
An empirical study of the relationship between absorptive capacity and technology transfer effectiveness

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Abstract: This study investigates the relationship of Absorptive Capacity (AC) and its elements to Technology Transfer Effectiveness (TTE) in the flexible packaging industry in Thailand. The relationship of each AC element to each dimension of TTE is assessed. Findings are that TTE is related to all AC elements, but not all to the same degree. While all AC elements were found to have a positive correlation with two TTE dimensions, namely product and process performance and human resources capability, only two AC elements, namely the ability to assimilate and the ability to apply the new technology, showed a strong positive correlation to the TTE dimension of business performance. The findings of this study help academics and practitioners to have a clearer understanding of the different elements of AC and TTE, the impact of AC on TTE, and especially the correlation of each AC element to each TTE dimension.

Keywords: technology transfer; absorptive capacity; flexible packaging industry.

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1 Introduction

Under fast changing technological and highly competitive market conditions, new customer requirements are continuously emerging. Firms in this environment are forced to search for new product and process developments and to respond quickly to these requirements. Since firms cannot develop new technology solely through in-house R&D due to high cost and risk (Ceh and Smith, 2001; Hollmer, 2003) and because this is time consuming, acquiring technology from outside helps increase their technological capability (Kim, 1999; Burger, 1999) at less cost, lower risk and higher efficiency (Kedia and Bhagat, 1988; Bratic and Warren, 2001).

When acquiring technology from other firms, a key concern is to really catch up and increase technological capability. Therefore acquired technology must be successfully utilised in operations to produce a product or service and thus links to technology transfer effectiveness. To be able to internalise the acquired technology successfully, firms require ‘absorptive capacity’ which is the ability to recognise the value of external technology, knowledge, and information (Cohen and Levinthal, 1990; Lane, *et al.*, 2001; Lin, *et al.*, 2002; Van Den Bosch *et al.*, 2003); to identify and acquire the new technology; to assimilate it (Cohen and Levinthal, 1990; Zahra and George, 2002); and to apply or exploit the new technology to commercial ends (Cohen and Levinthal, 1990; Zahra and George, 2002; Van Den Bosch *et al.*, 2003).

Many studies have focused on the factors that influence technology transfers, such as the type of transferred technology (Ounjian and Carne, 1987; Keller and Chinta, 1990); the transfer channel (Keller and Chinta, 1990); R&D activity, training (Grosse, 1996; Hakam and Chang, 1988; Osaman-gani and Ahad, 1999); communication (Gibson and Smilor, 1991; Ounjian and Carne, 1987); culture (Kedia and Bhagat, 1988; Keller and Chinta, 1990; Gibson and Smilor, 1991; Chen, 1997; Osaman-gani and Ahad, 1999) and the existing technological capability (Kedia and Bhagat, 1988; Stock *et al.*, 1996). Not many studies however, have focused on the influence of absorptive capacity on a technology transfer, especially at the firm level. This study aims to fill this gap by investigating the extent of influence of the multiple dimensions of Absorptive Capacity (AC) on Technology Transfer Effectiveness (TTE). This has been frequently discussed at the conceptual level but there is still no clear empirical analysis of how AC can support TTE or how each AC dimension can influence each TTE dimension. It is difficult for managers to implement effective AC policies that will ensure an effective technology transfer if they do not know exactly what they are trying to implement. The concepts of AC and TTE need to be more carefully defined so that they can be better measured and understood. We look at these issues in the flexible packaging industry in Thailand because this is a rapidly growing industry and technology is core for this industry.

This paper is divided into eight sections. After the introduction, a review of the literature focuses on how to define TTE and AC, including their dimensions and measures, and how to analyse and understand the particular relationship between AC and TTE. Part III presents a model depicting the relationship between the two concepts and the research hypothesis. Part IV describes the methodology and Part V reports statistical results, followed by a discussion of the findings. Part VII presents the conclusions and the final part presents recommendations for further research.

2 Literature review

2.1 Relationship between technology transfer effectiveness and absorptive capacity

AC has been defined as the ability to recognise the value of external technology, knowledge, and information (Cohen and Levinthal, 1990; Lane *et al.*, 2001; Lin *et al.*, 2002; Van Den Bosch *et al.*, 2003); to identify and acquire the new technology; to assimilate it (Cohen and Levinthal, 1990; Zahra and George, 2002) and to apply or exploit the new technology to commercial ends (Cohen and Levinthal, 1990; Zahra and George, 2002; Van Den Bosch *et al.*, 2003). It has been suggested that AC is such a

critical factor in determining the effectiveness of a technology transfer, that other related factors (such as the type of technology that is transferred, the technology transfer channel and the research and development process) will not be able to successfully support a firm's technology transfer performance without a strong AC (Lin *et al.*, 2002). The recipient's lack of AC can result in a poor transfer because a successful technology transfer entails much more than the mere acquisition of physical assets (TID, 1997). Hence, AC is not an alternative to a successful technology transfer but appears to be a necessary condition for it. A successful technology transfer leads to the improvement of a firm's technological capability, which allows for faster learning to accumulate higher levels of technological capability, which in turn enhances the firm's AC (Kim, 1997). The effectiveness of a technology transfer can be defined as meeting the objectives of a specific technology transfer project (Wong *et al.*, 1999).

Firms must make efforts to effectively use the new technology and integrate it with existing technology to create either a new product or process, in order to adjust to a continually changing business environment. Technological capability is a function of a firm's AC (Kim, 1997), as demonstrated in Wong *et al.*'s (1999) study of Taiwan's information technology industry, which showed that the intraorganisational diffusion of information, and learning and training procedures, supported TTE. The impact of AC on technology transfer performance was also confirmed in Lin *et al.*'s (2002) study of the Republic of China's electronic and chemical manufacturing industry. This study found that AC, R&D, organisational culture, and the mechanisms for interaction and connections within and outside the firm, influenced technology transfer performance. R&D, the organisational culture, the diffusion mechanism, and interaction mechanism all influenced AC. In summary, a firm's AC appears to be a necessary condition for effectively transferring and utilising new technology.¹

When considering TTE, firms should focus on performance outputs, which indicate effectiveness instead of efficiency (Schroer *et al.*, 1995). Technology transfer has different *outputs*, and different effectiveness measures are used based on the specific objectives, goals, mission, and roles of the technology transfer projects (Spann *et al.*, 1995). Firms transfer technology to create products and services to achieve business objectives, and human resource capability plays a critical role in the creation of a commercially viable product, service or process.

In order to accurately measure the effectiveness of a particular technology therefore, the three dimensions of product and process performance, business performance, and human resource capability must be considered.

2.1.1 Product and process performance

Firms transfer new technology to either produce a product or to establish the process required to produce a product, thus both are essential outcomes of the transfer project. Product and process performance of the transferred technology can be measured according to changes in the product defect rate; the increased number of products made in-house; the improved product quality and performance (Wong *et al.*, 1999); the increased number of new products, improved processes and modifications of existing products (Schroer *et al.*, 1995) and the shortened cycle time for product improvement and new product development (Chen, 1997; Wong *et al.*, 1999).

2.1.2 Business performance

The objective of transferring a product or process technology is to improve business performance. Thus, business results are the second outcome of the transfer project. Technology transfer involves the acquisition and processing of equipment, technical information, and knowledge, which is necessary but not sufficient for creating value (Camp and Sexton, 1992). Since use of this technology to generate profit in the market is important, assessing transfer performance must involve aspects of commercialisation, *i.e.*, new product and market development. Thus, commercial success is the dimension related to business performance of technology transfer. The business performance that results from a technology transfer can be assessed according to increased business volume (Lyles and Salk, 1996; Lyles *et al.*, 1997; Lane *et al.*, 2001); increased market share and the achievement of planned goals (Lyles and Salk, 1996; Lyles *et al.*, 1997; Lane *et al.*, 2001; Wong *et al.*, 1999); company growth (Wong *et al.*, 1999); profits (Chen, 1997; Lyles and Salk, 1996; Lyles *et al.*, 1997; Lane *et al.*, 2001; Lane and Lubatkin, 1998; Wang *et al.*, 2001); larger ROI; economies of scale and scope; international expansion; delivery cost reductions (Wong *et al.*, 1999); decreased operating costs (Schroer *et al.*, 1995); savings from process improvements in plant or product lines; factor cost reductions per product and the savings to users and shareholders (Weatherly and Iorio, 1993).

2.1.3 Human resources capability

A firm's ability to make a product or establish the production process to improve business involves human resources. Since technology transfer involves product- and process-embodied technology and all the peripherals of disembodied knowledge associated with such a task, it relies on human resource input, which is considerably more difficult to transfer than a product or equipment. Human resource development should be at the very heart of any technology transfer endeavour because it is the people that need to be taught how to use the equipment (Akinyemi, 2001). Human resource capability in a technology transfer has been evaluated according to its ability to manage and modify (Chen, 1997; Lin *et al.*, 2002; Lane *et al.*, 2001); the training offered by the technology seller (Chen, 1997; Lyles and Salk, 1996; Lyles *et al.*, 1997; Lane *et al.*, 2001); improvement of management capability and skills (Lyles and Salk, 1996; Lyles *et al.*, 1997; Wang *et al.*, 2001; Lane *et al.*, 2001); technological capability improvement (Chen, 1997; Wang *et al.*, 2001); the technical capability captured; the monitoring of technical change and getting access to the desired technology; the achievement of technical complementarity; the aversion of potential risk; the pooling of resources; and the achievement of vertical integration (Wong *et al.*, 1999).

As mentioned before, TTE is strongly influenced by AC and the AC concept has been a research focus for many disciplines such as the management of R&D (Cohen and Levinthal, 1989; 1990; Cockburn and Henderson, 1998; Deeds, 2001) and innovation (Vinding, 2000; Lenox and King, 2003); interorganisational learning (Lofstrom, 2000; Gupta and Govindrajana, 2000); alliances (Tasi, 2001); technology transfer both at national and firm level (Kim, 1997; Liu and White, 1997; Sung and Kyun, 1999; Wong *et al.*, 1999; Akubue, 2002; Lin *et al.*, 2002); and knowledge transfers (Szulanski, 1995; 1996).

This research categorises the different dimensions of AC in the following four ways: the ability to recognise the value of the new technology, the ability to acquire new technology, the ability to assimilate it, and the ability to apply it.

2.1.4 Ability to recognise the value of new technology

Before firms can assimilate the new technology they must go through the stages of value recognition, adoption and acceptance (Gilbert and Cordey-Hayes, 1996). Firms need prior basic knowledge to understand the importance of new technology (Lane and Lubatkin, 1998). Thus this ability is measured according to two components, 'basic knowledge' and 'specialised knowledge' (Lane and Lubatkin, 1998).

2.1.5 Ability to acquire new technology

The acquisition process determines which technologies the firm needs, which vendors have the technology that it wants to obtain, and what resources should be prepared before buying the new technology (Lin *et al.*, 2002). The ability to acquire is measured according to the extent the firm can learn from partners in terms of: technological expertise; marketing expertise; product development tools; managerial techniques, and manufacturing processes (Lyles and Salk, 1996; Lyles *et al.*, 1997; Wang *et al.*, 2001) and new knowledge about foreign cultures and trust (Lyles and Salk, 1996). The most frequently used measures in the literature to determine the acquisition ability are: number of years having experience in in-house R&D and the amount of R&D investment (Zahra and George, 2002).

2.1.6 Ability to assimilate the new technology

Assimilation of technology is the process through which firms bring new technology components into use. The ability to assimilate a new technology is a firm's ability to develop and refine the routines that facilitate combining existing technology with the newly acquired technology and its ability to integrate it operationally (Zahra and George, 2002). It involves a knowledge processing system for sharing knowledge, communication and coordination in planning, and implementing, and problem solving while the new technology is put into use. When new technology is properly assimilated it becomes an established routine. The new technology accumulation process assists firms in learning about new technology again and again. Assimilation ability can be measured through various processes and outputs, such as functional interfacing, knowledge sharing, and communication (Welsch *et al.*, 2001); knowledge processing system, compensation practices and firm structure (Lane and Lubatkin, 1998); and the number of cross-firm patent citations or citations made in a firm's publications about research developed with other firms (Cockburn and Henderson, 1998; Zahra and George, 2002).

2.1.7 Ability to apply new technology

A successful knowledge transfer is effective only when the knowledge transferred is retained for use (Szulanski, 1995), and to be retained for use, the knowledge acquired and communicated must be applied. It is the results of knowledge application that enable firm to learn (Gilbert and Cordey-Hayes, 1996), and knowledge transfer is achieved when an acquirer applies this knowledge to commercial ends (Ranft and Lord, 2002). Application

is required to develop new technology from the assimilated technology, but this needs time and the firm must adapt itself before being able to apply this new technology (Lin *et al.*, 2002). Application ability is a key dimension of AC as it may increase the firm's innovativeness. This ability can be measured through current knowledge learned from the foreign parent, international joint-venture strategies and training and development competence (Lane *et al.*, 2001); the number of external research communities in which the firm participates (Lane and Lubatkin, 1998); the number of patents, new product announcements or length of product development cycles (Zahra and George, 2002); New products and new applications using assimilated technology, finding alternative uses for the assimilated technology, and fusing assimilated technology with other technologies (Wong *et al.*, 1999).

3 Technology transfer and absorptive capacity conceptual model

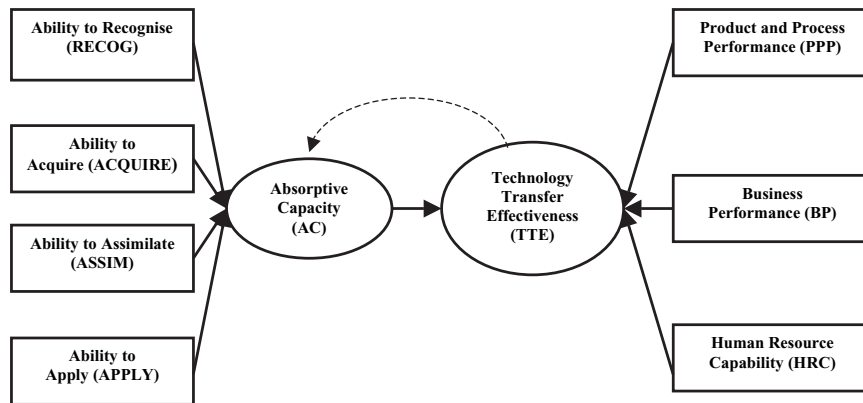
In this study, we propose that Technology Transfer Effectiveness (TTE) is influenced by the firm's Absorptive Capacity (AC) and that the relationship between AC and TTE is a positive relationship. As noted above, both concepts of AC and TTE have not been very clearly defined in the literature published so far, and an empirical analysis of their relationship is very rare. While we theoretically can expect that an improved TTE after having been enhanced by a sufficient level of AC, may in a secondary loop, feed back and help improve the firm's AC, the flexible packaging industry is relatively young in Thailand, and none of the 27 firms surveyed have established a proper process for assessing the quantity or quality of their TTE. Given the rather short history of this industry in Thailand, we decided to put priority on empirically investigating the first round, to focus on the immediate impact that AC had on the TTE of a firm's most recent technology transfer project. The empirical proof of a secondary, later feedback that the firm's improved TTE performance may have on enhancing its AC should be investigated in an industry that is more mature and has had more experience with technology transfer projects and the assessment of their performance.

Absorptive capacity is a firm's combinative ability to enhance its technological capability and it consists of the ability to recognise the value of external technology, knowledge, and information; the ability to identify and acquire the new technology; the ability to assimilate it; and the ability to apply or exploit the new technology to commercial ends. This internalisation of the new technology enhances the firm's competitive advantage and sustainability. Thus, in this study AC will be measured according to the following four dimensions; Ability to Recognise value of the new technology (RECOG); Ability to Acquire the new technology (ACQUIRE), Ability to Assimilate the new technology (ASSIM); and the Ability to Apply the new technology (APPLY).

Technology Transfer Effectiveness (TTE) is defined as meeting the objectives of a specific technology transfer project both in the short- and long-term. Since each technology transfer has specific objectives, these different objectives are measured using different TTE dimensions. This study proposes the following three TTE dimensions: Product and Process Performance (PPP), Business Performance (BP), and Human Resources Capability (HRC).

Figure 1 shows the relationship between the two research constructs and their related dimensions.

Figure 1 Absorptive Capacity (AC) and Technology Transfer Effectiveness (TTE) relationship model



4 Research methodology

4.1 Operational measures

Two sets of variables were measured in this empirical study of TTE and AC in the flexible packaging industry in Thailand, with TTE being the dependent variable and AC being the independent variable.

Technology Transfer Effectiveness (TTE) measures were developed mainly from the work of Chen (1997), Lyles and Salk (1996), Lyles *et al.* (1997), Lane *et al.* (2001), Lane and Lubatkin (1998), Lin *et al.* (2002), Wang *et al.* (2001) and from the results of in-depth interviews with industry experts. There are 16 items for the three TTE dimensions of PPP, BP, and HRC. All items were measured using four-point Likert scales, in which '1' means low and '4' means high.

Product and Process Performance (PPP) was measured according to four items based on the extent to which the firm was able to produce the expected product; achieve the required quality level; meet production efficiency targets; and increase technological capabilities from the new technology. These measures came from the work of Chen (1997), Wong *et al.* (1999), and Wang *et al.* (2001) except for the second measure, required quality level, which was developed from the interviews with industry experts.

Business Performance (BP) was measured using eight items based on the extent to which firms were able to increase new product development (increase innovation rate); achieve target costs; market the product on time; shorten product development cycle time; meet company growth targets; achieve planned goals; increase market share and increase profitability from the new technology. This modified version of business performance is based on the work of Chen (1997), Lyles and Salk (1996), Lyles *et al.* (1997), Lane and Lubatkin (1998), Lane *et al.* (2001), Wong *et al.* (1999) and Lin *et al.* (2002).

Human Resource Capability (HRC) was measured using four items based on the extent to which firms were able to manage the acquired technology; increase the ability to manage future technology transfers; receive training from equipment or know-how vendors, and increase management skills and capabilities. This modified version of human resource performance was developed from the work of Chen (1997), Lyles and Salk (1996), Lyles *et al.* (1997), and Wang *et al.* (2001).

Absorptive Capacity (AC) has 27 items for its four dimensions. All items were measured using four-point Likert scales, in which '1' means low and '4' means high.

These questionnaire items were developed and validated by the in-depth discussion with these industrial experts.

The measures for the Ability to Recognise the value of new external technology (RECOG), were developed from in-depth interviews with industry experts, since this dimension has not been discussed much in the literature. It was measured using two items based on the extent to which relevant personnel in flexible packaging firms saw the benefits of a new technology and tried to use it.

The measures for the Ability to Acquire the new technology (ACQUIRE) were developed mainly from in-depth interviews with industry experts except for one item: the extent of background knowledge to understand the new technology, which came from the work of Lofstrom (2000) and was also validated by the experts. Thus, ACQUIRE measures included six items based on the extent to which relevant personnel had prior background knowledge to understand the new technology; a clear understanding of company requirements related to adoption of new technology; the planning and identification of requirements regarding acquisition of new technology; the ability to ask questions and understand answers with the technology vendor; the ability to understand and communicate in the same language as the technology vendor; and the ability to understand the technology vendor's explanation of the new technology.

Measures for the Ability to Assimilate the new technology (ASSIM) included ten items based on the extent to which project team members involved in the implementation process were able to generate output according to the project's objectives. These ten items were: openness to the new technology; willingness to learn the new technology; knowledge of project details such as objectives, activities, milestones, *etc.*, knowledge or information sharing (dissemination) among concerned staff such as project implementation results, changes, new needs or requirements; achieving plan for the agreed or assigned work among members at each stage of the project; coordination of different project jobs and work activities among different departments; efficiency of concerned people from different departments who had to work together; timing of all related activities in the everyday routine of the project; planning of the work assignments for people from concerned departments who work together and establishing the routines of different departments that had to work with one another. The measures for one, two, three, and five were developed from the in-depth interviews with industry experts. All other measures were developed from the work of Welsch *et al.* (2001), and Sivadas and Robert (2000), and were also validated by industry experts.

Measures for the Ability to Apply the new technology (APPLY) were developed from the work of Wong *et al.* (1999) and from interviews with industry experts. These nine items are based on the extent to which the firm was able to develop the new packaging specification(s); new packaging process(es); new packaging application(s); modification existing packaging specification(s); modification existing packaging process(es); found alternative uses and applications; fused the assimilated technology with existing technologies and found additional products and process benefits from the assimilated technology beyond the project objectives.

Dependent and independent variable measures and their references are presented in Tables 1 and 2, respectively.

Table 1 Dependent variable, Technology Transfer Effectiveness (TTE), measure and dimensions

<i>Dimension</i>	<i>References</i>
Product and Process Performance (PPP)	Chen (1997)
Produced the expected product	Wong <i>et al.</i> (1999)
Achieved the required quality level	Wang <i>et al.</i> (2001)
Met production efficiency targets	Expert in-depth interviews
Increased technological capabilities	
Business Performance (BP)	Chen (1997)
Increased new products (increased innovation rate)	Wong <i>et al.</i> (1999)
Achieved target costs	Lyles and Salk (1996)
Marketed product on time	Lyles <i>et al.</i> (1997)
Shortened product development cycle time	Lane <i>et al.</i> (2001)
Achieved company growth target	Lane and Lubatkin (1998)
Achieved planned goals	Lin <i>et al.</i> (2002)
Increased market share	Expert in-depth interviews
Increased profitability	
Human Resource Capability (HRC)	Chen (1997)
Ability to manage the acquired technology	Lyles and Salk (1996)
Increased ability to manage future new technology transfer	Lyles <i>et al.</i> (1997)
Received training from equipment or know-how vendors	Wang <i>et al.</i> (2001)
Increased management skills and capabilities	

