

The Importance of Intellectual Capital on Industry-Academic Collaboration: A Preliminary Analysis

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Abstract. Intellectual capital is an important base for inter-organizational collaborative activities, including the industry-academic collaboration studied here. A preliminary study was conducted with analytic hierarchy process method, trying to know the dimensionalized associations between intellectual capital (i.e., Human, Structural, Customers, Organizational, Process, knowledge, and innovation capitals) and industry-academic collaboration (i.e., academic engagement and commercialization). Analyzing expert opinions, we gained matrices and priority scores, indicating that different forms of intellectual capital have different influences on academic engagement versus commercialization. The results remind scholarly works to look into detailed and differentiated mechanisms that utilize intellectual capital for governing industry-academic collaboration.

Keywords. Intellectual capital, Industry-academic collaboration, Analytic hierarchy process; Taiwan.


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1. Introduction

In the era of knowledge economy, more and more enterprises turn the basis of value from tangible resources to intangible resources, such as: human resources, corporate culture, operational processes, innovation, brand, patent, goodwill, customer relations, etc. So the wisdom of asset gradually rise. On the other hand, the interaction between the higher education institutions and the industry can achieve resource integration, the use of academic point of view to cut into the industry point of view, bring different thinking, stirring out the ideas and works that have not appeared before.


The core of Intellectual Capital comes from "knowledge", and university is the best knowledge base. So does the Industry-Academic collaboration. Cooperation between industry and academia is to create a win-win results of industry and academia, can use university's research and development of energy to complements the weakness for business and industry side. In the case of limited industrial resources, however, application of existing resources of the industry to the highest value is an important issue for industrial competitive advantage.


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Journal of Economics Bibliography

However, most of the research discuss the overall meaning of Intellectual Capital, and rarely appear to each facet in detail to measure the importance of the degree of difference, as well as their importance to Industry-Academic collaboration. Extant research on the output and application of R&D achievements Industry-Academic collaboration has discussed the factors that affect the performance of technology transfer or the cognitive differences between the two sides on the nature of research activities. Some research, from the perspective of university organization, explores the organizational characteristics of the development of innovation and entrepreneurship, the establishment of intellectual property management and promotion mechanism (such as technology transfer office, technology transfer center or breeding center) and entrepreneurship effectiveness and obstacles. There are even many to explore the characteristics of academic researchers, participative motivation and academic fields such as the impact of commercialization of research. Although the above studies believe that the results of academic research and development for economic development and industrial innovation has an important contribution, but most of the academic research is based intellectual property management and promotion mechanism. In the past, the study of Intellectual Capital mostly focused on the impact of the industry's innovative performance or only the concept of describing the composition of the wisdom of the asset and the importance of asset.

The results of the study allow us to determine which facets of the Intellectual Capital are the most important for the two facets of Industry-Academic collaboration (i.e., academic engagement and commercialization). The results will help the industry to allocate well in the resource system, pay more attention to the differences in the importance of different industries and universities, provide a more accurate direction for future strategies for industrial development, and ultimately lead to the industry's ability to maximize competitiveness.

2. Literature Review

2.1. Intellectual Capital

2.1.1. Human Capital

Human asset definition on the knowledge, experience, ability, technology, professional as the main axis. These human asset elements are deeply rooted in the staff rather than business, and that human asset combined with organizational characteristics can only create value for the enterprise. Nalbantian (2004) argues that human asset has two basic forms of "universal" and "company-specific." "Universalization" means that the qualities and skills that employees have are not only beneficial to the current employer, but also valuable to future employers. "Company-specific" means that the value of employees is only for a single company, with the staff tenure and qualifications and growth, characterized by the investment in the assets of the institution has a unique value. Brooking (1996) argues that human asset is the most dynamic in organizational assets and is directly related to employees. In addition, Dess & Picken (1999) defines human asset as subordinate to employees, unable to segment them with knowledge, skills and experience. Integration of knowledge, technology, innovation, and the ability of employees to master the task, while covering corporate values, culture, and philosophy, but not the company can have (Edvinsson & Malone, 1997).

2.1.2. Structural Capital

Structural asset refers to the structural characteristics of a whole organization, which includes the leadership, strategy and culture of the enterprise management authority, the organization rules and procedures, the control system and measures, the application degree of the database and information technology, the brand image and so on. The organizational structure of the enterprise through the various institutional arrangements has the unique nature of the asset, which is the basis of the existence of structural asset in the enterprise organization, reflecting the importance of the system efficiency improvement for the enterprise. Hence, structural asset is an effective conversion mechanism for the transformation of

Journal of Economics Bibliography

individual human resources into enterprise human asset. Structural asset is an important environmental factor that affects the efficiency of human asset and thus the investment of human asset.

The study of structural asset has not yet formed a systematic stream of works. Although there are many references to structural asset. But its connotation and form of expression is still difficult to reach an agreement. For example, Shelby thought structural asset is the implicit representation of the organization itself. Structural asset, can be a computer system or intra-network, or it can be simply the phones or conference room, which play pivotal roles in constituting Intellectual Capital. According to the current international mainstream view, structural asset is implied as organization structure elements such as institutional norms, corporate culture, etc., reflecting the organization of human resources, the creation of the potential of the operational mechanisms, rather than simply refers to the organizational structure itself.

2.1.3. Customers Capital

In the face of rapid market changes and competition, knowledge sharing and allocation between enterprise and its customers/partners should be implemented in addition to improving time efficiency and quality management, for creating direct value (Probst *et al.*, 2000). The definition of customer asset is proposed by Sveiby (1997), who thought customer asset refers to the values customer created for the organization and thus is an intangible assets. Customer asset is also known as relational asset for achieving co-created organizational value, based on good interactions with customers, suppliers, competitors partners and other interested parties during the organization's operations (Dzinkowski, 2000). Guthrie (2001) argues that customer asset is an external asset that measures brands, customer loyalty, access, and inter-firm agreements on collaborations. As a result, customer asset refers to the value of the firm generated by the continuing relationship between the organization and its customer, representing the potential external intangible assets of the firm, and the breadth of the customer, the depth of the customer and the customer loyalty (Saint-Onge, 1996; Bontis, 1998). As for the effect of the relationship asset on firms, it plays a key role in enhancing the competitive advantage of enterprises. Saint-Onge (1996) also points out that organizational asset, human asset and customer asset are complementary. When the organization asset and human asset increase, the customer asset will increase, which makes the company's financial asset increase (Wright, 2000). In short, customer asset plays a key role in improving customer relationships, corporate revenue, corporate competitive advantage, and organizational value creation.

2.1.4. Organizational Capital

In the twenty-first century, the competition for physical assets is no longer the key to winning the company. If the company does not have unique assets, it is difficult to survive long-term in today's well-developed and competitive environment, and a company that can survive for a long time There is a unique source of profit, the inevitable will have a good internal management process, the company's internal management process assets, academic known as the organization of asset.

The organizational asset is divided into the "structural asset" of the accumulation of knowledge in the organization, and the "social asset" accumulated in the organization and can strengthen the Intellectual Capital. It aims to transform human asset into the sum of the wisdom and information of the asset of the organization, and through the measure of efficiency, the wisdom asset can be measured at the level of the organization.

Organizational asset is derived from the observation of Intellectual Capital, Roos *et al.*, (1998) found that market value is usually several times higher than the book value. (Mac Donald, 1991; Bell, 1997); and the creation of valuable intangible assets within the organization are included in the context of Intellectual Capital, that the firm's market value and the value of the enterprise The difference in book value is created by Intellectual Capital (Galbraith, 1969; Roos *et al.*, 1998).

Journal of Economics Bibliography

2.1.6. *Process Capital*

According to the criterion of whether the organization can own and appropriate its value, the Intellectual Capital is divided into human asset and structural asset, and then based on its existence inside and outside the organization, the structural asset is further divided into customer asset and organizational asset, then again finally organizational asset into innovation asset and process asset. According to this hierarchical categorization, Edvinsson & Malone (1997) referred process asset refers to the process of work, specific methods, and employee plans to expand and enhance product manufacturing or service efficiency. However, in the core of the process asset, the representative of the real work is within the enterprise with experience and professional development of the technology, including management cost and other indicators.

Bassi & Van Buren (1999) define process asset as a overall design for workflow, technology, and employee programming. The process is an important source of organizational competitiveness, and the ability and talent of individual members must be combined with the various processes of the organization in order to truly form the overall competitive advantage of the organization (Stuart, 2006).

2.1.7. *Innovation Capital*

Economist Schumpeter (1912) argues that innovation refers to the introduction of a new combination of new factors of production and production conditions into the production system. The innovations proposed include the following five modes: develop new products or new features, reference new technology, open up new markets, control of new sources of supply of raw materials or semi-finished products, and new organization or business model. Innovation refers to the use of new technology and market knowledge to provide customers with new products and services. Technological innovation includes product innovation, process innovation and equipment innovation, while managerial innovation covers the system innovation, policy innovation and service innovation.

Innovation is a process of transforming ideas or inventions into goods or services and creating value for consumers. The so-called innovative ideas must be able to be cost-effective to be replicated to meet specific needs. Innovation involves the use of information, transforming resources into imagination and maximization of value, and bringing new concepts and ideas into valuable goods or services. In practice, innovation often comes when the company satisfies well customer needs and expectations derived from the invention. Overall, innovation has brought new models of cooperation, such as heterogeneous alliances, flexible working hours, and gain the bargaining chip.

2.1.8. *Knowledge Capital*

Stewart argues that "Intellectual Capital" refers to the sum of all knowledge and abilities that each person and team can bring to a competitive advantage for the company. That is, knowledge, information, technology, intellectual property, experience, and organizational learning that can be used to create wealth ability from an intellectual logic. Edvinsson and Malone point out that Intellectual Capital is a mastery of knowledge, practical experience, organizational skills, customer relations and professional skills, allowing companies to enjoy a competitive advantage in the market. Sullivan argues that the research of Intellectual Capital can be grouped into the following six imperative: (1) knowledge and learning: on human asset and Intellectual Capital of the tacitness, on the creation of new knowledge, methods and the environment to promote the creative process that is more productive (2) knowledge management: that is seen as, but often demands more of, a synonym for computer information systems. The focus is on how to deal with information and knowledge more efficiently and effectively; (3) innovation management: that focuses on the organization of research and development (4) market value: that focus is on utilization of Intellectual Capital in the market, such as how to assess the Intellectual Capital of this enterprise assets, the economic value (e.g., prices) of knowledge and asset (5) the shareholders as the source of Intellectual Capital, focusing on the interactive influences between knowledge and

Journal of Economics Bibliography

stocks and profitability of the company's assets and liabilities, as well as strategic positioning assisted by the stakeholders who can creation of the company's future cash flow, economic benefits and sustained competitive advantage (Sullivan, 2000).

2.2. Industry-Academic Collaboration

2.2.1. Academic Engagement

Academic engagement is mainly to establish a “pipeline” between universities and companies to strengthen the two-way communication between education and industry sectors. The education sector can guide the industry toward correct business philosophy and help industrial upgrading and economic development, while the industry side can relatively help improve the level of education research and development, and ultimately achieve scientific and technological integration Ideal.

Collaboration between universities and enterprises through knowledge and personnel exchanges improves research and development results, increase the efficiency of industry, academia, or the use of school resources to help SMEs to achieve its development potential of the operational concept. Collaboration is the use of the university's existing and abundant research talent, so that academic research and enterprise application are combined to facilitate greater economic effectiveness. Put differently, the biggest purpose is to make academic theory and business needs more closely coupled. Ruth (1996) argues that the advantages of Industry-Academic collaboration has the following four advantages: (1) by the cooperative university to nurture the talents needed of the enterprise; (2) to strengthen teacher's knowledge and skills; (3) The preparation of the future workplace; (4) both sides can profit (in terms of goodwill, equipment, resources, etc.).

2.2.2. Commercialization

Rahal & Rabelo (2006) argued that the dimensions for commercialization in the IAC context is five folded: 1. Academic Institutional: Technology Transfer Office, University Authorization Policy and Institutional Reputation; 2. Inventor factors: the inventor involved and cooperation in their technology has a realistic expectation of the incentive; 3. Technical factors: including the nature of technology, scope, sustainable competitive advantage, the extent of other necessary technology, compatibility with other necessary technologies and quantifiable technical risks and weaknesses; 4. market factors: the existing market demand, leading the market competitors, the market success rate, market pioneer, expected return on investment returns and so on; and 5. intellectual property rights factors: whether the literature and patent search integrity, confidentiality measures and intellectual property rights of the strength and exclusivity.

3. Methodology

3.1. Sample and Data collection

This study was conducted in December 2016 for nine expert respondents for the questionnaire with statistical analysis. A total of nine respondents, of which 6 are teachers (3 in business area, 1 in general management, 1 in life science, and 1 in engineering). Expert teachers all have a wealth of industry experience, including small and medium enterprises consulting, science and technology care project, cross-domain development of industry and education service group and so on.

After the questionnaires were returned, the AHP method is used to synthesize the deductive method and the induction method, that the complex problem system is divided by the induction method, and the nature of each part is analyzed by deductive method, then integrated together. First, we define the exact scope of the researched problem, incorporate all relevant causes that may affect the problem, and set up a grouping at the same time. Then we constructed a hierarchical structure, identify criteria, sub-criteria, the nature of alternatives, and alternatives that affect problem behavior. Third, we designed the questionnaire, with each level

elements in the upper level of a factor as a benchmark for evaluation, compared with one another then. Here, each pair of criteria needs to be reflected with relative questions that was rated with a 9 point scale. The questionnaire must clearly describe each pair of comparative questions and attach detailed guidance instructions. According to the results obtained from the questionnaire, the pairwise comparison matrix is established, and the eigenvalues and eigenvectors of each pair of comparison matrices are obtained, and the consistency of the matrix is verified. Finally, the level of consistency was tested, if the consistency of each pair of comparison matrix are in line with the required, you still need to verify the consistency of the entire hierarchy. If the degree of consistency of the entire hierarchy does not meet the requirements, the elements of the hierarchy are displayed otherwise.

4. Results and Discussions

4.1. Commercialization

As can be seen from Table 1, from the I.R. value <0.1 , through the consistency test, that meet the level of consistency. The order of the relative importance of its criteria: Intellectual Capital (0.24297) is the highest, followed by the innovation asset (0.18908), the organization of asset (0.13233), the lowest ranked two for the process asset (0.08369) and structural asset (0.11211).

Table 1. *The relative importance of different forms of Intellectual Capital in commercialization relative to Industry-Academic collaboration*

Criteria	Human	Innovation	Process	Knowledge	Organization	Structure	Customer
Direct Value	0.12618	0.18908	0.08369	0.24297	0.13233	0.11211	0.11364
I.R. Value				0.05862			

4.2. Academic Engagement

As can be seen from Table 4-2, from the I.R. value <0.1 , through the consistency test, that meet the level of consistency. The relative importance of its criteria is: (0.14804), the lowest ranked two is the structural asset (0.09749) and the organizational asset (0.10582). The second is the structural asset (0.09749) and the organizational asset (0.10582).

Table 2. *Academic engagement in different forms of Intellectual Capital relative to the relative importance of Industry-Academic collaboration*

Criteria	Human	Innovation	Process	Knowledge	Organization	Structure	Customer
Direct Value	0.11377	0.17344	0.14804	0.21473	0.10582	0.09749	0.14671
I.R. Value				0.05862			

According to the results, it can be found that in the context of industry-academia collaboration, it is most important to consider whether commercialization or academic engagement can be implemented with different forms of Intellectual Capital. Among these forms of asset, knowledge and innovation assets are both critical for engagement and commercialization. In addition, organization asset is more important in commercialization stage than in academic engagement stage, while process asset is more important for academic engagement than in commercialization stage. These results differentiates this study from extant ones by providing significant evidence stating that different strategic assets can have different roles and significance for different dimensions of Industry-Academic collaboration.

5. Conclusion

This study explores the differentiated importance of different forms of Intellectual Capital for the different dimensions of industry-academia collaboration. In the era of knowledge economy, the imperative is the value and use of knowledge and information, the industry's knowledge and technology is the

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culmination of the whole innovation process, and the key to create knowledge and technology is the academic community. Therefore, both of the competitiveness of the industry and the academia can be improved if we can better understand the influences of Intellectual Capital impact on Industry-Academic collaboration. It does matter in practice to invest in key assets for creating effective outcomes for Industry-Academic collaboration. Our results of differentiated effects of different Intellectual Capital on different dimensions of IAC have offered preliminary but important clues. The key factor in the Industry-Academic collaboration depends on the leader's degree of effort investment. Therefore, the organization plays an important role in the cooperation between industry and academia, the recognition of organizational goals and the degree of investment in educational organization, and the key factors that affect the effectiveness of production and research cooperation between R&D expenditure and organizational structure. Intellectual Capital is often presented in the form of intellectual property rights (such as patents, copyrights, etc.).

Some areas of academic research (such as nanotechnology, biotechnology, etc.) presents the potential for immediate commercialization, so the research results lead to more and more important sources of innovation for the Industry-Academic collaboration. Academic research technology, through the combination with the production of enterprises, can create a more diversified revenue pipeline and create more opportunities for technology transfer. Also, enterprises can amend the difficulties and errors academic can not find to help achieve process innovation and quality in production.

The success of industry-academia collaboration rely heavily on the well combination and application of the university theoretical knowledge and enterprises practical applications. The process of collaboration takes into account the professionalism of the teacher, the career preparation in the student's career goals, and the innovative goals and available resources of the enterprise. The outcomes are expected to be beneficial to the achievement of both of the two parties. International leadership in business competition, patent disputes, adaptation to laws and regulations, the development of R&D services, etc., are required to cultivate cross-disciplinary talent. Faced with a fierce global competitive environment, companies must seek cooperation to introduce technology to accelerate the development of enterprises. Because more and more R&D projects require huge capital investment, academic units and companies adopt an increasingly common way of cooperation - mutual introduction of technology and/or knowledge to one another to balance the huge investment required while shortening the development time. Taiwan's manufacturing industries have formed a base to promote the combination of soft and hard sides of industrial advantages. The university itself has a rich and innovative research and development energy, and is the major producer of knowledge and technology. In knowledge economy, it is an important connotation of Intellectual Capital theory, provoking for transformation for the innovation and R&D energy of the university into the innovation source of the industry, then enhance the overall competitiveness of the country.

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