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An evaluation framework for technology transfer of new equipment in high technology industry

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ABSTRACT

With the rapid advancement of technology, product life cycle is shortening continuously. In order to compete against other firms in fiercely competitive global markets, a firm has to keep developing new technology to differentiate itself from others. The acquisition of new core-technology equipment is especially important for manufacturing advanced products, and the technology know-how of the equipment must be transferred completely from equipment supplier to engineers and operators of the firm to effectively utilize the equipment. The objective of this paper is to explore the technology transfer of equipment and to establish a comprehensive framework for evaluating and selecting new equipment with critical technology transfer. Influence factors for technology transfer of new equipment are first collected by literature review and interviews with related experts in the thin-film transistor liquid-crystal display (TFT-LCD) industry in Taiwan. Fuzzy Delphi method (FDM) is applied next to select the most critical factors. Then, interpretive structural modeling (ISM) is employed to determine the interrelationship among the critical factors. A fuzzy analytic network process (FANP) model is constructed to evaluate the technology transfer performance of equipment suppliers. The results of this study should provide a base for firms in evaluating the purchase of new equipment and a reference for equipment suppliers to strengthen their technology transfer process to their buyers.

1. Introduction

A good technology transfer can enable a firm to improve manufacturing productivity, alliance efficiency and adaptability, international expansion, and sustainable competitive advantage [1]. While there are various kinds of technology transfer, this study focuses on the technology transfer from equipment supplier to buyer in the acquisition of high-technology equipment. New equipment is purchased to acquire new technology, expand capacity and increase competitiveness. For high-tech industries, equipment is the essential hardware for producing high-tech products, and the equipment itself is produced by the newest technology and is often complicated in nature. Thus, the purchase of equipment (a single piece of equipment or an entire system) requires technology transfer from the equipment supplier to the buying firm.

Technology transfer encompasses a complicated process involving the complexity of the technology, the owner's capability of teaching, the acquirer's capability of learning, and the complex interaction between the two parties. In the process of technology transfer of new equipment, buyer–supplier relationship and knowledge management must also be stressed. A buyer–supplier relationship should be maintained with trust, interdependence and sharing in a long-term perspective. When compared to a domestic context, technology transfer in an international context is subjected to more diversified environmental conditions, such

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as cultural differences, thus creating greater challenges [1]. Therefore, it is necessary to understand how environmental factors influence a firm's ability to transfer technology in an international environment. After obtaining the required technology, the buying firm must transform equipment know-how into new knowledge, which is stored and managed in the firm for the use of related personnel. High-technology equipment usually has very distinctive characteristics, and the transfer of technology knowledge, especially tacit knowledge, and the management of knowledge in the firm are essential to have a better control of equipment, and thus a higher overall productivity. To conclude, technology transfer, buyer–supplier relationship and knowledge management are interrelated in the acquisition of high-tech equipment.

Due to the sustained evolution of high technology, the socio-economic status in Taiwan has been developed rapidly. With the accumulated experience in applying and developing technology, Taiwan's high-tech industry is shifting from original equipment manufacturing (OEM) to original design manufacturing (ODM). With the upgrading in high technology, Taiwan's high-tech industry can manufacture products with higher speed, higher precision and higher value-added. TFT-LCD industry is one of the most brilliant industries in Taiwan, which is currently the world's largest supplier country of TFT-LCDs and produces more than 40% of the world's supply [2]. The TFT-LCD industry should keep flourishing in Taiwan with the transfer of Japan's TFT-LCD technology to Taiwan and the competitive advantages of Taiwan in abundant capital, technology from the semiconductor industry, numerous downstream clients, and a relatively complete supply chain [3]. However, most critical equipment is purchased from foreign suppliers. The divergence of culture, technology and technology experience between buyers and foreign suppliers must be monitored carefully, and tactics must be used to decrease the gaps. Therefore, a good technology transfer is necessary.

In this research, an evaluation framework for technology transfer of new equipment for TFT-LCD manufacturers is proposed. The process of technology transfer is reviewed through literature first, and experts in the field are interviewed. The criteria and sub-criteria that influence the success of the process are listed. Because the collected sub-criteria are numerous and the experts are not capable of handling pairwise comparisons with too many elements in ANP, it is essential to know the importance of each sub-criterion and to select the most essential ones for further analysis. While Delphi method can accomplish the task, it requires repetitive questionnaires and evaluations, and it cannot deal with the uncertainty of experts' expressions. Thus, Fuzzy Delphi method (FDM), which can both deal with fuzziness and vagueness in experts' expressions and reduce the number of rounds in facilitating the formation of a group judgment, is applied to select the most critical sub-criteria. For an ANP or FANP analysis, the network with the interrelationship among the elements must be constructed first. Interpretive structural modeling (ISM) is employed to incorporate experts' opinions to determine such an interrelationship among the criteria and among the sub-criteria. A fuzzy analytic network process (FANP) model, which can consider the uncertainty of experts' expressions, is finally constructed to evaluate the technology transfer performance of equipment suppliers. The relative importance weights of the criteria and sub-criteria are calculated, and the ranking of equipment suppliers is generated.

The rest of this paper is organized as follows. Section 2 reviews technology transfer, buyer–supplier relationship and knowledge management. Section 3 goes over the key concepts of FDM, ISM and FANP. An evaluation framework for technology transfer of new equipment is constructed in Section 4. Section 5 provides a case study of TFT-LCD manufacturer in evaluating equipment suppliers. Some concluding remarks are made in the last section.

2. Technology transfer, buyer–supplier relationship and knowledge management

2.1. Technology transfer

Technology is knowledge of systematization, and it is about design, production method or management system involved hardware or software. Briefly speaking, technology focuses on the know-how towards a specific technique and method to solve a problem [4]. Technology has been evolved by science research and R&D, and it is a critical element for economic development of industry. By improving efficiency of a firm's activities, technology helps to reduce production cost and increase manufacturing productivity [5].

Technology transfer is a process by which a technology supplier communicates and transmits the technology through multiple activities to the receiver, and this will ultimately enhance the technological capability of the receiver. Technology transfer can occur "between and among scientific disciplines, professions, industries, economic sectors, geographic regions, or societies/countries" [6]. Technology transfer involves strategic efforts to disseminate information regarding innovative and scientifically based practices to individuals, organizations, and communities and to help them manage the challenges of using that information to create change within their work settings [7]. While there is no general theory, model or structure for technology transfer and its descriptive theories, normative theories and data available are fragmented and disjointed, Reisaman [8] presents a taxonomy defining the technology transfer field in its entirety and delineating all of its facets in a manner that is parsimonious yet discriminating.

Technology transfer has been treated as an important tool which enables a firm to improve its competitive advantage, including but not limited to financial, technological and other benefits, and to survive in a competitive and diverse market. Klevorick et al. [9] listed technology transfer benefits to production processes, including improvement in process yields, product and service design, design for the market, standardization, product's physical properties and performance characteristics, and ability to change from intermittent to mass flow processes. Mechanisms for transferring technological knowledge include training (on the job, on-site or elsewhere), consulting, documentation (reports, assessments, programs or drawings), demonstration, meeting, and collaborative technical work [10,11].

While formal mechanisms are appropriate for capturing and transferring explicit part of technology, other approaches are necessary to share the tacit component, which is non-codifiable in nature [12]. This is particularly true for the operation of complex high-tech equipment. By simply studying equipment's operation manuals and other written documentations, a buyer cannot