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The Impact of Enterprise Resource Planning and Intellectual Capital on Organizational Performance: A Meta-analysis

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Abstract: The objective of this study was to understand the impact of enterprise resource planning and intellectual capital on organizational performance of listed companies in Taiwan's green energy industry. The data was collected from previous studies conducted by domestic and foreign scholars, and the collected data was analyzed by meta-analysis. The results showed that corporate resource planning and accumulation of intellectual capital have significant positive impact on organizational performance of listed companies in Taiwan's green energy industry. These results can be used by the operators of listed companies in Taiwan's green energy industry as decision-making reference.

Keywords: Resource planning, intellectual capital, organizational performance, meta-analysis

I. INTRODUCTION

Promotion, installation and subsidies for renewable energy and energy saving facilities have become major investments in green energy around the world. Such investment has translated into green competitiveness. Investment in green energy has become an important major measure in global economic development and economic recovery.

To actively develop the green energy industry, the Executive Yuan of Taiwan approved the Green Energy Industry Leap Program on August 6, 2014 to focus the resources on the promotion of four main industries: solar photovoltaics, LED lighting, wind power and energy information and communication technology (ICT). The program combined the sound foundation and advantages of ICT, semiconductors, electro-mechanics, materials and relevant industries to expand the development of downstream system service industry and the output capacity of overseas system with the thinking of manufacturing service, and rapidly took part in the global division of labor to create a new drive for green energy growth【1】. The development of renewable energy and enhancement of energy efficiency have become two major directions for Taiwan's vision of green energy at current stage.

Moreover, enterprise resource planning (ERP) has emerged as the best tool to respond to the fast-changing environment in an industrial environment towards global competition. Especially in the ERP and supply chain management (SCM) system, ERP is the central nervous system for information convergence, integration and exchange, and is also the backbone that supports the growth and development of e-commerce. For the value chain of corporate cooperation, ERP can integrate real-time information across companies and regions, and dynamically and optimally allocate and use resources to achieve the purpose of corporate value chain integration and operation. The entire value chain system can therefore rapidly respond to customer demands and enhance product or service level to further directly or indirectly affect the organization's performance【2】

Intellectual capital value emerges gradually in the era of a knowledge-based economy, and highlights factors that are critical to business success and future long-term profitability. The importance of tangible assets to a business is gradually replaced by the importance of intangible assets in the era of a knowledge-based economy. Due to the concern over the reliability of information quality, conventional financial accounting practices ignore a number of important intangible assets for the sake of objectively measuring and faithfully representing transaction data【3】. Therefore, more and more company-value items, such as patents, customer base, brands, and other such items, that cannot be listed on the balance sheet. The gradual rise in the value of intellectual capital in recent years highlights factors that are critical to business success and future long-term profitability. Therefore, high-performance work system can enhance the organization's human resources, structure and social capital, improve the organization's operational efficiency, further affect the organization's financial performance and finally brings about the organization's operating performance【4】.

This study used meta-analysis as a research tool to explore the impact of enterprise resource planning and intellectual capital on organizational performance of listed companies in Taiwan's green energy industry. This is the main objective of this study.

II. LITERATURE REVIEW

To understand the studies related to this topic, literatures related to the study topic are reviewed as follows:

Enterprise Resource Planning (ERP)

In this study, an ERP is conceptually defined as an on-line transaction processing (OLTP) system that is a ready-to-use software package supporting most major operating functions in the enterprise, such as logistics, sales and financial management, and can integrate the operating process of production, material management, quality management, sales and distribution, human resources management, corporate finance and accounting to form an inter-departmental and inter-regional information system. In other words, it can integrate all information in the enterprise, including process planning, marketing and market to help the business operator make the best decision. The above definition is consolidated from the following literature.

Chen【5】pointed out that ERP is essentially an on-line transaction processing (OLTP) system. The difference between the OLTP system and the traditional information management system is the real-time feature and integration. In terms of technical architecture, the OLTP system allows all users in the entire enterprise to use a single database system and common applications. Therefore, the ERP system can integrate production process, finance, sales and other relevant function to achieve the purpose of providing real-time information and effective management.

Hammer【6】believes that ERP system can integrate all information in an enterprise, including process planning, marketing and market to help the business operator make the best decision. ERP system is software that can integrate all departments in the enterprise and all functions. It is a software module family where all modules share a database and are closely combined together to support business operation process.

Chuang, Yu and Chang【7】also pointed out that ERP is a new concept that integrates major or all operating activities of an enterprise. It is an enterprise information tool that allows the enterprise to adapt to an ever-accelerating pace of business and quickly turn over in a changing environment through shortened information cycle and control cycle. Moreover, with the increased use of ERP and continuous expansion of software functions, the meaning of ERP also expands. Today, any integration software that enables the optimization of enterprise management resources can be broadly regarded as ERP.

Intellectual capital

In this study, intellectual capital is conceptually defined as the capital that covers skills, knowledge, information, experience, problem-solving ability and wisdom of the company as a whole, and is integrated into human capital, structural capital and relation capital. The above definition is drawn from the following literature.

In their book "Intellectual Capital Accumulation: Realizing Your Company's True Value by Finding Its Hidden Brainpower" Edvinsson & Malone【8】explained the intellectual capital implementation process and measurement indicators at Scandia Inc. They agreed that intellectual capital comprises human, structural and customer capitals, with the human capital being the sum of personal competencies, knowledge, skills and experiences of a company's entire staff and management, as well as the organization's capabilities in creativity and innovation. Structural capital, they said, is a supportive framework and organized capacity that gives human capital a tangible form, authority and support, including the palpable system for communicating and storing intellectual materials. The customer capital involves customer satisfaction, durability, price sensitivity, and the long-term customers' financial conditions, the argued.

Intellectual capital, according to Sveiby【9】, is made up of individual competencies and the internal/external structure of a company, where "individual competencies" is defined as the employees' capabilities of taking actions under varied circumstances with explicit knowledge, skills, experiences, value judgments, social networks, among others; the "internal structure" is defined as the sum of patents, concepts, patterns/models, computer and management systems; the "external structure", the sum of company-customer or company-supplier relationships such as brands, goodwill, and trademarks.

Johnson【10】addressed intellectual capital in three categories, namely the human, structural and relationship capitals, where "human capital" is defined as the combination of idea capital (or the labor force for knowledge-oriented tasks and employee aptitudes/attitudes) and leadership capital (or the personal qualities of an expert/manager); "structural capital" is defined as the combination of innovation capital (i.e., patents, trademarks, copyright and knowledge archives) and process capital (i.e., work procedures, trade secrets); "relationship capital", the sum of a company's relationships with customers, suppliers and online-community members.

The intangible intellectual capital is a major referential indicator of enterprise value(EV), as contended by Chen【11】, who said intellectual capital consists of human, structural and relationship capitals while

defining it as "something that integrates into such capitals all the skills, knowledge, information, experiences, problem-solving abilities and wisdom of a company." She went on to define human capital as "the knowledge, skills and experiences of a company's employees and management; structural capital, a company's overall system/procedures concerning problem-solving and value creation"; relationship capital, "the initiation, maintenance and development of an organization's external relationships with customers, suppliers, business partners, among others."

Edvinsson【12】gave a simple description of intellectual capital: something all businesses will rely on for future growth, as well as an indicator of efficiency in business operations. It is impossible to implement any corporate reform without first investing in intangible assets【13】.

Organizational Performance

In this study, organizational performance is conceptually defined as the high value meeting an organization's mission and vision and created by all relevant businesses and departments in the organization within a time limit in accordance with specific missions and guidelines of the organization to achieve a phased or overall goal. The above definition is drawn from the following literatures.

Venkatraman & Ramanujam【14】divided organizational performance into two different definitions. In the narrow term, performance is to meet the goal of the company's financial indicators; and in the broad sense, organizational performance refers to corporate performance, including financial (e.g., revenue and return on asset) and operational indicators (e.g., product quality and market share).

Xu【15】 suggested that "organizational performance" is divided into "efficiency" and "effectiveness". While, Drucker【16】provided a very good interpretation for "efficiency" and "effectiveness", that efficiency is "doing things right"; effectiveness is "doing the right things". Neither efficiency nor effectiveness should be neglected, but this is not to say that efficiency and effectiveness are equally important. For an organization, it is certainly preferable to improve efficiency and effectiveness at the same time; however, if both cannot be obtained, the organization should focus on effectiveness prior to aiming at improving efficiency.

Moreover, Ling & Hung【17】argued that organizational performance is the results achieved by all relevant businesses and departments in an organization within a time limit in order to achieve a phased or overall goal of the organization.

The research of Lee, Chen and Lee【18】suggested that the operational definition of organizational performance is that it is an indicator of the overall enterprise competitiveness, and it is also the measurement of the achievement level of an enterprise's strategic objectives while popular assessment indicators for organizational performance are income, productivity and profitability of the organization. Therefore, an appropriate organizational performance assessment affords its manager the understanding of the status of the organization.

Literature related to enterprise resource planning and organizational performance

An ERP system is real-time information software that links internal and external information of a company. The most important function of the ERP system is integration. Hammer & Champy 【19】believed that modern information technology can rapidly redesign business process. The business process reengineering (BPR) makes business operations more efficient.

Chang【20】pointed out that prospector and analyzer are obviously better than defender in terms of the conditions for ERP implementation and organizational performance. In addition, the conditions for ERP implementation and organizational performance are highly relevant. For analyzers, the higher the degree for ERP implementation, the better the performance in information technology and finance.

Tsai【21】 argued that based on the results of objective data analysis, after a company introduces an ERP system, the company's scale and revenue are positively correlated.

Cheng【22】believed that after the introduction of an ERP system, most companies are able to reduce the time on closing the book pretty well.

Lin【23】 believed that if a company can successfully introduce an ERP system, it can improve its operational management and increase revenue and profit through the ERP system. The results of a case study showed that the company's workflow is smoother, resulting in a positive cycle after the introduction of ERP system. The company's revenue grew every year, and its profit also increased.

Wu【24】pointed out that different departments respond differently to the performance of an ERP system. However, most performance indicators show positive indication.

Literature related to intellectual capital and organizational performance

Hung【25】pointed out that effective capital management could significantly improve IDE performance of technology companies through the promotion of internal relationship capital. His research findings also showed that human capital is the driving factor of internal relationship capital and organizational capital; while dynamic interactive effects are also found to be factors of intellectual capital.

Lin, Chen and Zhou【26】proposed that the higher the level of human capital in an enterprise, the higher the level of compensation; while the higher the level of compensation, the better the organizational performance.

Chen【27】indicated that intellectual capital has a significant positive relationship with organizational performance.

Peng【28】argued that, with the help of knowledge management, an organization could effectively accumulate human capital, organizational capital, and relationship capital, and thereby improve its organizational performance.

Chen, Fang, Chen and Chien【29】proposed that organizational culture is significantly correlated with intellectual capital, and that it also has a positive impact on organizational performance through intellectual capital.

III. RESEARCH METHOD

Figure 1 illustrates how motivations, research objectives and literature review cited in the previous passages led to this study's hypotheses and conceptual research framework:

Research Framework

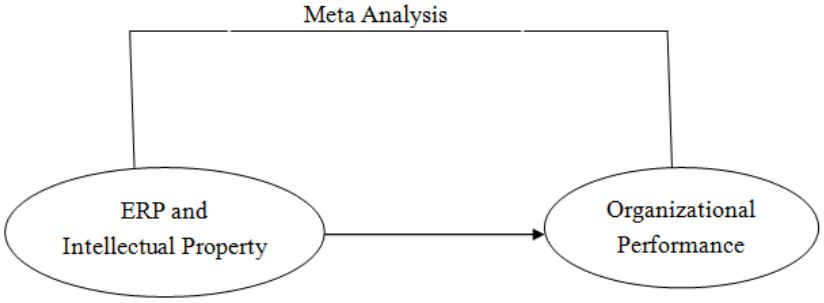


Figure 1 Research Framework

Data collection and methods

In this study, the data regarding organizational performance was collected from Taiwan Economic Journal (TEJ) database and questionnaire. Meta-analysis was adopted in this study and the software used was Stata. It was assumed in this study that the parameters followed normal distribution (N.D.). When the heterogeneity (standard error) is large, random effects are better than fixed effect. Therefore, random effects were adopted in this study for comparing various effects【30】.

The theoretical foundation of meta-analysis【31】

1. The Highlight of DerSimonian & Laird Method (Random effect method)
   (1) For binary or continuous outcomes
   (2) Effect size q_i for study *i* could be In (OR), In (RR), RD, difference in means or standardized mean difference.
   (3) Note that the effect sizes for OR and RR are logged.
   (4) Assumption that there is a single true answer that all studies are trying to estimate is relaxed.
   (5) Now assume that each study has a different true answer that they are trying to estimate.
   (6) Assume true effect sizes θ_i have normal distribution with mean θ and variance τ^2.
   (7) τ^2 is the between-study variance.
   (8) Between study variance:

$$\tau^2 = \frac{Q - (k-1)}{\sum_i w_i - \left[\frac{\sum_i w_i^2}{\sum_i w_i}\right]}$$

Where:

w_i are weights from the fixed effect inverse-variance method

Q is the heterogeneity test statistic form before (either form inverse-variance method or Mantel-Haenszel method)

K is the number of studies, and

τ^2 is set to zero if Q<k-1

(9) Random effect pooled estimate is weighted average:

$$\theta_{DL} = \frac{\sum_i w'_i \theta_i}{\sum_i w'_i}$$

(10) Weights used for the pooled estimate are similar to the inverse-variance, but now incorporate a component for between-study variation:

$$w'_i = \frac{1}{SE(\theta_i)^2 + \tau^2}$$

(11) When there is little heterogeneity, so Q is smaller than k-1, τ^2=0 and the weights are the same as the inverse-variance method.

(12) When τ^2>0 the weights are smaller and more similar to each other than in a fixed effect model.

(13) Because the weights are smaller, the sum of weights will be smaller, and the so the SE will be bigger, CIs wider, and p-values less significant.

(14) Small studies will have relatively greater influence.

(15) Advantages:

a. As widely applicable as the inverse-variance fixed effect model
b. Incorporates heterogeneity into the model

2. Confidence interval for pooled estimate

A 95% CI for the pooled estimate θ is:

θ-(1.96*SE(θ)) to θ+(1.96*SE(θ))

For ratios, θ is the log-transformed estimate.

3. Test for overall effect

Overall significance test for whether the pooled estimate is significantly different from zero (no effect):

$$z = \frac{\theta}{SE(\theta)}$$

Look up z in tables of the normal distribution to get the p-value.

For ratios, θ is the log-transformed estimate.

4. Test for heterogeneity

(1) Look up Q in tables of the chi-squared distribution on k-1 degrees of freedom. The null hypothesis is that the true effect size is the same for all studies.

(2) A statistically significant result means that there is strong evidence against there being one common effect size, so we take it that there is heterogeneity.

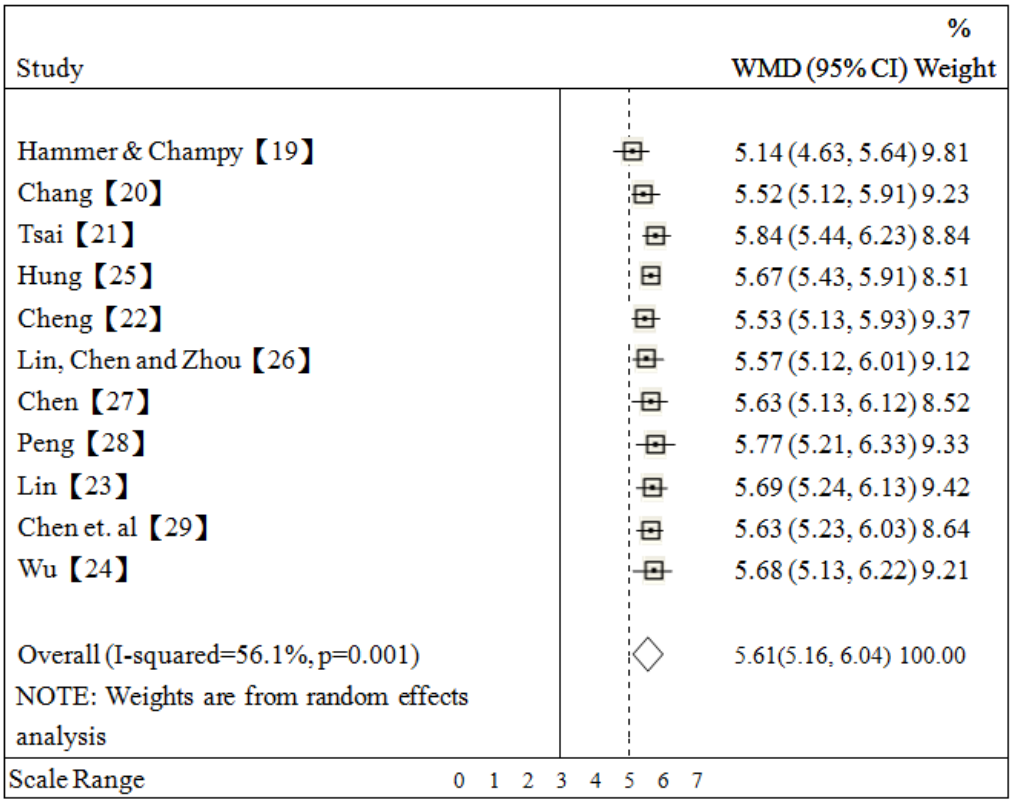
5. Getting Data into Stata

(1) Easier to enter into Excel then cut & paste into Stata's data editor
(2) Ensure each numeric column contains only numbers
(3) Leave cells empty if data missing
(4) One row per study

IV. RESULTS AND ANALYSIS

The results of random effects analysis through the meta-analysis are shown in Table 1:

Table1: Random Effects



Based on the overall results of Table 1 (I-squared=56.1 and p-value=0.001), the independent variables of this study have a positive significant effect on the dependent variables.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the study results, the enterprise resource planning has an impact on the organizational performance of the listed companies in Taiwan's green energy industry. This conclusion is the same as that of the studies conducted by Hammer & Champy 【19】, Chang【20】, Tsai【21】, Cheng【22】, Lin【23】 and Wu【24】. The differences were weight and industry.

The impact of intellectual capital on organizational performance of the listed companies in Taiwan's green energy industry was the same as that of the studies conducted by Hung【25】, Lin, Chen and Zhou 【26】, Chen【27】, Peng【28】and Chen et. al【29】. However, the weight and industry were different.

Contribution of this study

Most literatures used regression analysis for exploratory analysis. Meta-analysis was rarely used. In this study, meta-analysis was adopted, which is more innovative.

Moreover, the results can also be used as a reference for managers in Taiwan's listed companies in the green energy industry. Therefore, the results of this study are very valuable for practical reference.

Research limitations and recommendations

As mentioned above, this study aimed at Taiwan's listed companies in the green energy industry, and relevant domestic and foreign literatures were analyzed through meta-analysis to understand the impact of enterprise resource planning on organizational performance. It is recommended that the subsequent researchers can try to study other industry or the same industry at different scale or use other research methods, such as confirmatory factor analysis (CFA) to verify different industries or compare whether there are differences in the fitness of different industries in the same model.

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