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Use of information and communication technologies by small and medium-sized enterprises (SMEs) in building construction†

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Scholars usually agree that small and medium-sized enterprises (SMEs) active in construction are not very innovative when compared with large-size construction enterprises. This is particularly evident in the case of adoption and diffusion of innovation associated with information and communication technologies (ICTs). Although ICTs are powerful instruments for the rapid and broader diffusion of technical knowledge, few SMEs are fully able to exploit their benefits. There is little evidence of how SMEs perceive ICTs and of the extent to which these technologies are actually used in the construction industry. There is a relationship between organizational size and the use of ICTs within the SMEs in the building construction sector in Turkey. A set of ICT variables comprising the perception, investment, usage and the software preferences of SMEs were analysed by making use of the data collected in a survey of a randomly selected sample of 227 building construction firms in Turkey. In contrast to the common approaches that consider SMEs as part of a homogeneous set of firms with similar characteristics, this study seeks the differences in ICT-related attitudes between SMEs of different sizes. Rather than using arbitrarily pre-defined intervals to classify firms by size, cluster analysis was used in this study. Although what emerges as a whole is the common under-utilization of ICTs by SMEs in building construction, 'organizational size' appears to explain some of the ICT-related attitude differences within these SMEs. Policy makers can consider using the findings of this study as inputs in their activities, as these findings represent a generic overview of the diffusion of new technologies and can assist in identifying future research directions.

Keywords: Information and communication technology, organizational size, small firms, Turkish building construction industry

Introduction and background

Both the management science literature (Anderson and Schaan, 2001; O'Farrell and Miller, 2002) and the construction management literature (Blackley and Shepard, 1996; Koivu and Mantyla, 2000) suggest that the performance of SMEs is unsatisfactory in adopting and implementing innovations. This is particularly evident in the case of information and communication technologies (ICTs), which require particular organizational skills for effective implementation (Markus and Robey, 1988; Sauer, 1993 in Whyte *et al.*, 2002: 371).

Contractors can use ICTs as an enabler for integration, collaboration, knowledge management, procurement, site management and process improvement (Sarshar and Isikdag, 2004: 239). However, despite the apparent advantages ICTs offer, construction firms in general are slow to exploit their potential benefits (Egbu and Botterill, 2002: 126). The building construction industry invests little in ICTs compared with the other sectors such as financial services and manufacturing (Construction Industry Board, 1998: 27–8). Furthermore, the current use of ICTs in construction firms continues to be 'piecemeal' (Mak, 2001: 258): few contractors are fully able to integrate

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†This paper is based on a research project, in which the particular focus of interest was the diffusion of innovative technologies among construction SMEs in the Turkish building construction industry (Sey *et al.*, 2002). The findings associated only with ICTs are extracted and reported in this paper.

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ICTs with their business processes. Book-keeping and invoicing are the most common ICT applications even in the construction industries of relatively advanced countries (Samuelson, 2002). Except for a limited number of well-entrenched software packages, few computerized innovative solutions are easily welcomed by the majority. Most computer applications still consist of word processors, spreadsheets, accounts and administrative software (Samuelson, 2002: 23), and the usage is limited to the production of traditional documents (e.g. specification documents, detailed drawings or bar charts) that still require human interpretation (Luiten and Tolman, 1997: 114). E-mail attachments constitute the most 'sophisticated' use of the Internet for the majority of the construction firms (Björk, 2003: 106). Distribution of documents and graphics in digital format is not common (Samuelson, 2002: 11–12). Computer illiteracy and inadequate knowledge of ICT are the most frequently reported shortcomings of contractors in many countries (e.g. DHFETE, 2001: 67; Samuelson, 2002: 18). Construction professionals are quite attached to their conventional methods. This tendency can be observed easily in the realm of web-based technologies where the rate of adoption of various systems is far from the desired level (e.g. Doherty, 1998; Anumba and Duke, 1999; Ng *et al.*, 2003). Most of the firms have websites but these are usually 'static' sites, which just provide information about products and services, rather than 'dynamic' sites that allow business transactions. Samuelson (2002) showed that contractors do not exploit the potential of electronic trade either. Bäckblom *et al.* (2003) found that electronic document management (EDM) systems (e.g. project webs and project extranets) were not used widely in the project organization in the Finnish construction industry; contractors used them only as 'storage points' and there were few active users.

Researchers have identified various factors that explain the reluctance of the construction industry to adopt and use ICTs (e.g. see Rivard, 2000; Whyte *et al.*, 2002). Three of these factors best characterize the overall attitude of construction firms towards ICTs. First, rather than technical and financial problems (e.g. continuous demand for upgrading and high investment costs), cultural and psychological factors are increasingly receiving attention as barriers to the widespread adoption of ICTs (e.g. see Bäckblom *et al.*, 2003; Björk, 2003). Secondly, the fact that construction professionals are often satisfied with their traditional business methods and tools is a common barrier (Doherty, 1997: 10; Samuelson, 2002: 18). Thirdly, there is no single magic ICT solution for the whole construction market. The type of the ICT solution required by construction firms is likely to depend on the context of the work done (Egbu and Botterill, 2002: 131). Concerning the last argument, Samuelson (2002: 23) argues that the lack of effective applications for the core businesses of contractors might be one explanation for the low use of ICTs by contractors, when compared with other parties in the construction industry.

In reference to the Turkish construction industry, there is almost no empirical evidence relative to ICT use. One exception is, perhaps, Sarshar and Isikdag's (2004) work, even though they did not particularly focus on contractors, but on a combined group of 22 contractors, consultants and some industry associations. Sarshar and Isikdag (2004) investigated the current usage of ICT and the importance attached to the future of a set of ICT applications in the construction industry. Their findings from a limited number of semi-structured interviews suggest that 60% of the organizations believed that they use ICT as a strategic tool and that ICT use is critical to sustaining their future business strategy. The remaining 40% believed that ICT use 'may be' important in the future success of their organizations. 'Multimedia applications' (55%), 'groupware applications' (50%), 'integration of software' (36%) and 'digital catalogues' (36%) were considered to be 'vital' applications that can contribute to the future performance of the industry. Although based on a very small and combined sample that includes only a few general building contractors, Sarshar and Isikdag's (2004: 244) key findings reflect the climate in which Turkish contractors operate: (1) The Turkish construction industry faces ICT-related challenges that are similar to those faced in other countries; (2) senior industry figures and large construction enterprises view ICTs as strategic to their business but SMEs are less aware and capable of using ICTs; (3) lack of trained staff is one of the main reasons for the underutilization of ICTs; and (4) the relatively cheap workforce in Turkey is a major barrier to the automation of some processes.

Despite the rising interest in SMEs in the construction industry in recent years (e.g. Sexton *et al.*, 1999; Sexton and Barrett, 2003a, 2003b), there is no evidence of research that statistically analyses the relationship between organizational size and ICT usage within the SMEs in the building construction sector. This study attempts to fill this knowledge gap, while presenting a general picture of the ICT-related attitudes of SMEs. One should keep in mind that SMEs constitute the majority of the firms in the Turkish building construction industry.

Research questions

As part of a larger research project, a set of questions was directed to the top decision makers of the general building contractors. While the majority of these decision-makers are the owner-managers (75%), the rest of them are senior managers. Following a literature review, four groups of questions were identified for the purpose of investigating the ICT-related attitudes of SMEs active in the building construction industry (see Appendix for the full list of research questions and the operationalization of variables):

(1) Is there a significant difference between SMEs of different sizes regarding the perception of the influence of ICTs on business performance?
(2) Is there a significant difference between SMEs of different sizes in terms of their ICT investment attitudes?
(3) Is there a significant difference between SMEs of different sizes in terms of the level of usage of ICTs?
(4) Is there a significant difference between the software preferences of SMEs of different sizes?

Sampling

The 'stratified sampling method' is often considered as an appropriate approach for investigating ICT usage within the construction industry (see Samuelson, 2002; Bäckblom *et al.*, 2003). However, access to well-organized business statistics is a major difficulty for researchers in Turkey. Commonly available statistical data associated with construction firms are not fully organized on the basis of number of employees or other common parameters in order to perform stratified sampling. Accordingly, 'simple random sampling' was used to select 300 general contractors from the database of the Istanbul Chamber of Commerce that includes the names of about 15 000 construction firms. The generous budget of the research allowed researchers to continue random sampling, until 300 firms agreed to an interview. This was achieved after approaching 4500 firms, a rate of response of 15%. The preliminary analysis of the data collected from 300 firms showed that some of these firms specialized not only on building projects, but also on infrastructure and other types of projects. Since the ultimate goal of the study was to analyse the attitudes of 'building contractors', a total of 73 firms whose operations focused mainly on other activities within the previous 5 years were dropped from the sample. As a result, 227 of the 300 questionnaires (75.6%) were included in the final analysis. Data were collected through face-to-face contacts with the top decision-makers of the building construction firms. Table 1 shows the composition of the sample and indicates that the majority of the SMEs identify themselves as specialists in residential building construction.

Determining organizational boundaries

A problem associated with SME-related research is deciding where 'smallness' begins. Determining organizational boundaries has long been a problematic issue in both management science (see Kimberley, 1976) and construction management research (see Sözen, 1997). Particularly in the case of construction firms, this problem is complicated further because lateral (e.g. strategic alliances) and vertical (e.g. subcontracting) networking opportunities allow even the smallest firms to undertake projects disproportionate to the human and non-human resources available to them (Eyiah, 2001). Nevertheless, the majority of researchers continue to use the 'number of employees' as the measure of firm size for contractors. The rationale for choosing 'production value' rather than 'number of employees' to classify firms by size is presented below.

'Production value' is represented by the market value of the projects undertaken by a company. It was calculated for each company by multiplying the total volume of production (square metre area of all projects undertaken and *finished* within the last 5 years) with the current unit prices of these projects. Compared to 'number of employees', 'production value' was considered to be a more appropriate measure of firm size in the building construction industry because (1) it concentrates on the value of the final products regardless of how much of the works was subcontracted; and (2) unlike 'number of employees', it is sensitive to recent shifts from labour-intensive to capital-intensive production processes in the construction industry.

Table 1 Composition of the sample

Field of specialization (building types)	Number of firms	Percentage in the sample (%)
Low-rise residential buildings	166	73.13
Industrial buildings	15	6.60
Commercial buildings	13	5.72
Educational buildings	2	0.88
Health buildings	2	0.88
Tourism buildings	3	1.32
More than one building type	22	9.69
All building types	4	1.76
Total	227	100

The conventional use of pre-defined intervals is not appropriate to classify firms by size, as this method is quite arbitrary in nature. This is why an alternative approach was developed to classify contractors: cluster analysis was conducted, using 'production value'. Cluster analysis is an exploratory statistical technique, which is used in classification problems. It considers the degree of association between observations to group them into clusters with similar characteristics. Cluster analysis might be used to develop taxonomies for populations, to develop statistical models to describe them, or to develop measures of definition, size, etc. There are two basic types of cluster analysis: hierarchical cluster analysis and K-means cluster analysis. The latter is usually used for large samples, where n is larger than 200, which was the case in this study. Then, analysis of variance (ANOVA) and χ^2 tests were applied using the SPSS software in order to see to which extent smaller and larger firms differed.

The results of the cluster analysis are shown in Table 2. The most significant variability between the size-groups was observed with four clusters ($p<0.01$ and df=3 in ANOVA). Because the sample was not normally distributed, the observed 'production values' were transformed into logarithmic values ($p=0.200$ in Kolmogorov–Smirnov test of normality). Table 2 also shows the descriptive statistics relative to the numbers of employees in each cluster. The first cluster comprises the smallest contractors in the sample, whereas the fourth cluster comprises the largest ones. The terms 'smaller' and 'larger' contractors in this paper refers to the relative size of contractors within the sample and represent a continuum between the first and last clusters. Note that by common standards, which usually take into account 'the number of employee criterion', the vast majority of the firms in the sample can be classified as small and micro firms. On the other hand, the definition of SME is dynamic and evolves according to the cyclical movements of the national economies as evidenced by the frequent changes in the formal definition of SMEs in many countries including Turkey. Thus, one might consider the method of classifying SMEs in this study as illustrative of the current economic situation (e.g. size of the market) of the construction industry in Turkey.

Discussion and conclusion

This study sought answers for four major research questions associated with (1) perceptions of the impact of ICTs, (2) extent of investment in ICTs, (3) level of usage of ICTs and (4) software preferences. The results of the statistical analyses are shown in Tables 3, 4 and 5. The findings of the study demonstrate clearly the relationship between organizational size and attitudes towards ICTs within SMEs active in building construction, except when exploring the two reasons concerning the extent of investment in ICTs (item 2.2 in Table 3) and software preferences (item 4 in Table 5). The remaining two research questions, namely perceptions and usage of ICTs are discussed in the following paragraphs.

Concerning the respondents' perceptions of the impacts of ICTs, it can be observed that to a large extent SMEs have a shared view of the impact of ICTs on office performance (item 1.1 in Table 3). Indeed, SMEs appear to be experiencing the large impact of ICTs on office performance, as evidenced by a mean score of 4.5 on a scale of 1–5 where 1 represents 'not influential' whereas 5 'very influential' (item 1.1. in Table 4). On the other hand, according to the findings in item 1.2 in Tables 3 and 4, as firm size becomes larger, contractors perceive the impact of ICTs on construction performance to be larger. However, the full integration of ICTs into actual construction practices continues to be a distant target for all SMEs regardless of size, as the mean influence score for item 1.2 in Table 3 is only 3.67.

Concerning the level of usage of ICTs, it appears that as firm size becomes larger, contractors use ICTs more intensively in many fields (item 3.1 in Table 3). Mean scores of level of usage (item 3.1 in Table 4) suggest that, in general, record-keeping, accounting, scheduling and document-sharing within an office are the fields in which ICTs are extensively used by SMEs. Larger contractors have a stronger computerized organizational memory, as evidenced by the many statistically significant differences observed in the activities listed under item 3.4 in Table 5. Larger firms are more capable of using their organizational memory as shown by item 3.5 in Table 3. It appears that

Table 2 Descriptive statistics of clusters

Clusters	Number of Cases	Production value ($)			Number of employees		
		Mean	Median	SD	Mean	Median	SD
1st cluster	42	256.811	272.600	129.913	3.76	3.00	3.42
2nd cluster	92	1 287.647	1 056.000	576.158	4.58	4.00	3.42
3rd cluster	64	5 847.590	5 250.000	2 610.041	8.13	6.00	6.48
4th cluster	29	53 426.206	31 800.000	65 971.261	39.00	13.00	46.64

Table 3 ANOVA test summary

Variables	No. of firms in clusters	df	*F*	*p*
	n_1, n_2, n_3, n_4			
1.1. Perceived influence of ICTs on office performance	41, 92, 64, 29	3	0.371	0.774
1.2. Perceived influence of ICTs on construction performance	41, 92, 64, 29	3	2.876	0.037*
2.2. Reasons for investment in computer systems	No statistical analysis could be performed because very small number of observations fell into clusters			
3.1. Level of usage of computer systems in				
designing	31, 71, 57, 29	3	1.535	0.207
accounting	31, 71, 57, 29	3	3.442	0.018*
scheduling	31, 71, 57, 29	3	3.781	0.012*
record-keeping	31, 71, 57, 29	3	3.539	0.016*
marketing	31, 71, 57, 29	3	5.156	<0.01**
document- and knowledge-sharing (between head office and sites)	31, 71, 57, 29	3	10.504	<0.01**
document- and knowledge-sharing (with other firms)	31, 71, 57, 29	3	3.464	0.017*
document- and knowledge-sharing (within office)	31, 71, 57, 29	3	1.635	0.183
document- and knowledge-sharing (with clients)	31, 71, 57, 29	3	1.726	0.163
3.5. Usage of computerized records in				
scheduling new projects	38, 85, 60, 29	3	2.692	0.047*
measuring firm's productivity	32, 80, 56, 28	3	6.555	<0.01**
marketing	23, 60, 43, 24	3	3.050	0.031*
bidding for new projects	32, 80, 59, 28	3	3.155	0.026*
measuring partners' performance	22, 50, 21, 43	3	1.306	0.275
3.7. Reasons for under-capacity usage of computer systems				
lack of staff with appropriate skills	20, 34, 30, 10	3	0.173	0.914
lack of appropriate software	20, 34, 30, 10	3	1.743	0.164
lack of appropriate hardware	20, 34, 30, 10	3	1.317	0.274
satisfaction with existing methods	20, 34, 30, 10	3	0.427	0.734
lack of technical harmony with other firms in the firm's business network	20, 34, 30, 10	3	0.952	0.419

*Values at 0.05 significance level.
**Values at 0.01 significance level.

bidding, scheduling and measuring productivity are the fields in which SMEs use their memory better (item 3.5 in Table 3). However, according to the findings in item 3.3 in Table 5, there appears to be almost no difference between SME clusters in integrating ICT with their business processes (e.g. with placing/receiving orders). The only difference is that larger contractors use the Internet for receiving job applications more than smaller ones.

Interestingly, the descriptive analysis of the data shows that the two main reasons for the underutilization of ICTs are identical for all clusters (item 3.7 in Table 4): 'lack of staff with appropriate skills' and the 'satisfaction with existing methods'. More than half of the companies (53.30%) have an internet connection, but e-mailing appears to be the most common application with only 47.14% using it.

Finally, even though no inferential analysis could be made because of technical limitations, descriptive analysis shows that of the 112 software packages purchased by all contractors in the sample, 28% are associated with architectural design; 18% with structural design; 12% with Microsoft Office programs and 11% with operating systems. Also recalling from Table 3 (item 3.1) that there is no significant difference between clusters in their use of computer systems in the design services, it can be concluded that SMEs in the Turkish construction industry use CAD systems to the same extent.

The observed differences between the clusters may be the consequences of the fact that the needs of smaller and larger firms relative to ICTs differ, as they operate in different environments. Consider, for example, the finding that larger firms differ from smaller firms in their usage of the internet for receiving job applications. This is hardly surprising, because the employment policies of smaller firms are more likely to depend on their close-knit networks, and they usually have less formal procedures for procuring human resources. Thus, smaller firms have fewer reasons to use the internet for this purpose. As well, larger firms usually execute a larger number of projects

Table 4 Descriptive statistics by clusters

Variables	Overall sample All clusters		Clusters							
	mean	SD	1st		2nd		3rd		4th	
			mean	SD	mean	SD	mean	SD	mean	SD
1.1. Perceived influence of ICTs on office performance	4.50[1]	0.87	4.46	0.78	4.47	0.95	4.50	0.87	4.66	0.72
1.2. Perceived influence of ICTs on construction performance	3.77[1]	1.24	3.51	1.21	3.77	1.23	3.67	1.33	4.34	0.94
2.2. Reasons for investment in computer systems	–	–	–	–	–	–				
3.1. Level of usage of computer systems in										
designing	3.37[2]	1.65	3.16	1.81	2.94	1.84	3.37	1.65	3.72	1.67
accounting	3.56[2]	1.71	2.65	1.76	3.46	1.68	3.56	1.71	4.00	1.60
scheduling	3.44[2]	1.56	2.87	1.48	3.13	1.57	3.44	1.56	4.07	1.31
record-keeping	3.81[2]	1.33	3.39	1.52	3.34	1.53	3.81	1.33	4.24	0.91
marketing	2.05[2]	1.39	1.61	1.09	1.97	1.42	2.05	1.39	2.97	1.64
document- and knowledge-sharing (between head office and sites)	2.51[2]	1.58	1.42	0.99	2.06	1.49	2.51	1.58	3.45	1.66
document- and knowledge-sharing (with other firms)	3.21[2]	1.59	2.45	1.61	2.75	1.60	3.21	1.59	3.59	1.52
document- and knowledge-sharing (within office)	3.60[2]	1.37	3.45	1.50	3.62	1.36	3.60	1.37	4.17	1.28
document- and knowledge-sharing (with clients)	3.21[2]	1.57	2.55	1.52	3.06	1.59	3.21	1.57	3.41	1.66
3.5. Usage of computerized records in										
scheduling new projects	4.07[2]	0.88	3.66	0.99	3.95	0.84	4.07	0.88	4.24	0.91
measuring firm's productivity	3.48[2]	1.06	3.50	1.02	3.15	0.98	3.66	1.05	4.07	1.05
marketing	2.99[2]	1.13	2.78	1.04	2.98	1.07	2.79	1.04	3.58	1.35
bidding for new projects	4.13[2]	0.97	3.75	1.05	4.16	0.92	4.12	1.00	4.50	0.79
measuring partners' performance	3.10[2]	1.11	3.36	1.18	3.02	1.06	2.93	1.10	3.38	1.12
3.7. Reasons for under-capacity usage of computer systems										
lack of staff with appropriate skills	3.73[3]	1.33	3.75	1.45	3.79	1.32	3.60	1.35	3.90	1.20
lack of appropriate software	2.61[3]	1.31	2.10	1.12	2.79	1.34	2.83	1.39	2.30	1.16
lack of appropriate hardware	2.34[3]	1.27	1.90	1.07	2.41	1.40	2.60	1.19	2.20	1.32
satisfaction with existing methods	3.52[3]	1.27	3.70	1.34	3.35	1.41	3.63	1.00	3.40	1.51
lack of technical harmony with other firms in the firm's business network	2.18[3]	1.15	1.95	1.28	2.15	1.10	2.20	1.03	2.70	1.42

[1] On a scale of 1–5 where 1 is 'not influential' and 5 is 'very influential'.
[2] On a scale of 1–5 where 1 is 'never' and 5 is 'always'.
[3] On a scale of 1–5 where 1 is 'not important' and 5 is 'very important'.

concurrently and, as a result, they have a higher level of bureaucracy and documentary traffic, which make ICTs vital for monitoring operations. This may be one explanation for the relative intensity of ICT utilization by larger firms, and for why they are more likely to invest in ICTs. The importance attached by larger firms to the computerization of records may be the consequence of the fact that they usually have well-established departments in their headquarters that are responsible for storing and processing project-related information.

The findings may give initially the impression that larger firms have a more positive attitude towards ICTs. However, the similarities between the attitudes of SME clusters deserves special attention as the findings, supporting Sarshar and Isikdag's (2004) argument, imply that SMEs in building construction in general do not consider ICTs as strategic to their business. Taken as a whole, the findings suggest that the use of ICTs by SMEs is quite uniform but not extensive. Turkish SMEs in building construction appear to benefit partly from the advantages of ICTs

Table 5 χ^2 test summary

Variables	As percentage of overall sample	No. of firms in clusters $n_1/n_2/n_3/n_4$	df	χ^2	p	Cramer's V
2.1. Tendency to invest in computer systems						
invested in hardware	21.59	42, 92, 64, 29	9	18.845	0.027*	0.166
invested in software	6.60					
invested in both	26.00					
none	45.81					
3.2. Usage of internet	53.30	32, 73, 57, 28	3	7.302	0.063	0.063
3.3. Purpose of internet usage						
receiving job applications	11.01	16, 44, 38, 23	3	13.822	<0.01**	0.338
placing/receiving orders	10.57	16, 44, 38, 23	3	2.694	0.441	0.149
document-sharing within firm	33.92	16, 44, 38, 23	3	1.914	0.590	0.590
document-sharing with clients	33.92	16, 44, 38, 23	3	0.888	0.828	0.086
document-sharing with other firms	38.77	16, 44, 38, 23	3	3.688	0.297	0.175
e-mailing	47.14	16, 44, 38, 23	3	7.647	0.054	0.251
market research	22.91	16, 44, 38, 23	3	4.090	0.252	0.184
searching new jobs	14.10	16, 44, 38, 23	3	4.314	0.229	0.189
having a company web site	16.74	16, 44, 38, 23	3	2.312	0.510	0.138
3.4. Computerization of records (computerized memory) in						
project costs	41.85	42, 92, 64, 29	3	19.625	<0.01**	0.294
materials suppliers	32.16	42, 92, 64, 29	3	15.236	<0.01**	0.259
materials producers	31.28	42, 92, 64, 29	3	16.513	<0.01**	0.270
construction materials	40.00	42, 92, 64, 29	3	17.442	<0.01**	0.277
completed projects	43.61	42, 92, 64, 29	3	23.183	<0.01**	0.320
construction equipment usage	13.22	42, 92, 64, 29	3	18.254	<0.01**	0.284
daily progress reports	27.31	42, 92, 64, 29	3	22.632	<0.01**	0.316
clients' payments	59.91	42, 92, 64, 29	3	20.511	<0.01**	0.301
clients	45.37	42, 92, 64, 29	3	29.816	<0.01**	0.362
previous job proposals	44.93	42, 92, 64, 29	3	27.246	<0.01**	0.346
subcontractors	33.48	42, 92, 64, 29	3	25.022	<0.01**	0.332
3.6. Perceived capacity usage	41.40	31, 71, 57, 29	3	5.691	0.128	0.128
4. Software preferences	No statistical analysis could be performed because very small number of observations fell into clusters					

* Values at 0.05 significance level.
** Values at 0.01 significance level.

in the office environment (e.g. for accounting and record-keeping), but they are not particularly successful in exploiting the potential of these technologies to integrate their activities, collaborate with partners or to explore new ways of procurement. The evidence from the field survey suggests that small contractors lack staff with appropriate skills. Another possible explanation is that contractors might be unaware of the potential benefits of ICTs. Perhaps a more aggressive, visible and efficient campaign is necessary to raise smaller contractors' interests in ICT tools.

The findings of this research, in general, confirm some well-known arguments with regard to ICTs: piecemeal use of ICTs (Mak, 2001) often limited to the production of traditional documents (Luiten and Tolman, 1997) and the ignoring of the potential of electronic trade (Samuelson, 2002). The findings confirm also the existence of some well-known obstacles and shortcomings to the diffusion of ICTs: the lack of trained staff with computer literacy and ICT knowledge (DHFETE, 2001; Samuelson, 2002; Sarshar and Isikdag, 2004) and attachment to conventional ways of conducting business (Doherty, 1997; Samuelson, 2002), among others. However, there are also differences that deserve attention. For example, while the attachment of professionals to 'old ways of doing things' is reported to be a less important obstacle in advanced countries (e.g. see Samuelson, 2002), it is still an important obstacle in the Turkish building construction industry. This is not surprising, as there are many differences regarding ICT use even between the relatively advanced countries that have comparable cultures (see Samuelson, 2002 for the Nordic case). These differences illustrate that understanding the

cultural context of technology diffusion is necessary to develop successful policies.

One practical implication of this study for those who develop technology diffusion policies and implementation tools in the building construction industry is that the findings may be useful in understanding the relationship between organizational size and ICT-related attitudes of SMEs active in building construction. What is referred to as SMEs is not a homogeneous set of firms with identical characteristics; rather, SMEs consist of clusters of firms with varying characteristics. Policy makers should be cognizant of these differences. Secondly, given that smaller contractors are unaware of the potential benefits of ICTs as evidenced by the findings, policy makers might use new initiatives to overcome this problem such as exploring the adaptability of technology diffusion tools developed for SMEs in manufacturing industries (e.g. see OECD, 1995).

This study has methodological contributions as well. First, it is a strong reference to the use of 'production value' in determining the organizational boundaries of construction firms. Output measures, in general, may be sensitive to the networking capabilities of the construction industry and to the recent shift to capital-intensive production processes. The use of 'production value' enabled the detection of the existing differences between SME clusters. Secondly, researchers might consider using less common methods (such as cluster analysis) rather than pre-determined size intervals to classify construction firms, as this approach offers the potential to decipher the attitudes of different clusters within the SMEs. If, for example, the conventional SME definitions were used in this study, it is likely that the differences between the SME clusters would not have been as visible as demonstrated here.

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Appendix: Operationalization of research variables

Research questions

(1) Is there a significant difference between SME clusters regarding the perception of the influence of ICTs on business performance?

  (1) Influence of ICTs on office performance. Contractors were asked to rate the influence of computer systems on office performance (on a five-point Likert scale where 1 is 'not influential at all' and 5 is 'very influential').
  (2) Influence of ICTs on construction performance. Contractors were asked to rate the influence of computer systems on construction performance (on a five-point Likert scale where 1 is 'not influential at all' and 5 is 'very influential').

(2) Is there a significant difference between SME clusters in terms of their ICT investment attitudes?

  (1) Tendency to invest in computer systems. Contractors were asked to indicate whether they invested in hardware, software, or both within the previous 2 years (yes/no).
  (2) Reasons to invest in computer systems. Contractors were asked to rate the importance of a given set of investment reasons (on a five-point Likert scale where 1 is 'not important at all' and 5 is 'very important').

(3) Is there a significant difference between SME clusters in terms of the level of usage of ICTs?

  (1) Level of usage of computer systems. Contractors were asked to indicate the extent to which they used computers in a given set of fields (on a five-point Likert scale where 1 is 'never' and 5 is 'always').
  (2) Usage of internet. Contractors were asked to indicate whether they used Internet technology or not (yes/no).
  (3) Purpose of internet usage. Contractors were asked to indicate whether they used internet technology for a given set of purposes (yes/no).
  (4) Computerization of record-keeping (computerized organizational memory: 'the means by which organizations store knowledge for future use', Olivera, 2000: 813). Contractors were asked to indicate whether they used computers to keep their records in a given set of knowledge fields (yes/no).
  (5) Usage of computerized records. Contractors were asked to rate the extent to which they used computerized records in a given set of knowledge fields (on a five-point Likert scale where 1 is 'never' and 5 is 'always').
  (6) Perceived capacity usage of computers. Contractors were asked to specify whether they used computers in full capacity (yes/no).

(7) Reasons for the under-utilization of computers. Contractors were asked to rate the importance of a set of reasons for the under-utilization of computers (on a five-point Likert scale where 1 is 'not important at all' and 5 is 'very important').

(4) Is there a significant difference between the software preferences of SME clusters? Contractors were asked to list the software that they regularly used in their business. These were later categorized according to their functions.