generated from the Input-Output tables provided by Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan. To estimate the parameters of the model, we utilize time-series data for ICT capital (hardware) during the period from 1976 to 2004, counting a total of 29-year data set. Then we focused on the financial industry, which includes bank, stock and insurance industries.

Cross output (Y) The I-O table for capital, for labor, for energy, for software, for intermediate flows, and for value added in nominal dollars were linearly interpolated to generate pseudo annual data for the series. We then imposed the accounting identity: Gross output is the sum of intermediate inputs and value added, in nominal terms. The 1976 dollar gross output for the financial industry was computed as the aggregate of the 1976 dollar series for energy, software, other intermediate flows, and value added.

Capital stock (K) The capital stock for the sector was aggregated from the 1976 estimates of nonresidential fixed assets: Detailed industry by detailed type. Excluded from is the B-to-B software consisting of prepackaged software, custom software, and own-account software. These are now considered part of investment in capital stock in national income analysis.

Labor (L) Labor is expressed in billions of hours on an annual basis. It is the product of the Bureau of Labor Statistics data on employment for the financial industry and average

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weekly hours of production workers for finance, insurance, and real estate.

Energy (E) Using the energy from Electricity sector the value of output.

Intermediate flows excluding software (M) Intermediate flows excluding software are the sum of energy and intermediate flows excluding energy.

ICT hardware (ICTH) is part of the total capital stock and includes the following categories of stock:

Mainframe computers

Personal computers

Direct access storage devices

Computer printers

Computer terminals

Computer tape drives

Computer storage devices

Other office equipment

Communication equipment

Instruments

Photocopy and related equipment

Telecommunications

ICT software (ICTS) was the sum of I-O flows from computer and data processing services:

Computer programs investment e.g. SCM, CRM, ERP

Software designer, maintain and operation

Computer and data processing service, such as database building, up-date and analysis

The variables and data are summarized in table 1 and explained as follows:

Table 1 Variable notation, definition and data content, and expected sign of estimated results

Notation	Definition	Data Content	Expected Sign of Estimation
Y	Gross Output	Summation of K,L,E,M and total Value-added	+
K	Non-ICT Capital	Incremental Investment Times the Depreciation Rate	+
L	Labor	Compensation of Employees	+
E	Energy	Gross Value of Electricity Sector	+
M	Intermediate	Gross Value of Intermediate Inputs	+
ICTS	ICT Software	Gross Value of ICT Software	+
ICTH	ICT Hardware	Gross Value of ICT Hardware	+

Source: Modified by the authors, based on Klein et al. (2003)

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4.2 Empirical Results

The empirical data account 29 annual sample sets for the period from 1976 to 2004, and all input factors are adjusted for lag one year to reflect a "learning effect" in the use of both ICT hardware and software. The estimated results are presented in table 2.

Table 2 Estimated results

Variables	Without Separating a ICT Variable	With a Separated ICT Variable	Further Separating ICTH and ICTS Variables
K	0.23(1.78*)	0.25(1.76*)	0.22
			(1.64*)
L	0.28(1.87*)	0.24(1.71*)	0.22
			(1.82*)
E	0.10(1.42)	0.08(1.55)	0.09
			(1.64*)
M	0.35(1.63*)	0.31(1.66*)	0.32
			(1.71*)
ICT	–	0.49(2.90**)	–
ICTH	–	–	0.19(1.02)
ICTS	–	–	0.35(3.03**)
R^2	0.80	0.81	0.80
D-W	2.20	2.01	2.23

source: Parameters calculated from the study

note: Numbers in parameters is t value,*represents 90% confidence interval, and** represents 95% confidence interval

This shows that for the financial industry, if we separated the ICT capital vs. non-ICT capital investment, the input capital increases one unit (e.g., U.S. $1000) can cause the total output value increase 0.23 units. Also, if the labor input increases one unit, can cause the total output increases 0.28 units. In addition, if the intermediate inputs increase one unit, can cause the total output value increases 0.35 units. And they are all significant with 90% and 95% confidence intervals. However, when we modeling the production function with a separated ICT variable, the ICT capital increases one unit can cause the total output value increases 0.49 units. If we categorized capital into ICT hardware and ICT software service in the model, we can find that one unit (e.g., U.S. $1000) ICT software capital investment can increases 0.35 units output value, and increase one unit ICT hardware can increases 0.19 units output value. This implies that introduction of the ICT capital investment can enhance

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productivity of the financial industry in Taiwan. It also implies that the same investment amount in ICT software will result in a higher rate of return than that of ICT hardware.

Table 3 Estimated returns-to-scale of the ICT investment

	All Factors Input Increment	Gross Output Value Increment	Returns to Scale
Without Separating a ICT Variable	1%	0.96%	Constant
With a Separated ICT Variable	1%	1.37%	Increasing
Further Separating ICTH and ICTS	1%	1.39%	Increasing

source: Calculated from the present study

In estimating the economic returns to scale (see table 3), we find that for the Cobb-Douglas production function without separating ICT capital vs. non-ICT capital variables, the output value of financial industry is constant returns to scale, showing that all input factors increase by 1%, then production value will also increase by 1%. However by separating ICT capital vs. non-ICT capital variables, the output value of financial industry will become increasing returns to scale, showing that all input factors increases by 1%, the output value will increase by 1.37% (i.e., 0.25%+0.24%+0.08%+0.31%+0.49%). When we further categorize ICT capital into ICT hardware and ICT software service, all input factors increase by 1%, will increase by 1.39%. These figures are relatively noteworthy in term of business competitiveness management enhancement.

The underling reason that we separate ICT hardware and ICT software investment has to do with the service nature of the financial industry, i.e., if we compare the financial industry versus the manufacturing industry, the later one is mostly focus on production-oriented or "B2B" trading activities, rarely reaching the final end-users or consumers. However, the financial industry has to provide relevant service by wide-applicable ICT software in order to meet the satisfaction of customers of all ranks, including customer relationship management (CRM). Therefore, it is important to explore the different contribution of the ICT hardware and ICT software to the productivity of the financial industry.

5. Implications and Conclusions

This paper utilizes the data from I-O table of Taiwan from 1976 to 2004, to fit into the KLEMI production function for examining the economic impacts of ICT investment on the

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corporate competitiveness management of the financial industry in Taiwan. From the empirical results, we derive some implications and conclusions as follows:

If the financial industry had not separated the ICT capital investment from the conventional KLEM model, all input factors increase one unit (e.g., U.S. $1000), the total output value shows a positive effect of increasing 0.23 units, 0.28 units, 0.10 units and 0.35 units. When we separate the ICT capital into the KLEMI model, the ICT capital has a positive contribution in financial industry, i.e., if the ICT capital increases one unit, it can cause the total output value increases 0.49 units. Besides, if we further categorize the variable of ICT capital into ICT hardware (ICTH) and ICT software (ICTS), then we find that the ICT software investment is more positive than ICT hardware investment in terms of enhancing the total output value of the financial industry in Taiwan.

Furthermore, we find that without separating the variable of ICT capital investment, the financial industry is constant returns to scale industry. However, if we separated the variable of ICT capital investment, the financial industry will become increasing returns to scale. From the perspective of cooperate competitiveness management, it implies that the introduction of the ICT capital investment really can enhance the productivity and corporate competitiveness management of the financial industry in Taiwan. This maybe because ICT implementation can not only enhance the human and knowledge capital, but also reduce the searching/transaction cost and needed time for organization internal and external information searching and distribution, leading to a more flat hierarchy structure, down-sizing the management staff, improving the effectiveness of communication, thus increasing the returns of the corporation.

As to the uniqueness of this research model, contrasting to other financial index or accounting methods such as Bharadwaj, Bharadwaj, and Knosynski (1999), Rai, Patnayakuni, and Patnayakuni (1997), Sircar, Turnbow, and Bordoloi (2000), Stratopoulos and Dehning (2000), our study can provide more specific observation on the relationship among all input factors, i.e., we can compare the contribution of each input factor and to see which is contributing greater or smaller. This is the characteristic of the Leontief input-output model which is beyond the capability of other financial and accounting models. For example, empirical results in this paper shows that the contribution of ICT investment (both hardware and software) are more significant than that of other input factors, including labor, capital, energy and material.

Finally, to the best knowledge of the authors, this paper is an early attempt dealing with the ICT contribution to financial industry competitiveness of Taiwan. Particularly, we

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have investigated the ICTH and ICTS separately, and demonstrated that the contribution of the ICTS is greater than that of the ICTH. In addition, we have identified that the IRS contributed by ICT in Taiwan (1.37- 1.39%), which is greater than that of the ICT in U.S. (1.13%) according to Klein et al. (2003). This is maybe because Taiwan, being a newly developed country, ICT investment may be more important since the ICT infrastructure has not been mature enough as that of the advanced countries. This situation could be conformable to the general economic theory of diminishing marginal utility, i.e., a marginal ICT investment in Taiwan where the ICT infrastructure is less mature, could generate a higher return than that of U. S. Alternative way of looking into this difference could be drawn from the perspective of population density. One argument is that since Taiwan's population density is much higher than that of the U.S., a same unit ICT investment in Taiwan can serve relatively more customers than those of the U.S., leading to a higher return. On the contrary, the counter argument is that since the importance of ICT investment may be more important when population density is lower (because ICT mitigates the challenge of geographic dispersion), the higher return of ICT investment in Taiwan does not conformable to this argument. Therefore, the explanation from the perspective of population density does not seem to be reasonable and need more in-depth assessment.

All of the above findings are the major contributions of this study. However, one must note that although this paper has found that during the whole observation period of 29 years (from 1976 to 2004), the ICT does have a positive effect on the economic growth in Taiwan. For different observation period of time, it could lead to different results. For example, the meaning of ICT in 1970s is very different from the meaning of ICT today. Thus, it would be interesting to conduct a further in-depth research in the future to compare the impact of ICT on the financial industry in different time periods, specifically from 1976 to 1990 versus from 1991 to the present.

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APPENDIX

Table 1 The application of ICT & computer system in Taiwan's service industries

Industries	2006 availability rate (%)	2005 availability rate (%)	growth rate (%)
Wholesale and Retail Trade	72.39	66.30	6.09
Hotel and Restaurant Service	46.94	37.74	9.20
Transport, Warehousing and Telecommunication	83.34	79.90	3.44
Finance and Insurance	94.38	89.93	4.45
Real Estate and Renting & Leasing	81.94	74.81	7.13
Professional and Technical Service	92.80	94.55	-1.75
Education Service	95.84	95.77	0.07
Medical & Health and Social Welfare Service	91.30	86.07	5.23
Culture, Sport and Literature Service	88.10	85.50	2.60
Other Service	75.75	69.05	6.70
Public Administration Service	100.00	100.00	0.00
Service Sector Average	**75.27**	**70.18**	**5.09**

Source: From the Survey by Institute for Information Industries (see http://www.cisc.iii.org.tw)

Table 2 ICT & computer expenditure in Taiwan's industries (2004)

Industries	Hardware (10^3dollars)	Software (10^3 dollars)	Total Investment (10^3 dollars)	Share of Total Expenditure (%)
Mineral	156.88	88.13	245.01	0.39
Manufacture	12181.56	7327.19	19508.75	0.43
Electricity, Gas and Water	76737.19	15230.63	91967.82	0.40
Construction	3581.88	2706.25	6288.13	0.59
Commercial	4973.13	2615.00	7588.13	0.60
Transportation, Warehousing and Telecommunication	8171.25	3062.19	11233.44	1.02
Finance, Insurance and Real Estate	40130.00	15290.63	55420.63	1.39
Industry and Business Service	6064.69	2356.88	8421.57	1.98
Social and Personal Service	5332.50	3367.81	8700.31	2.42
Average Expenditure	**17481.01**	**5782.75**	**23263.75**	**1.02**

Source: From the Survey by Institute for Information Industries (see http://www.cisc.iii.org.tw)

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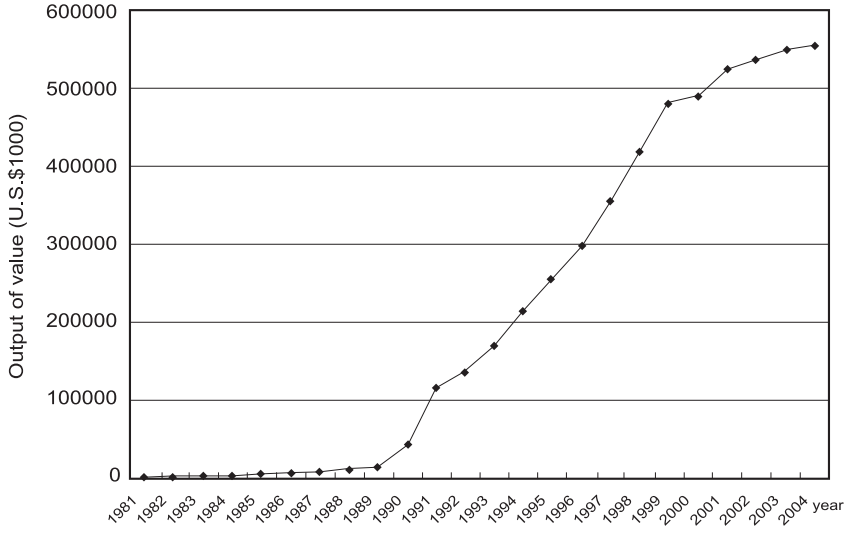


Figure1. Output Values of ICT Service of Taiwan's Finance Sector

Source: Taiwan Input-Output Tables

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