Sub-Theme: History and conditions for success

Measuring Triple Helix on the World Wide Web[1]

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Abstract

In this study, we examined the longitudinal trends in the university-industry-government (UIG) relationship on the Web in the Korea context by using Triple Helix (TH) indicators and various internet resources, such as, websites/documents, blogs, online cafés, and online news sites. The results indicate that the UIG relationship varied according to the government's policies and that there was some tension in the longitudinal UIG relationship. Further, websites/documents and blogs were the most reliable sources for examining the strength of and variations in the UIG bilateral and trilateral relationships on the Web. In addition, web-based T(uig) values showed a stronger trilateral relationship and larger variations in the UIG

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relationship than SCI-based T(uig) values.

Introduction

Information society theories postulate that information and flow, use, and control of information and knowledge is becoming central to the organisation of society, the economy, and our experience of everyday life. Knowledge-based societies have a well established knowledge infrastructure which works as an engine for organized novelty production and innovation to occur. It is believed that the linkages and interactions among government, academia, and industry is an essential element for the knowledge-based innovation system (Etzkowitz & Leydesdorff, 2000). Measuring and gauging the underlying structure and strength of relationship among the main components (University, Industry, and Government) of knowledge-based innovation system has attracted much attention (Leydesdorff and Guoping, 2001; Park et al., 2005; Leydesdorff et al., 2006; Leydesdorff & Fritsch, 2006; Leydesdorff & Sun, 2009) and several models and approaches have been proposed for measuring the knowledge infrastructure (Gibbons et al., 1994; Etzkowitz & Leydesdorff, 2000). For example, the Triple Helix Model (THM) is a well known approach for studying the linkages among industry, academia, and organization (Etzkowitz & Leydesdorff, 2000; Leydesdorff and Guoping, 2001). According to Park et al. (2005), "The network of university-industry-government relations can be considered as an institutional knowledge infrastructure that carries a system of operations containing science, technology, and knowledge-based innovations."(pp.6); and can be measured using techniques, such as, scientometrics, patens, and communication on the internet (Park, et al., 2005).

However, majority of the studies that measure this infra are conducted in non-Asian (i.e. English) context (Lee and Jeong, 2008) and are limited only to analyzing contents of written communication in English. In addition, existing studies that try to gauge the knowledge infra or relationship of the components of triple helix use well documented and formal written communications, such as, patent and publications, for example PARK et al. (2005). Furthermore, most of the knowledge-based innovation indicators, such as, Science Citation Index are available commercially and accessibly only to subscribers.

However, in this research, we try to measure the longitudinal trends of relationship among the three fundamental components of TH model: University, Industry, and Government (UIG) in Korean setup using World Wide Web (WWW). We showed that WWW and advanced search engines on the internet resources can indicate university-industry-

government relations using Triple helix indicators (Leydesdorff and Curran, 2000) in Korean context.

The rest of this paper is organized as follows: Section 2 provides a brief literature review. Section 3 discusses the research method. Section 4 presents the results, and Section 5 concludes.

Literature Review

The knowledge infrastructure of postindustrial societies plays a crucial role in their economic development. A number of studies have analyzed and gauged the underlying knowledge infrastructure (Gibbons et al., 1994; Leydesdorff & Guoping, 2001; Park et al., 2005; Leydesdorff et al., 2006; Leydesdorff & Fritsch, 2006; Jeong, 2008; Leydesdorff & Sun, 2009). Several approaches have been proposed for understanding the complex nature and behavior of entities involved in knowledge creation and diffusion within knowledge-based societies (Gibbons et al., 1994; Etzkowitz & Leydesdorff, 2000). For example, Gibbons et al. (1994) differentiated the so-called "Mode 2" knowledge production and diffusion from conventional knowledge creation, which they referred to as "Mode 1" and proposed that "Mode 2" knowledge production reflects a context-driven, problem-focused, and interdisciplinary process and is produced by interdisciplinary teams working together for a short period of time in a specific context. Criticizing Gibbons et al.'s (1994) concept, Etzkowitz and Leydesdorff (2000) proposed the TH model to explain the complex role of the knowledge infrastructure in the UIG relationship and stated that "The Triple Helix overlay provides a model at the level of social structure for the explanation of Mode 2 as a historically emerging structure for the production of scientific knowledge, and its relation to Mode 1" (pp.118).

The TH model can be used as a framework for measuring the underlying UIG relationship, and for this, various techniques have been used (e.g., Park et al., 2005; Leydesdorff et al., 2006; Leydesdorff & Fritsch, 2006; Leydesdorff & Sun, 2009). According to Park et al. (2005), the knowledge infrastructure can be measured over the internet by employing TH indicators. In addition, previous studies have employed TH indicators, together with webometric, scientometric, and co-word analysis techniques, to measure the knowledge infrastructure. For example, Park et al. (2005) provided a comparison of knowledge-based innovation systems between Korea and the Netherlands by using TH indicators in conjunction with webometric, scientometric, and technometric analysis techniques. Some studies have traced the UIG relationship by using the Internet. Leydesdorff

and Curran (2000) mapped the structural and institutional UIG relationships by using the Internet, particularly advance search engines, , and suggested that such relationships can be measured and compared using the Internet:

> The present research has taught us that it is possible to measure Triple Helix relations on the Internet and to compare among institutional agencies. From a theoretical point of view, it is important to note that these relations among textual units on the Internet can be considered as less codified counterparts of scientometric distributions retrieved in terms of co-words, co-authorship relations, etc. While the scientometric distributions refer to codified communication, Internet relations are not controlled and are based mainly on free text. (pp.14)

> I verified it. But, can we make changes in the quotation? As you did

Park et al. (2005) combined various techniques, including co-word analysis, to map the UIG relationship on the Internet and examined the relationship by using the occurrence and co-occurrence of the words "university," "industry," and "government" and employing advanced search techniques in specific internet domains. Similarly, Lee and Jeong (2008) used co-word techniques to analyze and map the overall evolutionary trend in Korea's national R&D efforts in robotics.

However, most of the previous studies have measured the knowledge infrastructure in non-Asian (English) contexts (Lee & Jeong, 2008), and thus, they have typically analyzed only the English content of written communication such as patents and publications (Park et al., 2005; Park & Leydesdorff, 2008; Park & Leydesdorff, 2010). Thus, the present study measures the strength of the UIG relationship in the Korean context by using the Web.

Research Methodology

Method

We employed webometric (Björneborn & Ingwersen, 2004), content analysis (Holsti, 1969), and co-word analysis techniques (Callon et al., 1991). According to Björneborn and Ingwersen (2004), webometrics is "the study of the quantitative aspects of the construction and use of information resources, structures and technologies on the Web drawing on bibliometric and informetric approaches" (pp.1217). Webometrics is also defined as "the study of web-based content with primarily quantitative methods for social science research goals using techniques that are not specific to one field of study" (Thelwall, 2009, pp.6). Similarly, bibliometrics is used to study or measure text and written communication (Pritchard, 1969). The two most commonly used bibliometric techniques are citation

4

analysis and content analysis. According to Holsti (1969), the purpose of content analysis is to objectively and systematically identify explicit characteristics of massages for the sake of inferences. Similarly, co-word analysis is a bibliometric technique for analyzing linkages and associations among pairs of words co-occurring in a particular domain. This technique helps researchers to trace the trend in a specific technology domain or linkages among entities. The strength of the co-word analysis technique lies in the fact that the object of analysis can be extended to different domains such as patents, reports, websites, and newspapers (Lee & Jeong, 2008). Co-word analysis involves four steps (Lee & Jeong, 2008): 1) the frequency of the co-occurrence of pairs of words in documents is determined, 2) a similarity matrix is created, 3) words/phrases are clustered, and 4) the results are interpreted.

Data collection

We collected the data from *Naver.com* in March 2010 by using WeboNaver. Naver.com is the most popular search engine/portal in Korea for emails, blogs, and online cafes, among others. WeboNaver is a webometric analysis tool for automatically collecting indexed data from Naver. WeboNaver can be downloaded free of charge from http://english-webometrics.yu.ac.kr.

To collect the data, we used the following search terms: "대학(dae-hawg: university)" "기업(ghi-oeup: industry)" and "정부(Jeong-bu: government)." Although the literal translation of the word "industry" is "산업(san-oeup)" in Korean, we used "기업(ghi-oeup)" because it was deemed to be more suitable for the query (Park et al., 2005). Park et al. (2005) also used these search terms to provide a comparison of knowledge-base innovation system between Korea and the Netherlands. *Naver* started its service in 1998, and thus we collected data from 1999 to 2009. The longitudinal data were used to track changes in the UIG relationship over the 1999-2009 period.

More specifically, as shown in Table 1, we determined the number of hits for queries reflecting different combinations of the terms "university" (U), "industry" (I), and "government" (G) by using Boolean operators (e.g., "and" and "not"). For example, the value "21" in the cell between "U" and "1999" means that there were 21 mentions of the term "university" in 1999. During this process, we excluded documents including the terms "industry" and "government." For this particular case, the search string was "university! industry! government." Therefore, we retrieved only those documents containing the term

"university."

We recorded the number of word occurrences in titles and content but used the number of hits occurring in the tittles only, because the data collected XXX were unreliable and inconsistent over time. Then, to specifically examine the UIG relationship, we collected data for each of the following five Naver categories: regular webpages/documents, Knowledge-In (comparable to Yahoo! Answers), blogs, online cafés/the bulletin board system (BBS) (e.g., message and discussion boards), and news (news articles from online news sites).

Table 1 Number of hits for TH components from 1999 to 2009

Year	U	I	G	UI	UG	IG	UIG
1999	21	23	8	0	0	0	0
2000	2210	13836	4712	47	10	187	1
2001	3024	17687	5977	30	7	184	0
2002	4537	28529	5984	80	24	170	2
2003	21767	36352	13947	308	147	567	81
2004	69717	55637	33825	2249	2399	4631	1088
2005	90899	68210	42696	2724	2939	5323	1475
2006	233,768	138,193	91,181	9,918	9,099	16,621	4,703
2007	496227	295467	151214	22063	15346	30305	7615
2008	677336	392342	271605	30568	21062	50311	10255
2009	814746	502035	276756	38755	24734	56293	12086

Analysis

We analyzed the data by using the TH indicators developed by Leydesdorff (2003) and Park and Leydesdorff (2010), who based the indicators on Shannon's information theory (Shannon, 1948; Shannon & Weaver, 1949). We also used the occurrence and co-occurrence of the terms "university," "industry," and "government" by using Boolean operators. According to Leydesdorff and Curran (2000), variations in the UIG relationship, that is, the strength and weakness of TH components, can be measured using TH indicators and advanced search engines. For example, Leydesdorff (2003) showed that mutual information on the two (e.g. university-industry (UI)) and three (e.g. university-industry-government (UIG)) dimensions can be expressed using T(ui) and T(uig) respectively. Here T(ui) and T(uig) denote the mutual information transmission in two and three dimensions, respectively.

The transmission (T) is measured by "bit." The T value can be negative or positive (or zero) depending on the relative size of the three TH components' contribution.

Note that T values for two dimensions:T(ui), T(ug), and T(ig)) are, by definition, positive and that trilateral relationships i.e. T(uig) are operationalized as negative (Leydesdorff, 2003; Park & Leydesdorff, 2010). We calculated the TH indicators by using the relative frequency or the probability distribution (for a mathematical definition, see Leydesdorff, 2003) and T values by using a standard technique in the TH program available at http://www.leydesdorff.net/th2/index.htm.

Results

Longitudinal Trends in the UIG Relationship by Category

Figure 1 shows the longitudinal trend in T(uig) values by category. *Blogs* indicated the strongest trilateral relationship since 2004, reaching T(-0.400) in 2008; the highest T values . Similarly, *Webpages/docs* showed large variations in the trilateral relationship, indicating several ups and downs in the relationship. Further, *News sites* indicated a consistently improving trilateral relationship since 2002, reaching to its highest point in 2009, as indicated by T values (Figure 1).

Furthermore, *Webpages/docs* revealed large variations in the UIG relationship. Before 2002, the T(uiq) values for *Webpages/docs* were stable, varying between -0.350 and -0.400 and indicating clear bilateral trends in the UIG relationship. However, since 2003, this relationship has weakened. This may be due to the effects of the global dot-com crash on Korea. Park et al. (2005) offered a similar conclusion. For 2004, 2005, 2006, and mid-2007 the T(uig) values were as low as -0.200, indicating the weakest trilateral relationships. However, the T(uig) values increased sharply from 2007, indicating the normalization of the UIG relationship. This may be due to the presidential election in December 2007 and political campaigning on the Web. Noteworthy is that the T values for *Webpages/docs* collapsed when blogs became popular in 2003-2004. In a similar vein, the T(uig) values for *News sites* increased steadily since 2002. During this period, there was a substantial increase in the number of blogs and online new sites containing the terms "university", "industry", and government".

Surprisingly, compared with other categories, *Knowledge-In* indicated a weak UIG relationship, despite its status as the most popular service in Korea. This may be because most of the Knowledge-In documents mentioned only the term "university"; most of the

7

Knowledge-In users are elementary/high school students with many questions about universities and are thus not likely to be interested in bilateral and trilateral UIG relationships. The following sections discuss each category (*Webpages/docs*, *Blogs*, *Knowledge-in*, *News sites*, and *Cafes/BBS*) separately.
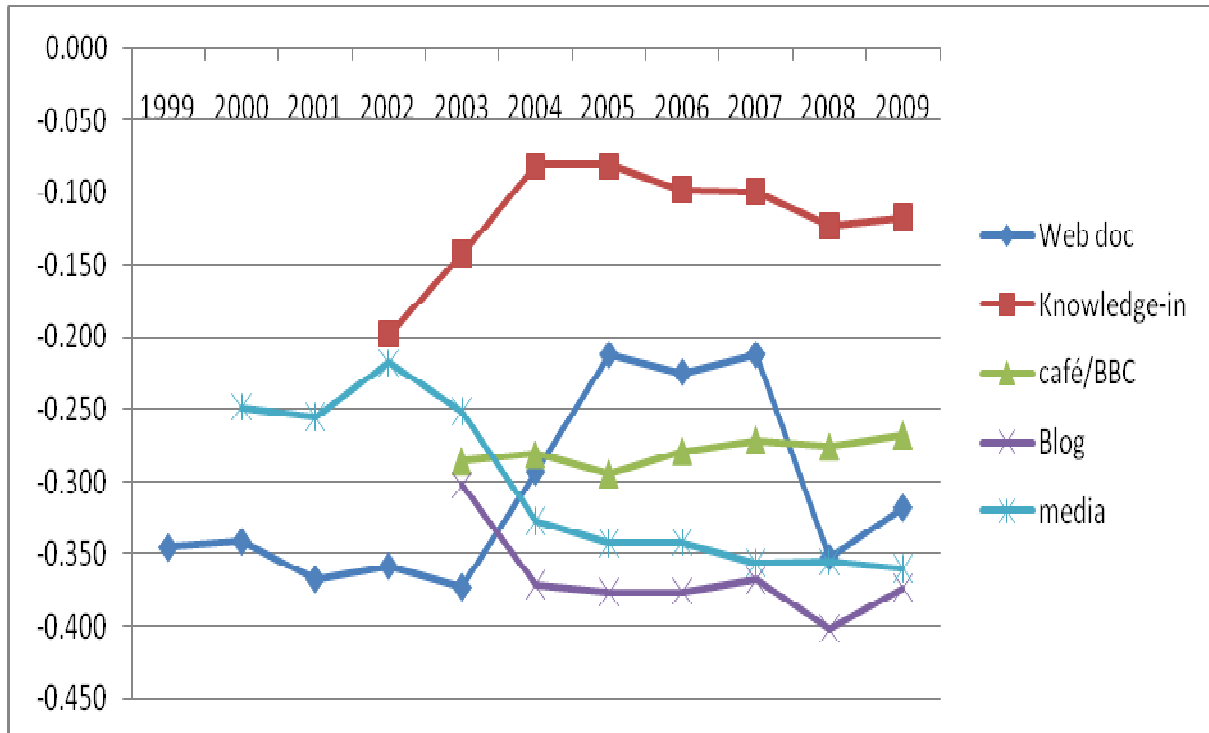

Figure 1 Longitudinal trends in web-based T(uig) values by category

Webpages/Docs

The Occurrences and Co-Occurrence of UIG Terms

Figure 2 shows the occurrence and co-occurrence of the terms "university" (U), "industry" (I), and "government" (G) for the *Webpages/docs* category. Although there was an increase in the number of webpages and documents containing the terms U, I, and G since 1999, there was no improvement in the bilateral and trilateral relationships as a percentage of the increase in the number of webpages and documents as a whole. (*Pls.verify.) There was a steady increase in the number of the terms U, I, and G. Figure 2 shows a clear division between the top three lines (U, I, and G) and the remaining lines (bilateral and trilateral relations: UI, UG, IG, and UIG). This division may be because most users in Korea employ the Internet for academic purposes. A large majority of users are university students who produce documents covering a topic of special interest and download/upload them on the Web. In addition, most of the universities in Korea have their own websites, making

academic procedures available on the Internet. Thus, these factors might have limited the exposure of bilateral and trilateral UIG relationships on the Web.
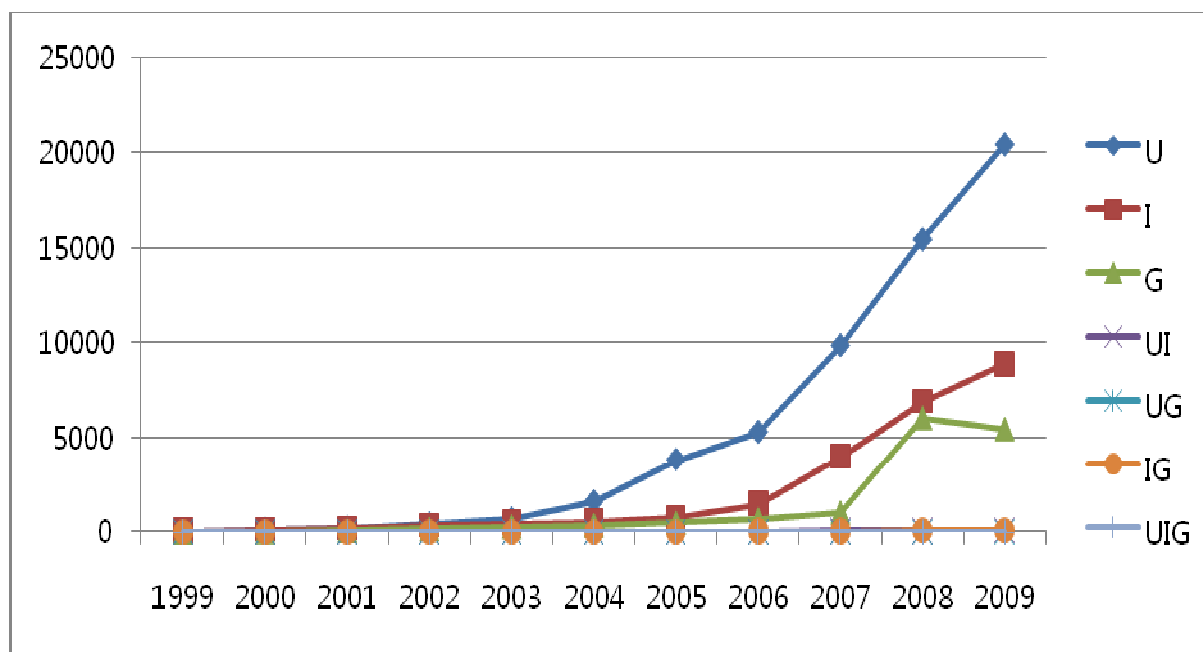

Figure 2 Longitudinal trends in the occurrence of U, I, and G in titles of webpages/docs

Longitudinal Trends in the UIG Relationship

Figure 3 shows the longitudinal trend in bilateral and trilateral UIG relationships for *Webpages/docs* (expressed in terms of T values). The bilateral T values for U and I were the highest, indicating the important role played by *Webpages/docs* in the UI relationship. Noteworthy is the conflicting behavior of the UI and UG bilateral relationships. The T(ui) values started to increase sharply in 2005 and peaked in 2007 (-0.600), whereas the T(ug) values started to decrease in 2005 and bottomed out in 2007 (-0.100). This provides evidence of some tension in the longitudinal UIG relationship in Korea. For example, between 1999 and 2009, the strengthening of the bilateral UI relationship was always accompanied by the weakening of the bilateral UG and IG relationships and vice versa. This may be due to the lack of coordination among the three TH components. This is also indicated by the lack of a strong trilateral relationship, that is, low T(uig) values, from 2005 to 2007.

Further, the IG relationship showed the lowest T values for all the years. The IG relationship was weakest between 2003 and 2007. This may be due to President Roh's preference for the UI relationship over the IG/UIG relationships. The UIG relationship, which showed the lowest T values during the Roh administration, provides support for this view. Further, the T(uig) values started to increase from 2007, when President Lee took office.
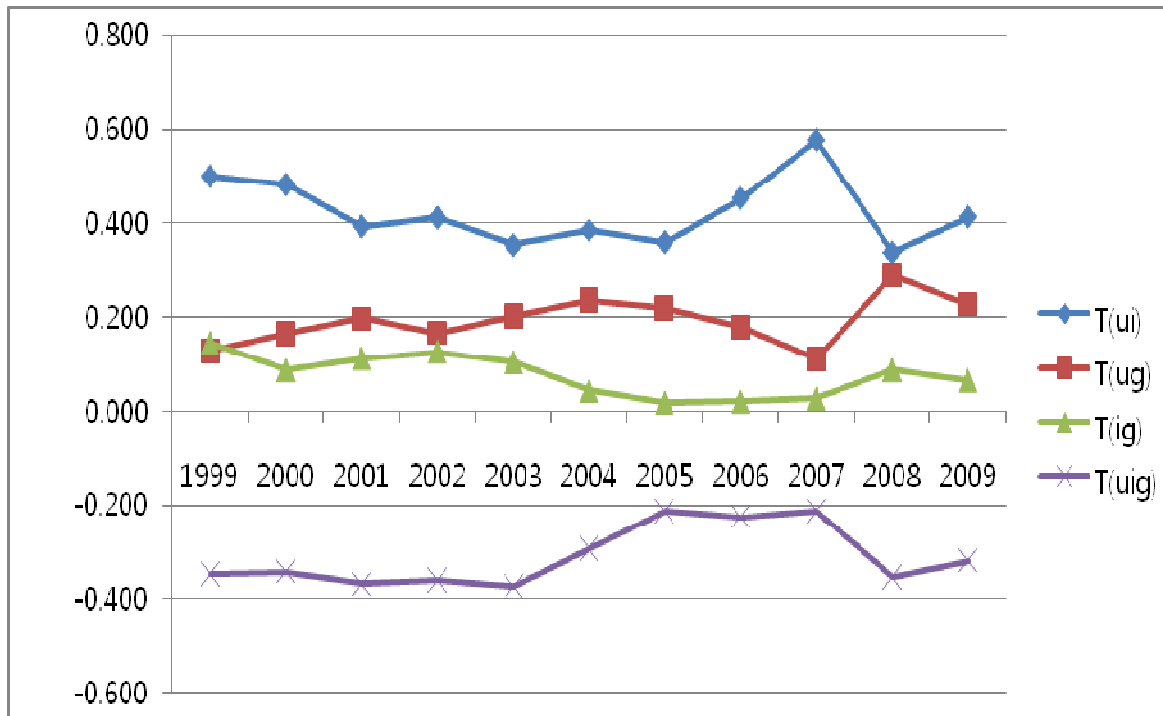
9

Figure 3 Longitudinal trends in bilateral and trilateral UIG relationships for *Webpages/Docs*

Knowledge-In

The Occurrences and Co-Occurrence of UIG Terms

Figure 4 shows the longitudinal trend in the occurrence of the terms U, I, and G in titles of documents obtained from Naver's Knowledge-In service. Only the term U increased noticeably since Naver started the Knowledge-In service in October 2002. Noteworthy is that whereas U increased dramatically, reaching 35,285 hits, the other terms remained below 5,000. In particular, the co-occurrence of the terms U, I, and G did not increase as much as that of individual terms. Most of the dramatic increases in the occurrence of U, I, and G in titles of Knowledge-In documents occurred from 2002 onward, demonstrating an upward trend. Within four months of the service, a total of 400,000 Knowledge-In documents were uploaded, and there were 6.5 million daily visitors. The occurrence of U increased sharply and continued at a high rate, whereas the occurrence of I and G kept low counts. As mentioned earlier, this may be because most of the Knowledge-In users are students whose main interest is in universities. In addition, even before the advent of Web 2.0, the convenience of searching, retrieving, and producing information by using Knowledge-In may have contributed to the explosion of questions and answers. In addition, since Naver started

offering Knowledge-In free of charge in 2002, its collection of web documents has expanded exponentially. Thus, it is likely that the hits for web content containing the term U were influenced by the Knowledge-In service.
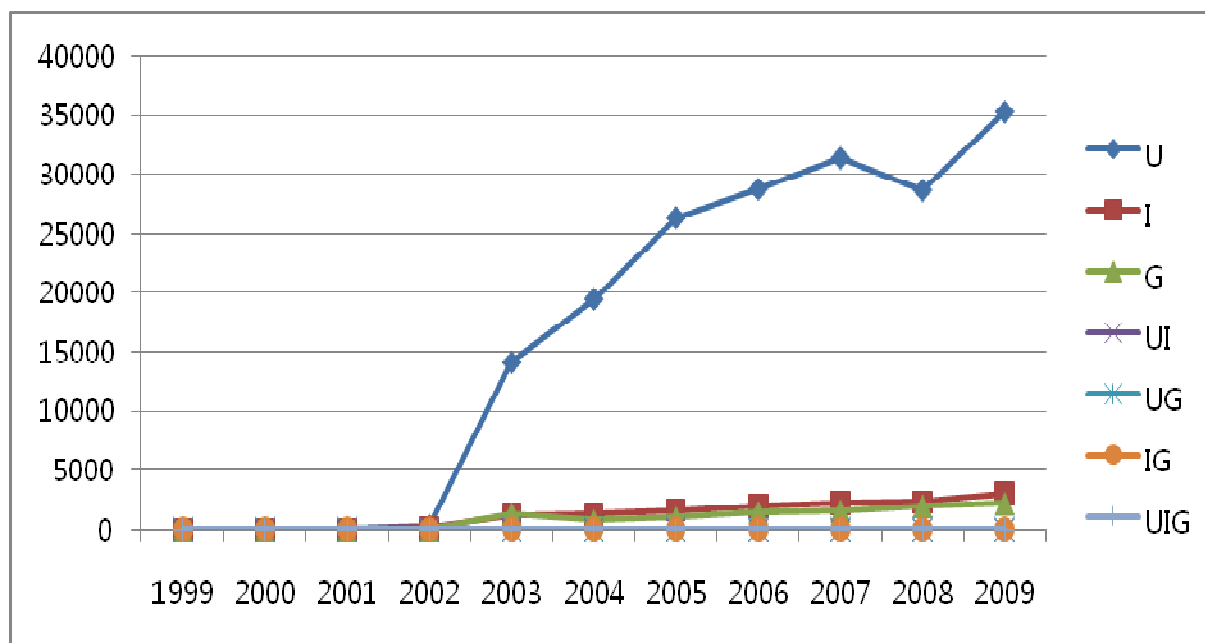

Figure 4 Longitudinal trends in the occurrence of U, I, and G in titles of Knowledge–In documents

Longitudinal Trends in the UIG Relationship

Although Knowledge-In users' interest is rooted in university-related topics, it is possible to observe and track longitudinal trends and variations in the UIG relationship by using T values. Figure 5 shows the longitudinal trend in bilateral and trilateral UIG relationships for *Knowledge-In*. As indicated by the T(ui) values, the bilateral UI relationship was stronger in mid-2002, when the Knowledge-In service was introduced. However, this relationship weakened dramatically since mid-2002 as a result of the dot-com crisis. The other bilateral and trilateral relationships also weakened during this period. The UIG relationship never normalized or reached the initial 2002 level. On the other hand, the T(ig) and T(uig) relationships were almost nonexistent. However, the higher T(ui) values suggest that Knowledge-In users are somewhat interested in the UI relationship. This may be because these users are likely to perceive this relationship as a source of financial support for their higher education. In addition, the government has been implementing policies to improve this relationship, which is supported by the slight improvement in the UIG relationship and the bilateral UI relationship in 2007, when President Lee was in office.
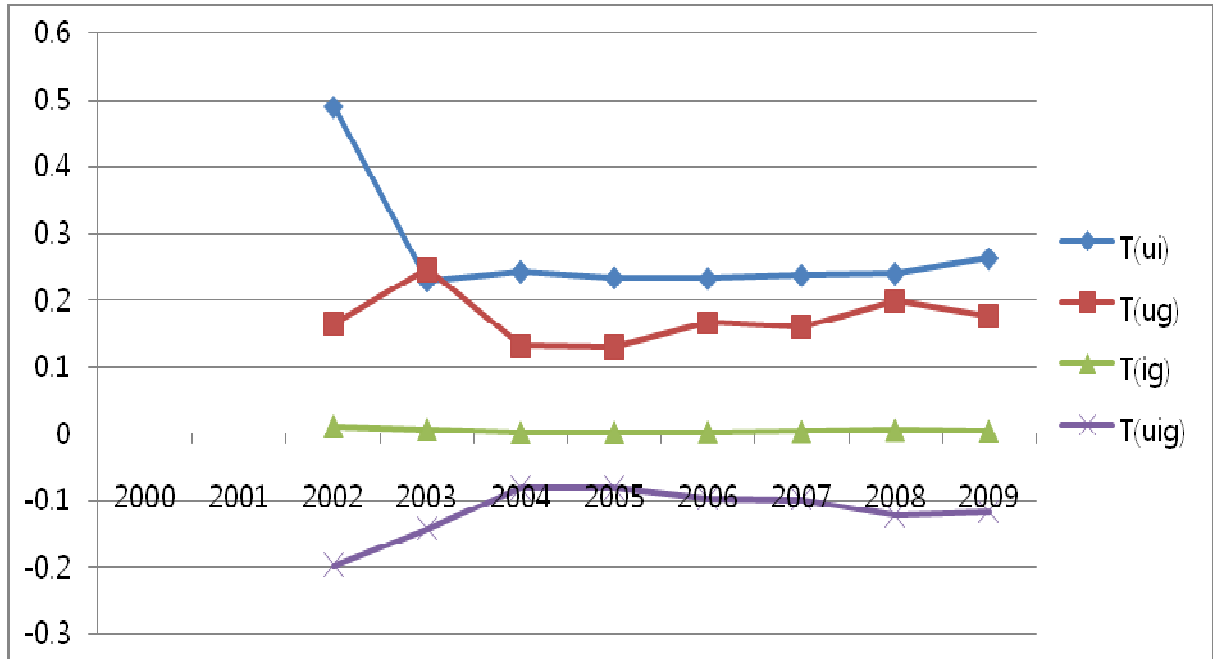
11

Figure 5 Longitudinal trends in bilateral and trilateral UIG relationships for Knowledge-In

Blogs

The Occurrences and Co-Occurrence of UIG Terms

Figure 6 shows the longitudinal trend in the occurrences and co-occurrence of U, I, and G in blog titles. Noteworthy is that the occurrence of U and I increased at almost the same rate since the blog service started in 2003. The occurrence of U increased from 254 hits in 2003 to 64,208 in 2009, and the occurrence of I increased from 173 to 64,209. The occurrence of G also increased from 2003 to 2008, the last year of the Roh administration, but it leveled off in 2009. Compared with Knowledge-In (Figure 4), blogs (Figure 6) facilitated more discussions about I and G because of their professional focus. However, the co-occurrence of U, I, and G was relatively low.
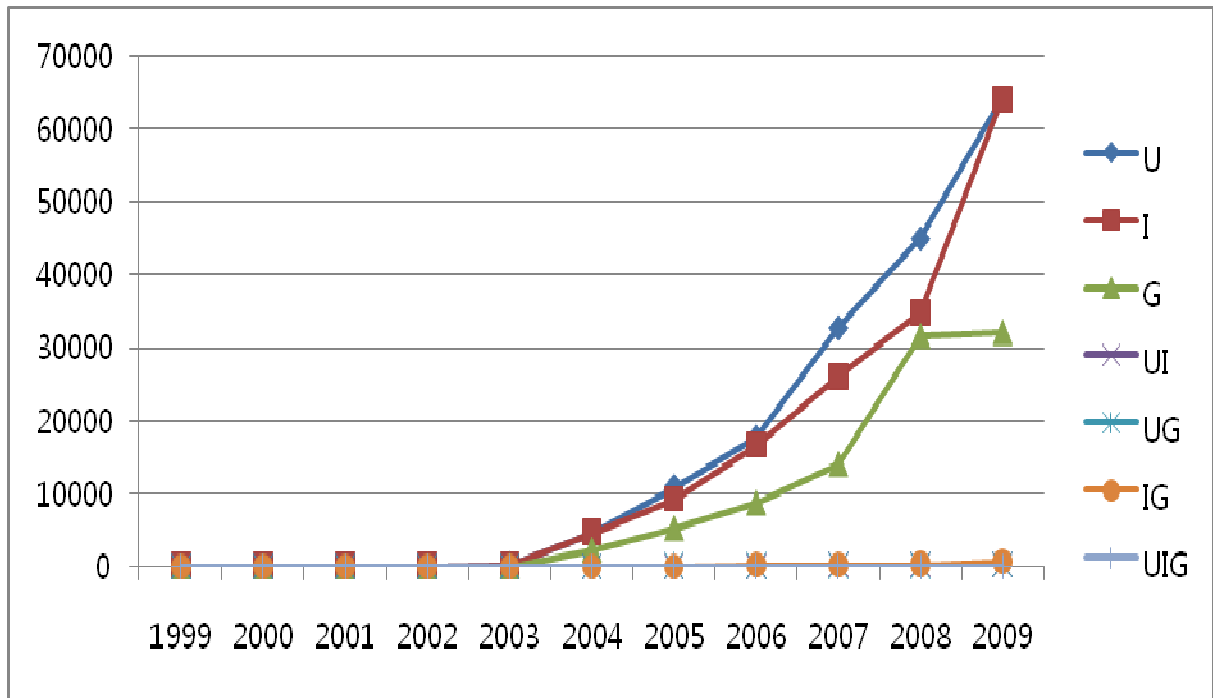
Figure 6 Longitudinal trends in the occurrence of U, I, and G in blog titles

Longitudinal Trends in the UIG Relationship

Figure 6.1 shows the longitudinal trend in bilateral and trilateral UIG relationships for *Blogs*. Noteworthy is that *Blogs* showed the strongest trilateral relationship. The trilateral relationship remained steady throughout the 1999-2009 period, and the T(uig) value reached -0.400 in 2008. Further, among bilateral relationships, the UI relationship was the strongest. The UI relationship peaked in 2003 in terms of the T(ui) value, and since then, the relationship weakened dramatically and stayed weak from 2004 to 2007. The relationship weakened again in 2008 but returned to previous state in 2009. In addition, the T(ug) and T(ig) values remained lower than the T(ui) values, and there were no noticeable variations.

Noteworthy is the conflicting behavior of the T(ui) and T(ug) relationships. An increase (decrease) in T(ui) values was accompanied by a decrease (increase) in T(ug) values.

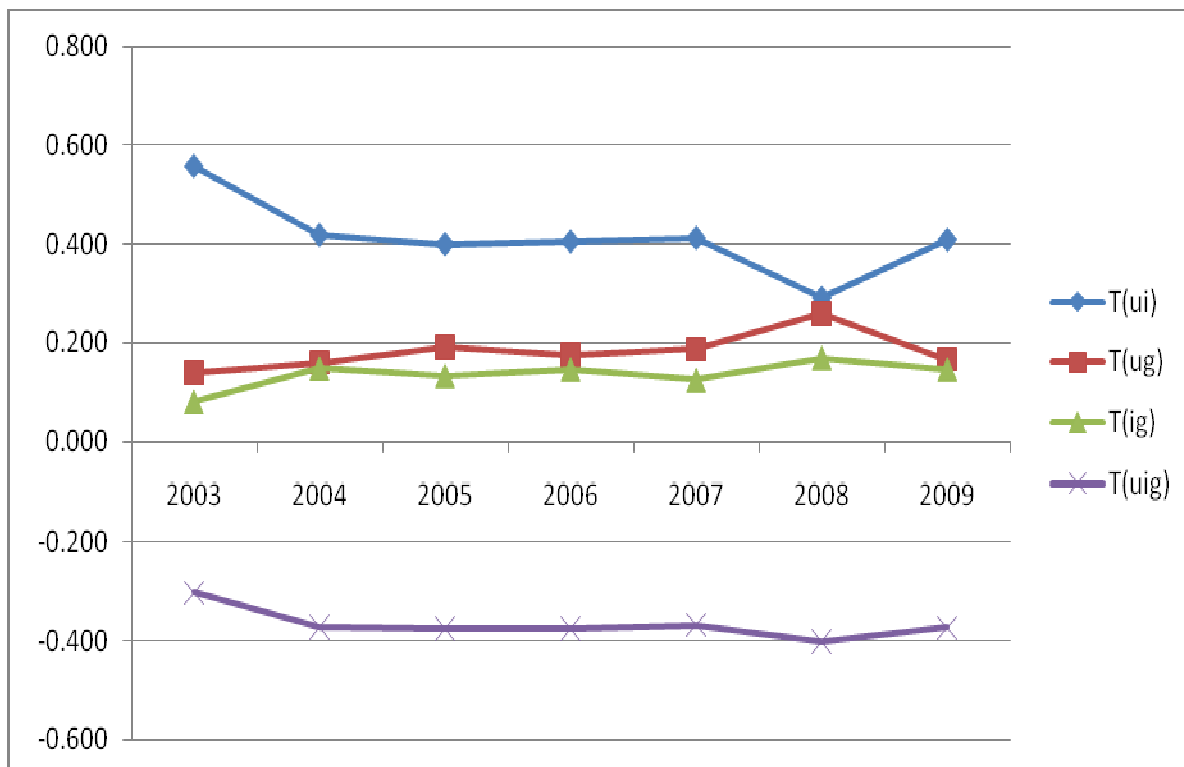**Figure 6.1 Longitudinal trends in bilateral and trilateral UIG relationships for _Blogs Cafés/BBS_**

The Occurrences and Co-Occurrence of UIG terms

Figure 7 shows the longitudinal trend in the occurrences and co-occurrence of the terms U, I, and G in titles of café/BBS documents. The results are generally consistent with those for the other categories. There were 1,549 hits for U in 2003, when Naver started its café/BBS service, and 664.941 hits in 2009. There were 952 hits for I in 2003 and 353.196 hits in 2009. Noteworthy is that there were nearly 70,000 hits for IG between 2008 and 2009 and approximately 50,000 hits for UI, which were the highest numbers of hits across the categories for the co-occurrence of IG and UI. This may be due to the professional nature of cafes and the BBS and users' interest in the country's affairs and business.
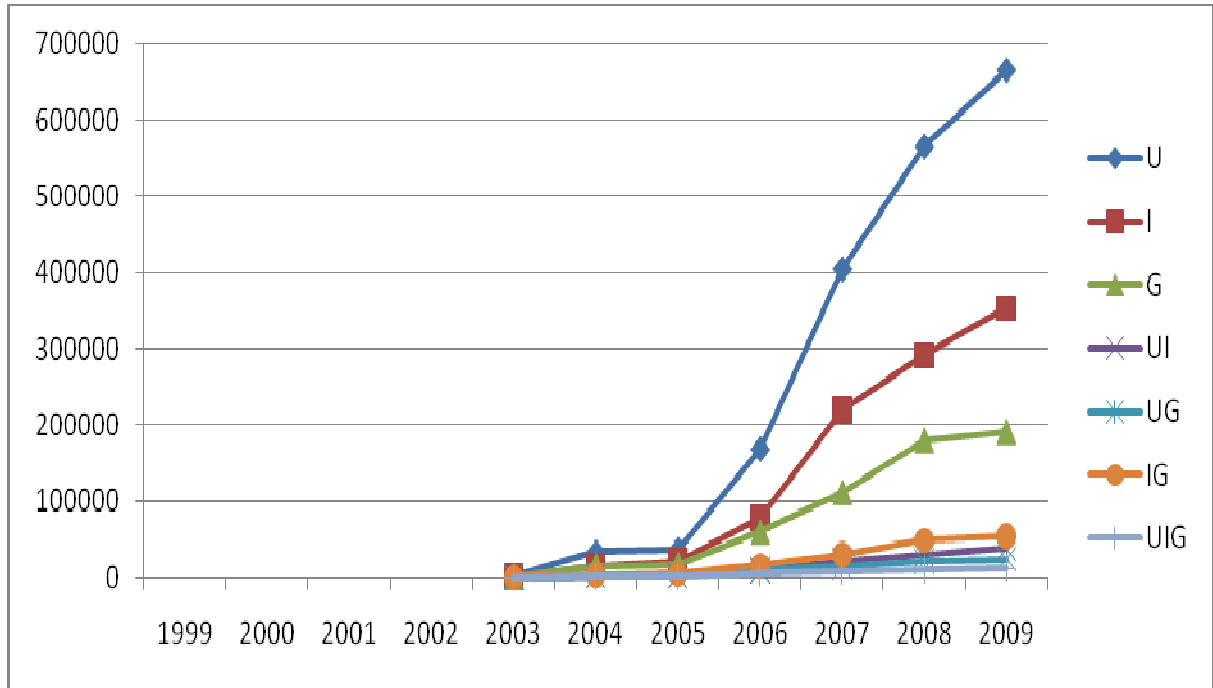
Figure 7 Longitudinal trends in the occurrence of U, I, and G in titles of café/BBS documents

Longitudinal Trends in the UIG Relationship

Figure 7.1 shows the longitudinal trend in bilateral and trilateral UIG relationships for *Cafés/BBS* in terms of T values. *Cafés/BBS* provided the highest T(ui) values, which showed an upward trend. The bilateral UI relationship peaked in 2007. The T(ui) and T (ug) values diverged beginning in 2004. An improvement in the UI relationship weakened the UG relationship and vice versa. On the other hand, the IG relationship was almost nonexistent. Finally, *Cafés/BBC* showed a strong trilateral relationship, but here were no large variations in the relationship.
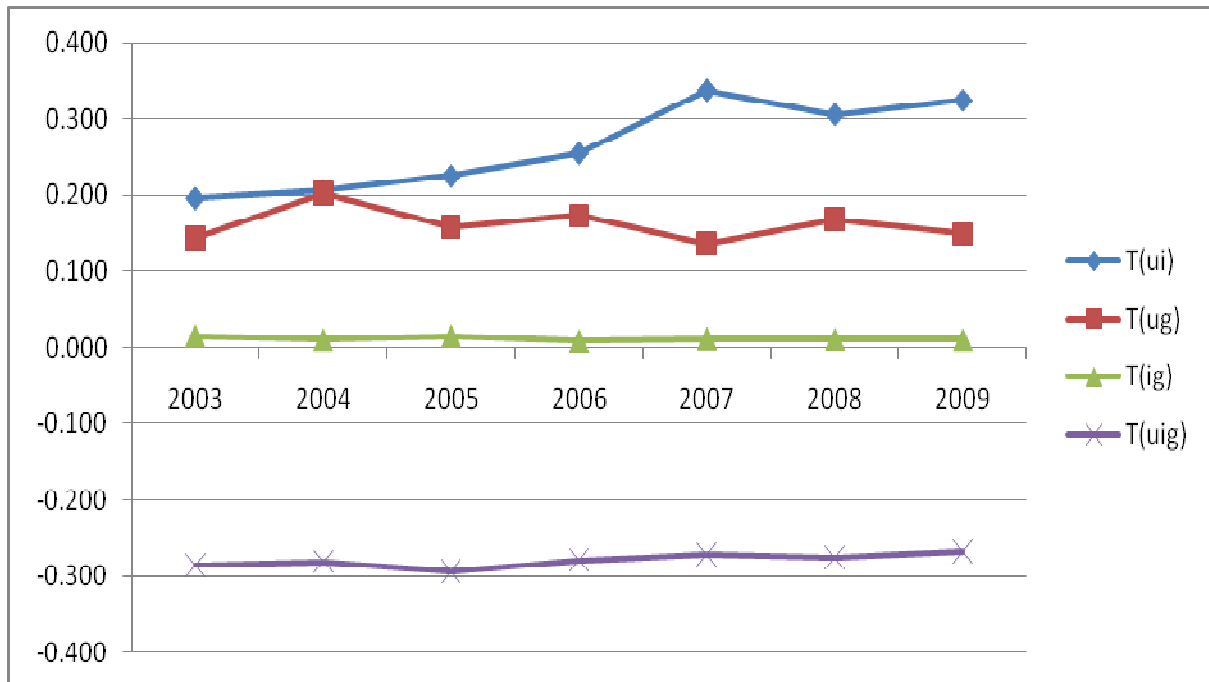
15

Figure 7.1 Longitudinal trends in bilateral and trilateral UIG relationships for *Cafés/ BBS*

News Sites

The Occurrences and Co-Occurrence of UIG Terms

Noteworthy is that the titles of documents from online news sites, unlike those of documents from other categories, provided the highest number of hits for I, followed by G (Figure 8). This is consistent with the media's keen interest in business and politics. The occurrence of the term I led that of the other terms and showed a steady upward trend since 1999 (with minor ups and downs). The occurrence of the term G increased steadily since 1999, rising sharply in 2007 and then declining slightly in 2008. In contrast to the other categories, *News sites* provided the lowest number of hits for the term U. This may because of the media's lack of interest in academic matters. Finally, the terms U, I, and G did not receive much attention from online news sites.
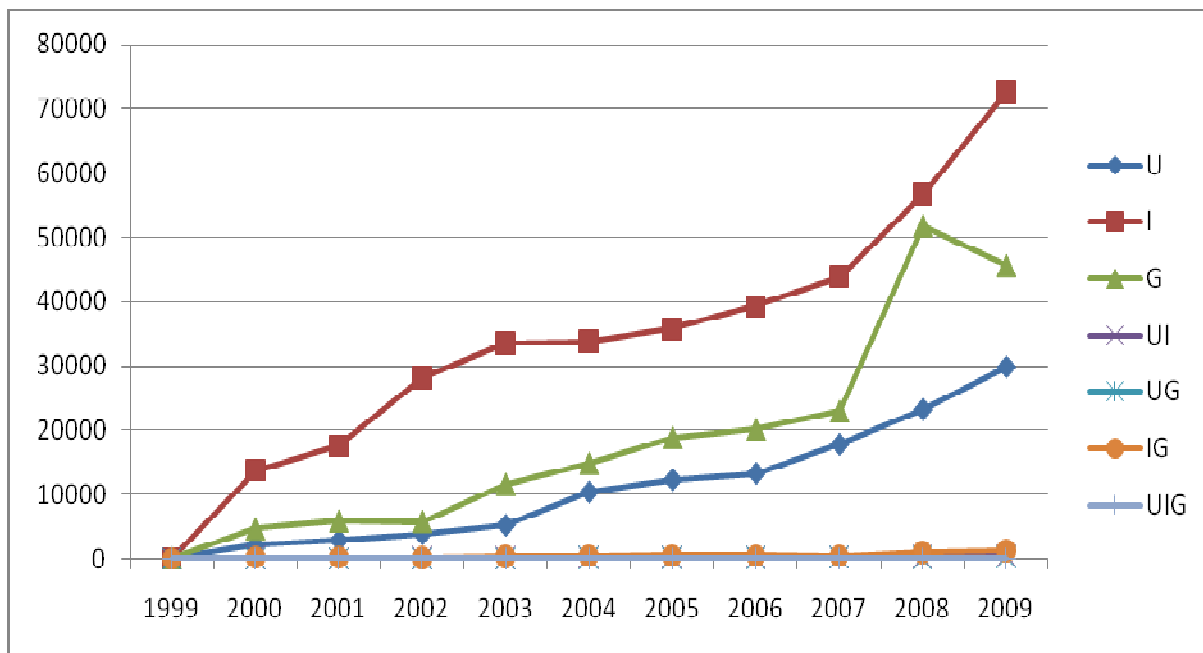
Figure 8 Longitudinal trends in the occurrence of U, I, and G in titles of documents on online news sites

Longitudinal Trends in the UIG Relationship

Consistent with the results in previous sections, News sites showed the strongest bilateral IG relationship in terms of the T value (Figure 8.1). Noteworthy is that an improvement in the bilateral IG relationship was accompanied by a decline in the bilateral UI relationship and vice versa. Further, the trilateral relationship strengthened since 2002 onward, peaking in 2009. Similarly, the UG relationship was at its weakest (almost nonexistent) in 2002 but showed some improvement in subsequent years. However, this relationship was weaker than the UI and IG relationships.
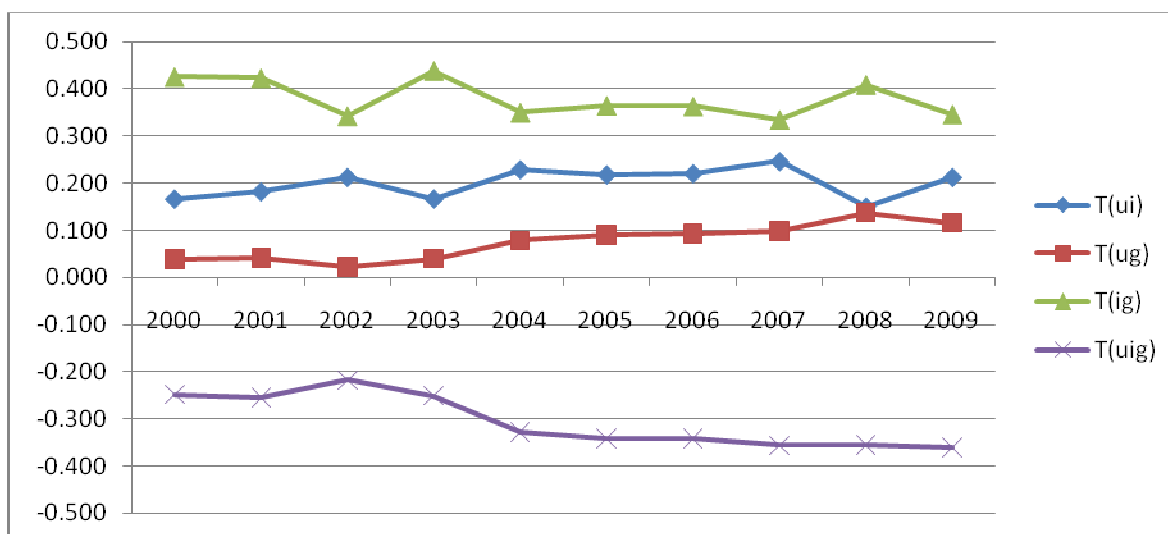

Figure 8.1 Longitudinal trends in bilateral and trilateral UIG relationships for *News*

17

sites

A Comparison Between SCI–Based T(uig) and Web-Based T(uig)

We compared web-based T(uig) values with SCI-based T(uig) values, which were calculated using SCI publications for the same period for each TH component (Figure 9). Using SCI-based T values to examine bilateral and trilateral relations among TH components is well known (Park et al., 2005; Leydesdorff & Fritsch, 2006; Park & Leydesdorff, 2010). Surprisingly, compared with SCI publications, web-based resources (i.e., blogs, online news sites, Knowledge-In, webpages/documents, and cafés/the BBS) showed a stronger trilateral relationship: the web-based resources showed lower T(uig) values. Similarly, web-based T(uig) values accounted for a larger portion of the variation in the UIG relationship than SCI-based T(uig) values, which, to some extent, remained steady throughout the sample period. This striking difference may be because internet resources are more diverse than SCI-based indicators, which are strictly codified and available commercially only to a restricted number of users.
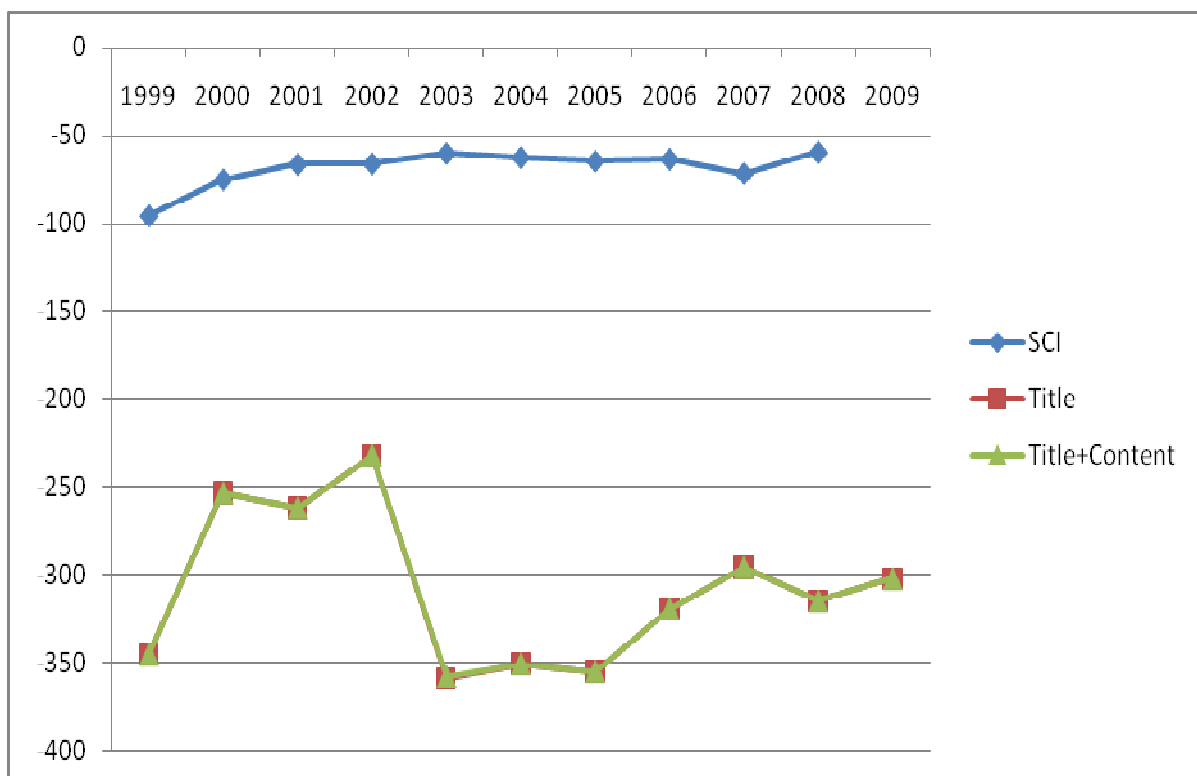

Figure 9 A Comparison between web-based T(uig) and SCI-based T(uig) values

Discussion

This study gauges the longitudinal UIG relationship by using the Web in the Korean context.

The results provide evidence of some tension in the longitudinal UIG relationship in

Korea. For example, an improvement in one bilateral relationship was always accompanied by a decline in another bilateral relationship and vice versa. This tension was mostly apparent in the bilateral UI and UG relationships. This may be due to political and economic constraints influencing these parties. In addition, the UIG relationship varied according to the government's policies.

Webpages/Docs showed the highest T(ui) value (0.600) for the bilateral UI relationship. That is, *Webpages/Docs* was the best indicator of the UI relationship. Similarly, *Webpages/Docs* accounted for the largest portion of the variation in the trilateral relationship. On the other hand, *Blogs* showed the highest T(uig) value (-0.400) for the trilateral relationship. In other words, *Blogs* was the best indicator of the trilateral relationship. These results suggest that webpages/documents and blogs are the most reliable internet sources for examining the strength of and variations in biliteral and trilateral UIG relationships and that *Webpages/Docs* and *Blogs* are important indicators of bilateral and trilateral UIG relationships on the Web

Further, except for *News sites*, all the categories showed the highest T value for the UI relationship; *News sites* provided the highest T value for the IG relationship. In addition, except for *News sites*, all the categories provided the highest number of hits for U, followed by I and G, in that order; *News sites* provided the highest T value for IG, followed by UI, and UG ,in that order. This suggests that U and I have the most visible relationship on the Web, followed by UG and IG, in that order, and that, unlike other internet sources, online news sites are interested mainly in the bilateral IG relationship. This may be due to the media's keen interest in business and politics, which is consistent with the media's fundamental motivation.

The highest numbers of hits were for IG and UI in titles of documents from cafes and the BBS. This may be due to the professional nature of cafés and the BBS and users' keen interest in the country's affairs and business. Compared with SCI publications, web-based resources (i.e., blogs, online news sites, Knowledge-In, webpages/documents, and cafés/the BBS) showed a stronger trilateral relationship. In addition, web-based T(uig) values accounted for a larger portion of the variation in the UIG relationship than SCI-based T(uig) values, which, to some extent, remained steady throughout the sample period. These results indicate that internet resources (e.g., advanced search engines and web documents), together with TH indicators, can be used to examine the UIG relationship, which is consistent with the findings of previous studies (Leydesdorff, 2000; Leydesdorff, 2003).

Contributions and Limitations

This study contributes to the literature by using the Web to measure longitudinal trends in the UIG relationship. First, the study add to the existing literature that measure the UIG relationship by using the Web (Leydesdorff, 2000; Leydesdorff, 2003; Park et al., 2005) and empirically validate the existence of such relationships. For this, this study proposes the use of a number of internet resources, including blogs, online news sites, Knowledge-In, webpages/documents, and cafés/the BBS for measuring UIG relationship on the Web. Second, this study demonstrates that internet resources (e.g., advanced search engines), together with TH indicators, can be used to examine the UIG relationship, which is consistent with the findings of previous studies (Leydesdorff, 2000; Leydesdorff, 2003). Finally, the study provides a better understanding of how a diverse, open environment such as the Web can be used to gauge and examine the longitudinal trend in the UIG relationship and offers an alternative to strictly codified and commercially available indicators such as SCI publications.

This study has some limitations. First, the study was conducted in a diverse, open environment (i.e. the Web), and the data, collected using internet search engines, may have some political and technical constraints (Introna & Nissenbaum, 2000). However, the openness and diversity of the Web are its important strengths, and thus, they need to be employed constructively. Second, different search engines may yield different results even if they use the same search criteria (e.g., this study's search criteria) in that their logic and algorithms are likely to be different. Thus, the generalizability of the findings may be limited. Finally, we assumed that the bilateral and trilateral relationships (measured in terms of T values) are only positive. However, that may be cases in which such relationships are negative, and thus, future research should ascertain the existence of negative relationships on the Web by using T values.

Conclusion

This study examines the longitudinal trends in the university-industry-government (UIG) relationship on the Web in the Korean context by using various internet resources, including websites/documents, blogs, online cafés, Knowledge-In, and online news sites. The results indicate that the UIG relationship varied according to the government's policies and that there was some tension in the longitudinal UIG relationship. Further, websites/documents and blogs were the most reliable sources for examining the strength of and variations in the bilateral and trilateral UIG relationships. These results suggest that webpages/documents and

blogs are important indicators of bilateral and trilateral UIG relationships on the Web. In addition, web-based T(uig) values showed a stronger trilateral relationship and larger variations in the UIG relationship than SCI-based T(uig) values. Finally, the results suggest that various internet resources (e.g., advanced search engines), together with TH indicators, can be used to explore the UIG relationship.

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