Diffusion of Computer Aided Design Technology in Architectural Design Practice

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Abstract: Computer aided design (CAD) technology is one of the most influential information technology (IT) innovations of the last four decades. This paper studies the factors that influence the spread of this important IT innovation in the context of the Turkish architectural design practice. It builds on the innovation diffusion theory which proposes that internal (i.e., copying behaviors of others) and external influence (i.e., complying with clients' requirements, changes in government regulations, demand conditions, and consulting firms' suggestions) factors drive diffusion of an innovation. The paper empirically tests the propositions of innovation diffusion theory by using three mathematical models: The internal influence model, the external influence model, and the mixed influence model. Research findings point out that the mixed influence model has the highest exploratory power. They show that the diffusion of CAD technology in architectural design practice is primarily driven by internal rather than external influence factors. This study is of importance to researchers because this is the first application of the influence models to the study of the diffusion of CAD technology in architectural design practice. It is also of relevance to design practitioners since the findings should provide a useful guide in their decision to adopt or not to adopt CAD technology.

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Introduction

Computer aided design (CAD) technology has been one of the most influential information technology (IT) innovations. Architectural, engineering, and construction (AEC) firms' response to this IT innovation has been the subject of numerous surveys conducted in Scandinavia (Howard et al. 1998; Samuelson 2002), Canada (Rivard 2000), New Zealand (Doherty 1997), and South Africa (Arif and Karam 2001). These research studies reveal that the use of CAD technology has quickly spread among AEC firms. Yet, these IT diffusion surveys are silent on the factors that influence the diffusion process. Moreover, most previous research studies conducted on the diffusion of advances in IT focus on identifying the factors that hinder the diffusion of IT innovations among AEC firms (e.g., Laage-Hellman and Gaade 1996; Tucker and Mohamed 1996; Love et al. 2001; Steward and Mohamed 2002). Only a few research studies published in the construction management literature (e.g., Hansen 1993; Mitropoulos and Tatum 2000; Manley and McFallan 2003) have explicitly explored the factors that drive the diffusion of CAD technology among AEC firms. It appears that exploring the factors that drive the diffusion of IT and in particular of CAD technology among AEC firms is a developing research area in the construction management field. The research presented here intends to contribute to this developing research area. It considers CAD technology as one of the most important IT innovations of the last four decades. It proposes the use of innovation diffusion theory (Mansfield 1961; Coleman et al. 1966; Bass 1969; Rogers 1983) to explore the diffusion of CAD technology. Not only can this approach provide important insights on how IT innovations spread among AEC firms, but it can also provide a useful perspective on one of the most persistently challenging topics in IT: How to improve technology assessment, adoption, and implementation. Innovation diffusion theory proposes that the diffusion of an innovation in a social setting (i.e., industry, region, country) is driven by internal and external influence factors (Rogers 1983). The study presented here empirically tests propositions of the innovation diffusion theory in the context of the architectural design firms located in Turkey.

Innovation Diffusion Theory

Innovation Diffusion Theory (Rogers 1983) builds on well-established theories in sociology, psychology, and communications. It presents a simple conceptual framework for understanding the diffusion of the innovation process. Rogers (1983) defines *diffusion* as "the process by which an innovation is communicated through certain channels over time among the members of a social system". This definition implies that there are four main elements of diffusion, namely (1) innovation, (2) time, (3) communication channels, and (4) social system. *Innovation* is an idea, practice, or object that is perceived as new by an individual or other unit of adoption. An innovation can be technological, such

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as a new product, processing system, production process, physical equipment, or tool; or it can be administrative such as an organizational structure, administrative setup, training program, or strategic planning method that is new to the adopting organization (Daft 1978). *Time* relates to the speed with which an innovation is adopted by potential adopters. *Communication channels* are the paths of information flow between and among social units (i.e., individuals, groups, organizations)—the means and medium of communication. *A social system* is a set of interrelated units (i.e., individuals, informal groups, or organizations) engaged in joint problem solving to accomplish a common goal.

Innovation diffusion theory (Rogers 1983), in its simplest form, investigates how these four major factors, and a multitude of other factors, interact to facilitate or impede the adoption of a specific product/service or practice among members of a particular adopter group. Over the years, a number of different approaches (Rogers 1983; Davis 1989) were set forth for studying how these factors influence social actors' adoption decisions. *Influence models* stand out in this respect. The main objective of influence models is to explain or predict rates and patterns of innovation adoption over time and/or space (Mahajan et al. 1990). Using influence models for studying the diffusion of innovations presents a number of advantages (Goldenberg et al. 2001). First, influence models provide a relatively easy and efficient way to look at the social system and interpret its behavior. Second, influence models are parsimonious yet based on a rich and empirically grounded theory. Finally, influence models can be used in any social setting in which decision makers are interested.

Influence models (Mansfield 1961; Coleman et al. 1966; Bass 1969) have been used for studying the diffusion of innovations for more than four decades. The emergent picture from research studies that builds on influence models is that the cumulative adoption of an innovation over time follows a general *S*-shaped (sigmoid) curve composed of: (1) An initiation and implementation phase (with slow growth of adopters), (2) an adoption phase (with accelerating growth of adopters), and (3) a saturation phase (with decelerating growth of adopters) (Mahajan et al. 1990). A number of influence models have been set forth in the literature for exploring different forms of *S*-shaped curves for different innovations (Teng et al. 2002). The most popular influence models include: (1) *the internal influence model* (Mansfield 1961), (2) *the external influence model* (Coleman et al. 1966), and (3) *the mixed influence model* (Bass 1969).

Internal Influence Model

The internal influence model proposes that the driving force for the diffusion of an innovation is imitative behavior within a social system (Mansfield 1961). Imitative behavior in an industry setting can be explained by: (a) rational efficiency and (b) bandwagon propositions (Abrahamson and Rosenkopf 1993). The rational efficiency hypothesis proposes that firms rationally choose to adopt an innovation because of updated information about the innovation's expected efficiency or returns (i.e., profitability, growth in market share) (Farrell and Saloner 1985; Katz and Shapiro 1985). Proponents of the rational efficiency hypothesis (Farrell and Saloner 1985; Katz and Shapiro 1985) argue that the more firms adopt an innovation, the more information about efficiency or returns of the innovation is generated and disseminated from adopters to nonadopters. As a direct result of this information generation and dissemination process, a greater number of firms adopt the innovation. On the other hand, the bandwagon hypothesis proposes that firms choose to adopt an innovation not because of its expected efficiency or returns, but because of bandwagon pressures created by the sheer number of firms that have already adopted this innovation (DiMaggio and Powell 1983; Abrahamson and Rosenkopf 1993). Proponents of the bandwagon hypothesis (DiMaggio and Powell 1983; Abrahamson and Rosenkopf 1993) argue that it is information concerning which and how many firms have adopted the innovation, rather than information about the innovation itself that creates social pressures to conform to bandwagon behaviors. Bandwagon pressures can be: (a) Institutional or (b) competitive. Institutional bandwagon pressure refers to pressure on firms arising from the threat of lost legitimacy and the consequent erosion of stakeholder support (Abrahamson and Rosenkopf 1993). The increase in the number of firms adopting the innovation makes firms that do not adopt the innovation appear abnormal or illegitimate to their stakeholders. On the other hand, competitive bandwagon refers to pressures on a firm arising from fear of losing competitive advantage (Abrahamson and Rosenkopf 1993).

The internal influence model can be represented as follows:

$$\frac{dN(t)}{dt} = aN(t)[m - N(t)] \tag{1}$$

where $N(t)$=cumulative number of adopters of organizational innovation at time period t; m = total number of potential adopters in the social system; a = coefficient of internal influence (i.e., imitative behavior); $dN(t)/dt$ = first derivative of $N(t)$ representing the rate of diffusion at time t. m (the total number of potential adopters) and a (the coefficient of internal influence) are expected to be positive ($m \geqslant 0$ and $a \geqslant 0$). In the internal influence model, the diffusion of innovation is related to the interaction between prior adopters and potential adopters. Integrating Eq. (1) yields a cumulative adoption function.

$$N(t) = \frac{m}{1 + \frac{m - m_0}{m_0} \exp[-amt]} \tag{2}$$

where m_0 = number of adopters in the initial period. Plotting $N(t)$ against t results in an *S*-shaped diffusion curve that rises initially at an increasing rate until a point of inflection and thereafter at a decreasing rate.

External Influence Model

The external influence model proposes that the diffusion process is solely driven by information from a source external to the social system (Coleman et al. 1966). It assumes that no communication exists between the members of a social system and that the rate of diffusion at time t is dependent only on the potential number of adopters present in the social system. The external influence model does not consider the interaction between prior adopters and potential adopters and thus it attributes any diffusion only to the imitation process. It proposes that a firm adopts an innovation not because of the firm's rational choice or bandwagon pressures but because of influences that come from the outside of the social system (e.g., changes in government regulations, client/customer requirements, demand conditions, and consulting firms' suggestions). The external influence model can be represented as follows:

$$\frac{dN(t)}{dt} = b[m - N(t)] \quad (3)$$

where b = coefficient of external influence; and b is expected to be positive ($b \geq 0$). Integrating Eq. (3) yields a cumulative adoption function over time

$$N(t) = m[1 - \exp(-bt)] \quad (4)$$

The external influence model gives rise to a modified exponential diffusion curve with a negative exponent. The general shape of this curve is concave; the number of adopters increases at a decreasing rate over time.

Mixed Influence Model

The mixed influence model assumes that internal and external factors jointly influence a firm's decision to adopt an innovation. Therefore, it subsumes the external and internal influence models by incorporating parameters representing both the internal and external influence factors (Bass 1969). Its basic premise is that the adoption of innovation is partly triggered by imitation and partly by influences that originate outside the social system. The mixed influence model can be represented as follows:

$$\frac{dN(t)}{dt} = [b + aN(t)][m - N(t)] \quad (5)$$

Integrating Eq. (5) yields the following cumulative adopter function:

$$N(t) = m\left[\frac{1 - \exp(-(b+a)t)}{1 + \frac{a}{b}\exp(-(b+a)t)}\right] \quad (6)$$

Plotting the cumulative distribution of adopters in this influence model gives rise to a generalized logistic curve. The shape of this curve is jointly determined by a and b.

The internal, external, and mixed influence models have been commonly used in the marketing domain for explaining the factors that underlie the diffusion process and the market potential of durable consumer goods, such as refrigerators, color televisions, and washers (Mahajan et al. 1990). These models have also been used for exploring the diffusion of administrative (Teece 1980) and technological (Shao 1999; Teng et al. 2002) innovations among organizations. These research studies reveal that the mixed influence model is a powerful model for explaining the diffusion processes of organizational innovations. The relative influence of the internal (a) and external (b) influence components varies across administrative and technological innovations.

Computer Aided Design Technology and Architectural Design Practice

The architectural design process involves a number of different activities: Analysis, synthesis, representation of design, archiving design and design data, and communication with other parties. The unprecedented advancements in IT have revolutionized the architectural design process. CAD technology constitutes the cornerstone of these advancements and is considered to be the most important IT innovation of the last four decades. Early research on CAD technology started in the late 1950s and early 1960s. Sutherland's (1963) Sketchpad system was a milestone in the development of CAD technology. The Sketchpad system integrated computers and graphic devices to draw two/three-dimensional objects. Early systems such as Sketchpad were expensive prototypes and required most of the computing power of the then-largest computers. As a consequence, most of the early users of CAD technology were aerospace, automobile, and electronics firms. Several important developments in the 1960s and 1970s, such as the development of powerful mini- and microcomputers, the development of cheaper and more efficient display monitors, and the continuing decline in the cost of hardware and software facilitated the maturation of CAD technology.

CAD technology has evolved from drafting automation tool to design media, to a communication tool, to a shared design workspace and database. A brief review of this evolution reveals that there are three distinct generations of CAD technology, including (1) computer aided drafting, (2) geometric modeling, and (3) product modeling. The primary objective of the first generation of CAD technology was to automate drawing and produce simple drawings. It automated the drawing process by assembling several short lines to create simple lines and objects. CAD technology allowed drawings to be created and stored in an electronic format but it did not recognize construction/building objects. Therefore, printed or plotted drawings were interpreted by users in the same way as manually prepared documents. The second generation of CAD technology was introduced in the 1970s. It was concerned with developing a mathematical description of the geometry of an object. It had fixed symbols and parametric element libraries (walls, windows, and doors). This generation of computer CAD technology had knowledge of the components being represented and could hold information on the third dimension. Furthermore, it enabled designers to produce three-dimensional visualizations of buildings. The third generation of CAD technology was introduced in the late 1980s. The primary purpose of the third generation of CAD technology was to integrate geometric information with nongeometric data and establish associative and parametric relationships between geometric and nongeometric data. Geometric data include the definition of objects in terms of three-dimensional solids and surfaces expressed by either user defined or database-defined parametric information. Nongeometric information includes object characteristics such as weights, materials, strength, etc. The first and second generations of CAD technology have been widely adopted by architectural design firms. The third generation of CAD technology is not as widely adopted yet, as were previous generations of CAD technology.

These three different generations of CAD technology present a number of opportunities to architectural design firms, including better communication with clients, contractors, subcontractors and regulatory bodies, better document management, simplified production of working drawings, better drafting quality, higher efficiency in the production of drawings, shorter production time of construction and working drawings, simplified process for accommodating design changes, shorter time for implementing design changes, better control of information, higher consistency in drawings, powerful visualizations and presentations, and more convenient archiving of design data for future use (Pendergast 1991; Lawson 1998).

The use of CAD technology in architectural design has generated considerable debate concerning the impact of CAD technology on the creative processes in the practice of architectural design. Some architects argue that CAD technology reduces the potential for creativity and depersonalizes drawing production. Some others advocate that CAD technology, in particular second and third generations, enhances creativity and facilitates the evaluation of design alternatives. Research indicates that the benefits of CAD technology are dependent on how effectively it is used; in other words, mismanagement of the CAD process can result in poor design performance (Collins and King 1988; Robertson and Allen 1993).

Some research studies have explored the reasons why AEC firms would adopt CAD technology. They conclude that expected increases in productivity, anticipated improvements in quality of work, (Pendergast 1991; Fraser 1993; Manley and McFallan 2003), complying with client requirements, capturing benefits of a technological opportunity, and addressing process problems (Hansen 1993; Mitropoulos and Tatum 2000; Manley and McFallan 2003) were the factors that motivate AEC firms to adopt CAD technology. But none of these studies explicitly uses influence models to explore the diffusion of CAD technology among AEC firms.

Research Methodology

The data set used in this study was collected by conducting structured telephone interviews. The telephone survey guidelines recommended by Frey (1989) were followed. The participants consisted of chief designers in architectural firms. The structured telephone interview protocol consisted of two parts. The first part presented a brief statement of the research objectives to the respondents and assured respondents of the confidentiality and anonymity of their answers. The second part requested respondents to answer the following three questions: (1) In which year was your design firm established? (2) Does your design firm currently use CAD technology? (3) If the answer is yes, in which year did your firm adopt CAD technology for the first time? Three research assistants were trained by one of the writers to conduct the telephone interviews.

Telephone directories, on-line databases, and the membership list of the Turkish Chamber of Architects were consulted to construct a database of 250 Turkish architectural design firms. As recommended by Frey (1989), firms were considered to be ”noncontact” and removed from the sample after three unsuccessful attempts (no answer, wrong number or unavailable) to contact them during weekdays from 8.30 a.m. to 5.00 p.m. The total number of architectural design firms who were successfully contacted and that participated in the study totaled 236.

The telephone interviews were conducted in January 2004. The average length of time to conduct an interview and secure the necessary information averaged less than 4 min.

Methods

The use of internal, external, and mixed influence models for exploring the diffusion of an innovation requires the estimation of three parameters: (1) The coefficient of internal influence (a), (2) the coefficient of external influence (b), and (3) the total number of potential adopters in the social system (m). One of the procedures proposed to estimate these diffusion parameters was the ordinary least-squares procedure. However, the ordinary least-squares method has been criticized due to its shortcomings, including multicollinearity and the impossibility of calculating standard errors (Mahajan et al. 1990). Schmittlein and Mahajan (1982) suggest that these shortcomings can be overcome by adopting a nonlinear least-squares estimation procedure that has been used by some researchers to estimate the diffusion parameters a, b, and m (e.g., Venkatraman 1994; Teng et al. 2002). The research presented here uses the Levenberg and Marquardt method of nonlinear least squares to estimate the parameters of the influence models. The goodness of fit of each influence model was evaluated by using the coefficient of determination (R^2) which represents the proportion of the variance fitted to the model, the F value, the significance level (p), and the values of the estimated diffusion parameters (i.e., a, b, and m).

Table 1. Age Profile of Architectural Design Firms Using Computer Aided Design Technology

Year architecture design firm established	Number of architectural design firms	Percentage (%)
Prior to 1975	68	31
1975–1980	36	17
1971–1985	62	29
1986–1990	27	12
1991–1995	15	7
1999–2003	9	4

Research Findings and Discussion

The results of structured telephone interviews indicated that—out of 236 architectural design firms surveyed—217 (92%) had adopted CAD technology between the years 1990 and 2003. This finding suggests that the diffusion CAD technology in the Turkish architectural practice has reached a high level of saturation.

A review of trade magazines suggests that a mass market for the purchase and sale of CAD technology in Turkey emerged in the late 1980s. Following Teng et al.'s (2002) recommendation, the sample of firms had to be adjusted to include only those firms that were in existence before the mass market of the latest generation of CAD technology became available (i.e., 1990). Table 1 presents the age profile of the architectural design firms that had adopted CAD technology. It shows that 193 architectural design firms were established before 1990 while 24 firms were established after 1990. These 24 firms were excluded from the analysis because they were established after the mass market for CAD technology had emerged in Turkey. The number of adoptions for each year and the cumulative adoption of CAD technology by architectural design firms that were founded prior to 1990 are plotted in Fig. 1.

The results of the nonlinear least-squares estimation procedure are presented in Table 2. The coefficients of determination (R^2) of the three diffusion models range from 0.05 to 0.92 and are statistically significant ($p \leqslant 0.01$). The *external influence model* had the worst fit of the three models. It has the lowest coefficient of determination ($R^2=0.05$ and F value$=10.93$). The coefficient of external influence ($b=0.0329$) and the potential number of adopters ($m=526$) are both positive but the external influence model overestimates the number of potential adopters (i.e., $m=526$ exceeds the sample size).

The *internal influence model* has a reasonable fit to the data as indicated by its coefficient of determination ($R^2=0.84$ and F value$=95.46$). The coefficients of internal influence (b) and the potential number of adopters (m) are 0.0051 and 166, respectively. It underestimates the number of potential firms that adopted CAD technology, as the predicted number of adopters ($m=166$ firms) is far less than the actual number of firms (193) that had adopted CAD technology during the study period 1990–2003.

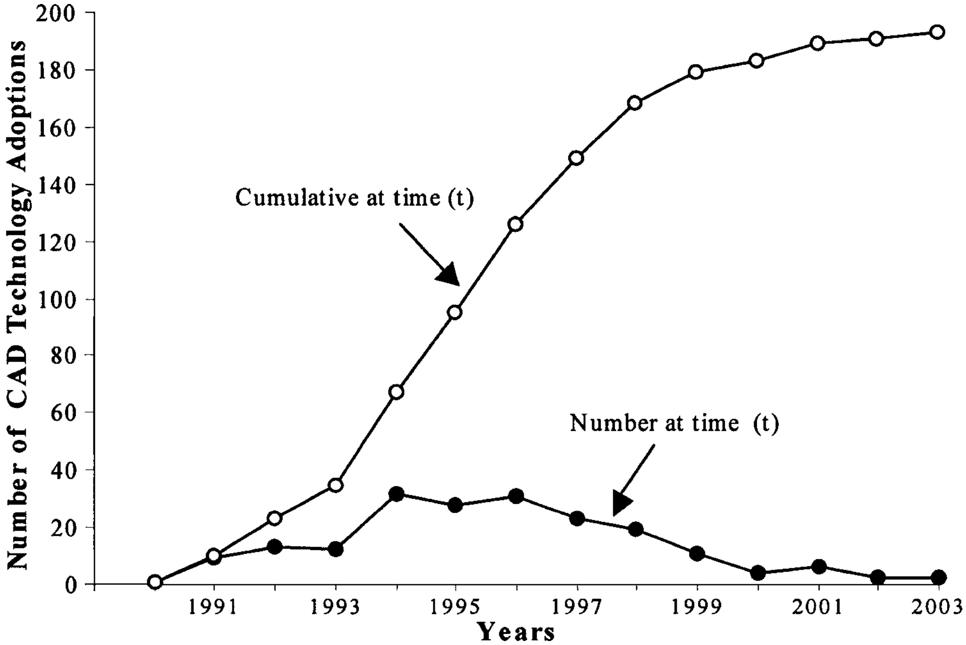

Fig. 1. Diffusion of computer aided design technology in architectural design practice

The *mixed influence model* provides the best fit as suggested by the coefficient of determination ($R^2=0.92$ and F value $=125.46$), which indicates that, in global terms, an acceptable level of precision has been reached with regard to the data. It shows that the predicted number of potential adopters ($m=193$) is exactly equal to the total number of firms that adopted CAD technology (193) during the study period 1990–2003. The coefficients of internal influence (a) and external influence (b) are 0.6232 and 0.0142, respectively. These coefficients suggest that the internal influence factor (a) plays a more important role than the external influence factor (b) in the diffusion of CAD technology.

These research findings jointly point out that the diffusion of CAD technology among Turkish architectural design firms is primarily driven by internal (i.e., imitative behavior) rather than external (i.e., complying with client requirements, changes in government regulations, demand conditions, and consulting firms' suggestions) influence factors. These research findings suggest that increases in the number of architectural design firms that adopt CAD technology influenced the number of remaining architectural design firms that have subsequently adopted CAD technology. These findings are consistent with Teng et al.'s (2002) findings that external influence factors constitute an inadequate explanation for the spread of CAD technology among North American firms and that the primary reason that causes North American firms to adopt CAD technology is imitative behavior.

Table 2. Diffusion of Computer Aided Design Technology in Architectural Design Practice

Description	Diffusion model: Internal influence	External influence	Mixed influence
Parameter estimation			
a (coefficient of internal influence)	0.0051 (0.0003)	—	0.6232 (0.05694)
b (coefficient of external influence)	—	0.0329 (0.0542)	0.0142 (0.2764)
m (potential number of adopters)	166.2918 (11.4382)	525.5961 (706.1096)	193.2319 (12.0385)
Model fit			
Mean-square error	1,992.2752	1,367.1555	1,371.5801
F value	95.46	10.93	125.46
R^2	0.84[a]	0.05[a]	0.92[a]

Note: Standard errors in parenthesis.

[a]All models are significant at $p \leqslant 0.01$.

The imitative behavior observed in Turkish architectural design firms can be explained by the rational efficiency hypothesis. Studies conducted by Manley and McFallen (2003) and Toole (1998) point out that information on the costs and benefits of adopting an innovation in the construction industry is obtained by means of various communication channels. For example, increased adoption of CAD technology by architectural design firms is likely to capture the attention of professional journals and trade magazines, and may be debated at architectural design exhibitions and competitions, trade shows, and similar gatherings. Architectural design firms might become aware of the existence of CAD technology through these information channels, or by communicating with previous adopters, and by observing the outcomes of CAD technology adoption (e.g., profits, market share, etc.) by other firms.

The imitative behavior observed in Turkish architectural design firms can also be explained by the bandwagon hypothesis. The sheer number of firms adopting CAD technology can cause competitive and institutional bandwagon pressures, promoting other firms to adopt CAD technology. A firm that has not adopted CAD technology may appear not be totally legitimate to clients, i.e., it may give the impression that the firm is not qualified even though it has provided excellent service over the years. Architectural design firms want to avoid the negative inferences that could come from being disqualified by potential clients for not using the latest CAD technology. It follows that architectural design firms are sometimes forced to adopt CAD technology due to the fear of losing competitive advantage. Indeed a firm's rivals that have adopted CAD technology might have a better chance in getting commissions even if the firm has an excellent service record but does not use CAD.

Some scholars (DiMaggio and Powell 1983; Abrahamson and Rosenkopf 1993) suggest that the greater the uncertainty associated with the efficiency returns (i.e., benefits) of an innovation, the more pronounced become bandwagon pressures, as opposed to rational choice. Abrahamanson and Rosenkopf's (1993) research has provided strong empirical evidence for this argument. Yet the influence models used in our study are unable to distinguish between adoption due to rational efficiency or adoption due to bandwagon pressures. Therefore, it is impossible to identify exactly the role of rational efficiency (i.e., communication between adopters and nonadopters) or bandwagon pressures (i.e., institutional or competitive bandwagon pressures) in the diffusion of CAD technology among Turkish architectural design firms. The resolution of this research question is a challenging task.

The research presented here has some managerial and academic implications. First, architectural design firms, like other AEC firms, operate in an environment that host a multitude of institutional and competitive pressures that can lead them to adopt IT innovations even if these innovations will not result in any improvement in the firm's performance. Therefore, architectural design firms should be aware of the subtle operation of institutional and competitive bandwagon pressures in their environments. Second, the subtle operation of bandwagon pressures coupled with the accelerating pace of technological advances in IT require AEC firms to conduct a comprehensive strategic analysis before adopting any IT innovation. The quality of this decision-making process will be one of the most important success factors in architectural design practice in the years to come. Finally, AEC firms are commonly criticized in the construction management literature for their skepticism in adopting IT innovations. This skepticism is considered to be an important hindrance to performance improvements in the construction industry. Yet, it should also be noted that a certain degree of skepticism is beneficial in innovation adoption decisions since it can lead to a healthy decision-making process.

The research presented here, like many other research studies, has some limitations. First, it uses the industry setting to conduct its analysis. Therefore, it does not consider the impact of individual and organizational factors that might be influencing the diffusion of CAD technology. Constructing a longitudinal sample by collecting data at different time intervals on organizational characteristics may also provide deeper insights into the analysis. Finally, the research presented here is confined to the study period of 1990–2003. Since CAD technology has been in existence for over four decades, a longer study period may provide better insights into the operation of internal and external influence factors.

Concluding Remarks

The research presented in this paper considers CAD technology to be one of the most important IT innovations of last four decades. It explores the diffusion of this important IT innovation among Turkish architectural design firms by building on the conceptual foundations of innovation diffusion theory, which proposes that internal and external influence factors motivate organizations to adopt an innovation. The research presented here empirically tests this proposition by using three mathematical models. Some key research findings emerge from this research. First, it points out that the mixed influence model is the most powerful model for exploring the diffusion of CAD technology among architectural design firms. Second, it reveals that the spread of CAD technology in architectural design practice is driven by internal influence factors rather than external influence factors. Third, the imitative behavior of the firms can be explained by the firms' rational choice based on the efficiency returns of CAD technology and also by bandwagon pressures (i.e., fear of losing competitive advantage, erosion of legitimacy, and fear of losing stakeholder support). Finally, AEC firms should conduct a comprehensive analysis before adopting a technological or administrative innovation.

This study is of importance to researchers because this is the first application of the influence models to the study of the diffusion of CAD technology in architectural design practice. It is also of relevance to design practitioners since the findings should provide a useful guide in their decision to adopt or not to adopt CAD technology.

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