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The knowledge intensity and the economic performance in Taiwan's knowledge intensity business services

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ABSTRACT

The service sector plays a key role to employment growth and increased public well-being in OECD countries. The service industries contributed more than 63% of GDP in 2016 and have become the core of economy in Taiwan. Within the service sectors, knowledge-intensive business services (KIBS) particularly illustrate higher levels of productivity and profitability. Moreover, due to lack of the clear measurements of the knowledge intensity with prior investigations in KIBS, the aim of this article is to explore the knowledge intensity of Taiwan's KIBS. This study then further probes into the relationship between knowledge intensity and economic performance. Panel data from 13 service sectors in Taiwan during the period 2007–2015 is analysed with a fixed effect model. This empirical research shows four findings: first, 13 industries are classified into three groups as high, low, and no level of knowledge intensity; second, most of the level of knowledge intensity has been increased from stage one to stage two; third, education level and vocational training rate positively influence productivity; and, finally, the percentage of knowledge workers and vocational training rate have a positive effect on the margin rate.

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1. Introduction

The service sector plays a key role to employment growth and increased public well-being in OECD countries (Miles, Belousova, & Chichkanov, 2017; OECD, 2012; 2017). The expected economic performance of knowledge-intensive business services (KIBS) is higher levels of productivity and profitability/margin than traditional manufacturing industries (Bontis, 2003; Cusumano, Kahl, & Suarez, 2015; Rabetino, Kohtamäki, Lehtonen, & Kostama, 2015; Smith, Maull, & Ng, 2014; Visnjic, Weingarten, & Neely, 2016). Within the service sector, KIBS particularly illustrates high growth rates, including the developing countries (Janger, Schubert, Andries, Rammer, & Hoskens, 2017). As well as in Taiwan, according to the report issued by

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Directorate-General of Budget, Accounting, and Statistics Department of Taiwan in 2016, the data shows that economy growth comes mainly from the service industry and service sectors contribute more than 63% of GDP. The service industries have become the core of economy, in particular KIBS (Pai & Tseng, 2008; Tseng & Pai, 2008; 2009; Tseng, Pai, & Hung, 2011). However, the prior KIBS research has no clear measurement about the knowledge intensity of KIBS (Muller & Doloreux, 2007; Tovoinen, 2006; Wood, 2002). Therefore, the aim of this empirical investigation is to examine the knowledge intensity of Taiwan's KIBS, and further analyse the relationship between knowledge intensity and economic performance.

KIBS has been discussed widely (Antonelli, 1999; Corrocher, Cusmano & Morrison, 2009; den Hertog & Bilderbeek, 1999; Fernandes, Ferreira, & Marques, 2015; Freel, 2006; Miles, 2005; Miles et al., 2017; Miozzo, Desyllas, Lee, & Miles, 2016; Muller & Doloreux, 2009; Muller & Zenker, 2001; Sirilli & Evangelista, 1998; Zenker & Doloreux, 2008), and it is thought that KIBS could bring greater economic performance through the utilisation of knowledge. It is clear from this perspective that the intensity of knowledge in KIBS forms the important sources of competitive advantages.

In generally, KIBS can be defined as 'firms performing, mainly for other firms, services encompassing a high intellectual value-added' (Muller, 2001). However, this definition ignores the diversity of KIBS forms and activities (Muller & Zenker, 2001). As a matter of fact, Miles et al. (1995) have identified two main KIBS categories: KIBS I refers to traditional services that include marketing/advertising, legal services, management consultancy, financial services, design, accounting and book-keeping, etc., liable to be intensive users of new technology; and KIBS II refers to new technology-based KIBS that include computer networks/telemetric, software, telecommunications, design about new technologies, training in new technologies, management consultancy about new technologies, technical engineering, R&D consultancy and high-tech boutiques, etc. These two categories were later labelled T-KIBS (technology-based KIBS) and P-KIBS (professional KIBS) and this demarcation also received the support of empirical studies indicating that differential propensity to specialise leads KIBS sectors to expand at different rates across regions (Corrocher et al., 2009; Freel, 2006; Muller & Zenker, 2001).

Moreover, the prior main studies of KIBS implicitly assume that KIBS are a homogeneous clod, with rare exceptions trying to examine the variety of KIBS (Freel, 2006; Miles et al., 2017; Zenker & Doloreux, 2008). However, as Malerba (2005) has indicated, failure to explicate the importance of within-industry heterogeneity constitutes a serious limit to understanding the autocatalytic nature of economic evolution. With this in mind, the study examines knowledge intensity, which is measured by education level, the percentage of knowledge workers, the percentage of R&D expenditure, vocational training rate and e-learning rate in Taiwan's KIBS and probing into the relationship between knowledge intensity and economic performance, measured by productivity and margin rate. Responding to the Malerba's (2005) call of studying on the within-industry heterogeneity to better understand the evolution of industrial dynamics, the paper takes Taiwan's KIBS as its object of study.

The paper is organised as follows. The next section is the theoretical background and literature review; it is further divided into two sub-sections, including briefly describing the characteristics of KIBS, as well as discusses prior research on KIBS to identify the unsolved issues in the large amount of literature on KIBS, and the indicators of knowledge intensity and the economic performance of KIBS which discusses how knowledge intensity influences economic performance. [Section 3](#), methodology, introduces the analysis method and the data sources this study utilised. [Section 4](#) shows the empirical results. Finally, [Section 5](#), concludes and proposes some possible avenues in future research.

2. Theoretical background and literature review

2.1. KIBS

The literature on service innovation over the last decade has got an almost consensus among innovation scholars. That is, the nature of innovation in service is different from that of innovation in manufacturing sectors. KIBS emerged in the late 1980s and early 1990s, when researchers identified traits of some specific firms in the service sector (Bilderbeek, Hertog, Marklund, & Miles, 1998; Doloreux, Freel, & Shearmur, 2010; J-Figueiredo, Vieira Neto, Gonçalves Quelhas, & de Matos Ferreira, 2017; Miles et al., 1995). Furthermore, it is also different between KIBS and other service industries. KIBS's innovation is highly dependent on the knowledge flow. It is recognised comprehensively to be important in terms of innovations and supports in helping cultivate innovation to manufacturing clients (Miles et al., 2017). KIBS has now been regarded as not simply transmitters of innovation, but also 'potentially as receptors, interfaces and catalysts' of knowledge-creation and diffusion (Muller & Zenker, 2001). As indicated by Freel (2006): 'KIBS are increasingly recognised as occupying a dynamic and central position in "new" knowledge-based economies, as creative innovators in their own right, rather than as mere adopters and users of new technologies'.

The two main traits of KIBS are 'knowledge' and 'service'. In contrast to other service industries whose main products are their services and knowledge is the peripheral products, what KIBS produces primarily is knowledge and service is the peripheral products. This study combines the definitions of Muller and Zenker (2001) and Miles et al. (1995) and defines KIBS as a kind of high-revenue service industry serving their clients with high value-added knowledge, satisfying their clients with professional consultation, and as a media creating, applying, and spreading information and knowledge. From this definition, it is clear that the services of KIBS are based on high-quality knowledge outputs which in turn are based on high-quality inputs of information and knowledge.

2.2. The indicators of knowledge intensity and economic performance of KIBS

Knowledge intensity plays an important role in services, but it is hard to be defined and evaluated (Abreu, Grinevich, Kitson, & Savona, 2010; Hauknes, 1999; Zhou, Kautonen, Wang, & Wang, 2017). This concept reflects the extent to which an

organisation depends on the inherent knowledge in its activities and outputs as a source of competitive advantage (Autio, Sapienza & Almeida, 2000). Hauknes and Hales (1998) address that knowledge intensity should be explained on the basis of the relative demand between service providers and service receivers, and it means that knowledge intensity is dependent on the particular needs, transmission, and absorptive ability of service providers and service receivers. The knowledge intensity can be defined as an expansion of the knowledge potential utilisation (Otcenášková, Bures, & Mikulecká, 2012) and it can be provided not only at the organisational level, but also all sectors, including national economics (Chen & Dahlman, 2005; Otcenášková et al., 2012).

Nowadays, under the trend of electronisation and informationisation, KIBS tend to use new technology to provide high professional services to their clients. The investment of KIBS in obtaining information is more important than other industries and new information and communication technologies (ICTs) give KIBS firms a global scope of action (Antonelli, 1999; Chen & Dahlman, 2005; Kuna, 2016). The development of digital infrastructures can positively facilitate the interaction between KIBS and manufacturing firms, then increasing the economic outcome (Chen & Dahlman, 2005; Lafuente, Vaillant, & Vendrell-Herrero, 2017). Once service firms adopt new technologies developed by manufacturers, its efficiency of processes and the quality of service tend to increase (Toivonem & Tuomiene, 2009). In addition, the quality of services of KIBS firms largely depends on the nature of the interactions between the service providers and clients (den Hertog, 2000), and that means the quality of the communication process involved has to be paid much attention. ICTs let firms operate without the limit of locations and exchange codified, as well as tacit knowledge, no matter how far the distance involved (Antonelli, 1999).

Thus, for the above reason, the investment or expenditure in information acquisition would be an important indicator. For a service activity, it requires highly skilled workers who exercise professional or technical capabilities to produce situation-specific results (Chen & Dahlman, 2005; Miles, 2008). Freel (2006) also shows that the development of KIBS is strongly associated with highly qualified employees, compared to manufacturing firms. When KIBS produces a service, it needs a well-skilled worker to employ its professional or technical capabilities (Miles, 2008). Knowledge workers employ the data or information provided by their firms to strengthen their professional skills to solve problems, to innovate, or to develop new products.

Accordingly, the services of KIBS are based on high-quality knowledge outputs which, in turn, are based on high-quality inputs of information and knowledge. High-quality inputs of knowledge primarily come from well-educated and highly knowledgeable workers. Knowledge workers with a more professional ability and higher education level would have great knowledge power and judgement, which is necessary for providing high-quality knowledge outputs. KIBS has a very strong orientation towards higher education level, much more than most other industries (Kox & Rubalcaba, 2007). Additionally, KIBS is an essential sector for improving innovation performance as they carry out strong efforts in R&D. Firms of KIBS will

actively invest in R&D expenditure that can enhance knowledge input to build knowledge. The R&D inputs bring stronger knowledge absorptive capacity a company possesses (Bocquet, Brion, & Mothe, 2016; Chen & Dahlman, 2005; Shearmur & Doloreux, 2015; Tseng et al., 2011). Moreover, KIBS learns by the process of hiring, training, and dismissing people, and training can turn employees' knowledge into collective property (Chen & Dahlman, 2005; Starbuck, 1992). KIBS are more intensively engaged in training activities than their manufacturing sectors (Wong & He, 2005). KIBS has a plenty of opportunities to learn knowledge from both inside and outside industries (Zhang, 2016). Thus, KIBS can obtain knowledge through training courses, including physically vocational training programmes and e-learning courses. To enhance skills acquisition and transfer of knowledge through learning experience in physical and virtual environments. Besides, high-quality inputs of information come from effective applications of new information technology. Businesses with higher e-learning rate would have higher degree/efficiency of computer utility to obtain advanced knowledge, and that could decrease the cost of information, and increase the employment of new technology under an efficient way. It is thought that the development of individual software can improve the services offered to others (Guerrieri & Meliciani, 2009).

As a result, this study employs education level, percentage of knowledge workers, percentage of R&D expenditure, vocational training rate, and rate of e-learning to be the indicators to identify the knowledge intensity of KIBS. The indicator, rate of e-learning, focuses mainly on the capacity of information acquisition in a KIBS, while the other four indicators attempt to capture the capability of KIBS's employees to transform information into useable knowledge outputs. The study attempts to empirically explore the knowledge-intensive degree of KIBS and analyse the change of their knowledge intensity and the impact of knowledge intensity on economic performance in Taiwan's KIBS.

Furthermore, the emergence of KIBS is considered as a physiological adaptation to progressively better specialisation in an economy with high levels of productivity. The productivity shows the expansion of KIBS, which affects the formation and spread of knowledge throughout the economy (Cainelli, Evangelista, & Savona, 2006; Chadwick, Glasson, & Lawton, 2008; den Hertog, 2000; Zhang, 2016). The anticipated benefits are high levels of productivity and profitability/margin (Chen & Dahlman, 2005; Cusumano et al., 2015; Rabetino et al., 2015; Smith et al., 2014; Visnjic et al., 2016). Therefore, knowledge intensity contributes to economic performance in that KIBS firms focusing on knowledge creation and exploitation are more likely to devote much more effort to cultivating learning skill useful to efficiently adapt and successfully grow in dynamic environments in which KIBS firms operate to develop distinctive knowledge intangible resources that are positively associated with performance in stable environments (Miller & Shamsie, 1996).

3. Methodology

The Taiwan government in 2016, Directorate-General of Budget, Accounting and Statistics, categorised all service economic activities into 13 main categories of

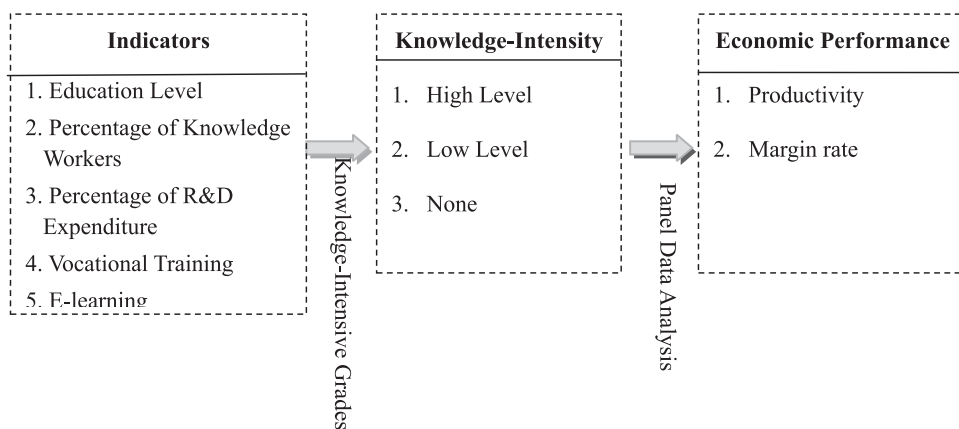


Figure 1. Research framework.

services, which were derived from the International Standard Industrial Classification (ISIC) 4th revision of the United Nations. Accordingly, this study investigates the 13 Taiwanese service industries and probes the relationship between knowledge intensity and economic performance, as shown in Figure 1. It conducts this by following the next three steps: First, this study adopts some indicators to represent the knowledge intensive degree of KIBS and transform these indicators into knowledge-intensive grades that could be compared to each other by standardisation (Chen & Dahlman, 2005). Second, it separates KIBS into three groups and analyses their change during the period 2007–2015. Then this study employs Panel Data Analysis to examine whether the level of knowledge-intensity will influence the economic performances of firms in KIBS.

This study adopts five indicators to evaluate the knowledge-intensive degrees of 13 service sectors in Taiwan. In other words, these knowledge-intensive grades are compared among different industries in the same year. The knowledge-intensive grade of one industry in a year was estimated with five indicators and then by obtaining the average of these knowledge-intensive grades in the period 2007–2015. This is the way this study evaluates the knowledge-intensive degree of service industries. The higher the knowledge-intensive grade the more intensive its knowledge is, and it is expected that this would result in greater economic performance.

The data this study collected is called panel data, and this Panel Data Analysis could construct and test more complicated models than purely cross-section or time-series data. If using the traditional OLS (Ordinary Least Square) method to estimate, it might lead to heterogeneity bias (Hausman, 1978). Therefore, this study draws on pooled regression to conduct an analysis and uses a fixed effect model and random effect model to avoid heterogeneity bias (Hausman, 1978).

The data this study collected is from the Directorate-General of Budget, Ministry of Science and Technology of Taiwan, Accounting and Statistics Department of Taiwan and Council of Labor Affairs of Taiwan, including education level, percentage of knowledge workers, percentage of R&D expenditure, vocational training rate, and E-learning rate. The operationalisations of these five variables and the indicators this study uses to estimate economic performance are as follows:

- Education level: this study separates education level into five types, including junior high level, senior high level, college level, master level, and doctor level.
- Percentage of knowledge workers: it presents the manpower enterprises utilise.

$$\text{knowledge workers}(\text{managers and professional})/\text{total employees} \quad (1)$$

- Percentage of R&D expenditure: this presents the enterprises how to attach importance to and allocate the creative or knowledge resources.

$$\text{R\&D expenditure}/\text{gross domestic product} \quad (2)$$

- Vocational training rate: this presents the efforts enterprises make to enhance the ability of their employees.

$$\text{person—times of vocational training}/\text{total employees} \quad (3)$$

- E-learning rate: this is used to estimate the degree enterprises obtain knowledge through the internet.

$$\text{person—joined on line courses}/\text{total employees} \quad (4)$$

- Productivity: per capita production, this is the way this study evaluates the economic performance.

$$\text{gross domestic product}/\text{total employees} \quad (5)$$

- Margin rate: rate of net profit, this is another way this study evaluates the economic performance.

$$\text{net profit}/\text{gross domestic product} \quad (6)$$

4. Empirical results

4.1. The evolution of knowledge intensity in Taiwan's KIBS

Knowledge-intensity in this paper is composed of education level, percentage of knowledge workers, R&D expenditure, vocational training rate and E-learning rate and transferred into knowledge-intensive grades by standardising to evaluate the knowledge intensity degree of KIBS. The higher the grade, the greater the knowledge-intensity degree. By using this estimation, this study classifies Taiwan KIBS into three groups: high, low and none. When the average knowledge intensity grade is higher than the third quartile, this industry is classified into the high knowledge intensity group; when it is lower than the first quartile it is the low knowledge intensity group, and the others belong to the no knowledge intensity group.

Table 1. Rank and classification of Taiwan's KIBS from 2007 to 2015.

Classification	Rank	13 Service industries	Knowledge-intensity
High knowledge-intensity group	1	Information and Communication	1.23
	2	Human Health and Social Work Activities	0.99
	3	Education	0.66
	4	Professional, Scientific and Technical Activities	0.42
	5	Financial and Insurance Activities	0.33
Low knowledge-intensity group	6	Public Administration and Defence; Compulsory Social Security	0.05
	7	Real Estate Activities	(0.25)
	8	Arts, Entertainment and Recreation	(0.45)
	9	Wholesale and Retail Trade	(0.61)
No knowledge-intensity group	10	Support Service Activities	(0.69)
	11	Transportation and Storage	(0.71)
	12	Accommodation and Food Service Activities	(0.78)
	13	Other Service Activities	(0.83)

Note: The first quartile (Q1) is -0.69 , and the third quartile (Q3) is 0.42 .

Source: Authors' calculations based on data provided by the Ministry of Science & Technology, and the Council of Labor Affairs, Taiwan.

From Table 1, it shows that the industries higher than the third quartile ($Q3 = 0.42$) are 'Information and Communication' (1.23), 'Human Health and Social Work Activities' (0.99), 'Education' (0.66), 'Professional, Scientific and Technical Activities' (0.42), and these four industries are the high knowledge-intensity group. 'Financial and Insurance Activities' (0.33) is slightly lower than the third quartile, but the operation style is similar to the high knowledge-intensity group. In addition to that, the knowledge-intensity grade of 'Financial and Insurance Activities' is very near to 'Professional, Scientific and Technical Activities', thus this study classifies 'Financial and Insurance Activities' into the group of high knowledge-intensity. 'Support Service Activities' (-0.69), 'Transportation and Storage' (-0.71), 'Accommodation and Food Service Activities' (-0.78) and 'Other Service Activities' (-0.83), whose knowledge-intensity grades are lower than the first quartile ($Q1 = -0.69$), thus, are classified into the no knowledge-intensity group. Between the first and the third quartile is the low knowledge intensity group, including 'Public Administration and Defence; Compulsory Social Security', 'Real Estate Activities', 'Arts, Entertainment and Recreation', and 'Wholesale and Retail Trade'.

Further, this study wants to know more about the knowledge-intensity level of each component in Taiwan's KIBS and the results are shown in Table 2. The most knowledge-intensive industry is 'Information and Communication', and its Percentage of R&D expenditure (2.51) is the highest among all sampled industries. Education level, percentage of knowledge workers, and vocational training rate of 'Information and Communication' are the top three of all. Aggregatively, the knowledge intensity of 'Information and Communication' is up to 1.23 and is the greatest, followed by 'Human Health and Social Work Activities', 'Education', and 'Professional, Scientific and Technical Activities' and 'Financial and Insurance Activities'. The knowledge intensity of 'Public Administration and Defence; Compulsory Social Security' is 0.05 and is classified into the low knowledge-intensity group, but it is worth paying much attention to its rate of e-learning (1.29), which is the highest compared to all other industries. This probably means that knowledge workers of 'Public Administration and Defence; Compulsory Social Security' are much more knowledgeable than any other members in the low knowledge-intensity group.

Table 2. Knowledge-intensity level of Taiwan's KIBS.

Classification	Rank	13 Service industries	Education level	Percentage of knowledge workers	Percentage of R&D expenditure	Vocational training rate	E-learning	Knowledge-intensity
High knowledge-intensity group	1	Information and Communication	1.17	1.29	2.51	0.41	0.65	1.23
	2	Human Health and Social Work Activities	0.91	1.50	0.32	1.47	0.82	0.99
	3	Education	1.27	2.04	(0.56)	(0.78)	1.12	0.66
	4	Professional, Scientific and Technical Activities	0.91	0.55	0.95	(0.32)	(0.08)	0.42
	5	Financial and Insurance Activities	0.89	(0.42)	(0.28)	1.11	0.46	0.33
Low knowledge-intensity group	6	Public Administration and Defence; Compulsory Social Security	0.72	(0.52)	(0.56)	(0.78)	1.29	0.05
	7	Real Estate Activities	(0.06)	(0.59)	(0.56)	0.07	(0.08)	(0.25)
	8	Arts, Entertainment and Recreation	(0.78)	(0.28)	(0.56)	(0.56)	(0.09)	(0.45)
No knowledge-intensity group	9	Wholesale and Retail Trade	(0.64)	(0.61)	(0.50)	(0.52)	(0.76)	(0.61)
	10	Support Service Activities	(0.89)	(0.69)	(0.56)	(0.41)	(0.83)	(0.69)
	11	Transportation and Storage	(0.91)	(0.72)	(0.52)	(0.49)	(0.87)	(0.71)
	12	Accommodation and Food Service Activities	(1.28)	(0.81)	(0.56)	(0.61)	(0.60)	(0.78)
	13	Other Service Activities	(1.33)	(0.72)	(0.51)	(0.53)	(1.03)	(0.83)

Source: Authors' calculations based on data provided by the Ministry of Science & Technology, and the Council of Labor Affairs, Taiwan.

Table 3. Rank and classification of Taiwan's KIBS at two stages.

Classification	Rank	First stage (2007 ~ 2010)		Second stage (2011 ~ 2015)	
		13 Service industries	Knowledge-intensity	13 Service industries	Knowledge-intensity
High knowledge-intensity group	1	Information and Communication	1.35	Information and Communication	1.13
	2	Human Health and Social Work Activities	0.82	Human Health and Social Work Activities	1.12
	3	Education	0.54	Education	0.76
	4	Financial and Insurance Activities	0.33	Professional, Scientific and Technical Activities	0.59
	5	Professional, Scientific and Technical Activities	0.21	Financial and Insurance Activities	0.34
Low knowledge-intensity group	6	Public Administration and Defence; Compulsory Social Security	0.03	Public Administration and Defence; Compulsory Social Security	0.06
	7	Real Estate Activities	(0.27)	Real Estate Activities	(0.23)
	8	Arts, Entertainment and Recreation	(0.45)	Arts, Entertainment and Recreation	(0.45)
No knowledge-intensity group	9	Wholesale and Retail Trade	(0.61)	Wholesale and Retail Trade	(0.60)
	10	Support Service Activities	(0.69)	Support Service Activities	(0.69)
	11	Transportation and Storage	(0.70)	Transportation and Storage	(0.71)
	12	Accommodation and Food Service Activities	(0.82)	Accommodation and Food Service Activities	(0.74)
	13	Other Service Activities	(0.83)	Other Service Activities	(0.83)

Note: In the first stage (2007–2010), the first quartile (Q1) is -0.69, and the third quartile (Q3) is 0.33; In the second stage (2011–2015), the first quartile (Q1) is -0.69, and the third quartile (Q3) is 0.59.

Source: Authors' calculations based on data provided by the Ministry of Science & Technology, and the Council of Labor Affairs, Taiwan.

Table 3 shows the results of the two stages. The first stage is in the period 2007–2010, and the second stage is in the period 2011–2015. The membership of each knowledge-intensity group does not change, but their rank has changed

Table 4. Relationship between five knowledge-intensity indicators and productivity.

Knowledge-intensity indicators	Co.	SE	t-value
Education Level	0.28	0.14	2.00*
Percentage of Knowledge Workers	0.12	0.08	1.60
Percentage of R&D Expenditure	(0.00)	0.00	(0.83)
Vocational training rate	0.50	0.06	7.91***
E-learning Rate	(0.01)	0.03	(0.44)

Note: * p -value < 0.05; *** p -value < 0.001.

Source: Authors' calculations based on data provided by the Ministry of Science & Technology, and the Council of Labor Affairs, Taiwan.

Table 5. Relationship between five knowledge-intensity indicators and margin rate.

Knowledge-intensity indicators	Co.	SE	t-value
Education Level	3,541	3,594	0.99
Percentage of Knowledge Workers	4,236	1,919	2.21*
Percentage of R&D Expenditure	(8)	8	(0.99)
Vocational training rate	14,190	1,597	8.89***
E-learning Rate	(894)	783	(1.14)

Note: * p -value < 0.05; *** p -value < 0.001.

Source: Authors' calculations based on data provided by the Ministry of Science & Technology, and the Council of Labor Affairs, Taiwan.

somewhat within the group. For example, 'Professional, Scientific and Technical Activities' is ranked lowest in the high knowledge-intensity group at the first stage, but it advances into the fourth one at the second stage.

Comparing these two stages, no industry changes its membership among groups during the period 2007–2015, only knowledge-intensity rank changes. Besides, from the results this study finds that the knowledge-intensity grades of the high knowledge-intensity group in the second stage are all greater than that in the first stage, except 'Information and Communication'. For example, the knowledge-intensity of 'Professional, Scientific and Technical Activities' is 0.21 in the first stage, and in the second stage it is up to 0.59. Knowledge-intensity of 'Information and Communication' is 1.35 in the first stage, but in the second stage it reduces to 1.13.

4.2. Knowledge intensity and economic performance

In Table 4, we can see that education level (p -value < 0.01) and vocational training rate (p -value < 0.001) have significantly positive influences on per capita production and that means enterprises with a higher education level and more vocational training rate can increase the productivity (Götzfried, 2004). This result is consistent with the expectation of this study. In Table 5, the empirical results show that the percentage of knowledge workers (p -value < 0.01) and vocational training rate (p -value < 0.001) are significantly positively related to margin rate, that is, the productivity creates higher values and brings a higher economic performance.

5. Conclusions and discussions

This study was undertaken to verify the degree of knowledge intensity and the relationship between knowledge intensity and economic performance in Taiwan's KIBS. Panel data from 13 KIBS sectors in Taiwan during the period 2007–2015 were

employed with a fixed effect model. The research period was further divided into two stages, 2006–2010 and 2011–2015, and there were four empirical findings in the study: first, the industries are classified into three groups as high, low, and no level of knowledge intensity, and the membership in each group does not change during the two stages; then, mostly the level of knowledge intensity increased from stage one to stage two, except ‘Information and Communication’ and ‘Transportation and Storage’; third, education level and vocational training rate positively influence the productivity of KIBS; finally, the percentage of knowledge workers and vocational training rate positively affect the margin rate.

There are some practical implications that can be derived from the empirical results of this study. Vocational training is positively related to the productivity of KIBS and margin rate, which means greater economic performance to a KIBS firm. The operation of KIBS is strongly associated with highly qualified employees, compared to manufacturing firms (Freel, 2006) and this would enhance the quality of service. If KIBS enterprises train their employees more and hire more knowledgeable workers, these high-quality knowledge inputs can contribute a virtuous circle to produce high-quality knowledge outputs and finally to bring about giant economic performance to them.

This study tries to empirically test the KIBS. First of all, prior studies rarely touch upon the diversity of KIBS (Consoli & Elche-Hortelano, 2010), which is done in this study by examining the knowledge intensity of service sectors. Then, this paper develops a unique measurement of knowledge intensity suited to the conditions of KIBS, which are further divided into three groups as high, low, and no level of knowledge intensity.

There is no standard approach and accepted definition of KIBS (Wood, 2002), but the NACE (nomenclature statistique des activités économiques dans la communauté européenne), which establishes the statistical classification of economic activities in the European community, has proven increasingly popular in identifying KIBS. The NACE lists KIBS, but does not further rank high knowledge-intensity, low knowledge-intensity and no knowledge-intensity. Therefore, according to our study, the high knowledge-intensity KIBS includes five sectors: Information & Communication, Human Health & Social Work Activities, Education, Financial & Insurance Activities, Professional, Scientific and Technical Activities. Moreover, this study integrates previous research (Cusumano et al., 2015; Rabetino et al., 2015; Smith et al., 2014; Visnjic et al., 2016) to examine the economic benefits of KIBS. The empirical findings show the achievements of KIBS in high levels of productivity and profitability/margin. On the other hand, the percentage of R&D expenditure (Bocquet et al., 2016; Chen & Dahlman, 2005; Rodriguez, 2013; Shearmur & Doloreux, 2015; Tseng et al., 2011) and e-learning rate (Starbuck, 1992) don’t seem to influence KIBS’ economic performance, according to the empirical findings. It is difficult to identify R&D in service activities because the boundaries between R&D and other innovation activities are usually not clear and are not specialised in a field of research, so R&D may be under-estimated in many cases (OECD, 2002; 2015) and doesn’t positively impact KIBS in the empirical study.

The limitations of this paper constitute possible avenues for future works. First, the measurement method of knowledge intensity is not limited to the one proposed

here. Future researchers can develop other measurement methods suited to their study objects. Then, the empirical results of this paper demonstrate that knowledge intensity is positively related to economic performance. However, this relationship may not be that direct. It is possible that there are underlying mechanisms operating to lead to the final economic benefits. For example, the study of Tseng et al. (2011) indicate that absorptive capacity induces innovative performance of a KIBS firm. One component of absorptive capacity in their study is knowledge input, which is similar in nature to the notion of knowledge intensity in this article. Thus, a logical inference can be made to propose the statement that knowledge intensity is the antecedent of absorptive capacity which leads to the final results of innovative performance or economic performance. The limitation of space makes it impossible to investigate this complex relationship in a paper. It is urged that future researchers conduct this kind of study to help scholars and practitioners to gain deeper understanding about this issue.

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