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Micro- and Small-to-Medium Sized Enterprises in the Austrian Computer Software Industry: Their Economic Importance, Software Process Characteristics and ICT Utilisation

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ABSTRACT

This paper reports on results from an empirical investigation of the Austrian computer software industry. A questionnaire was used to interview a random sample of key executives in 174 Austrian software enterprises. Firstly, the important role of micro- and small to medium software enterprises is outlined. Secondly, the article focuses on specificities of micro- and small to medium software enterprises regarding inquired software process characteristics and in the utilization of new information and communication technologies for the development of new products and services.

RESEARCH OBJECTIVES

Scholars in economic sciences have focused on the role of smaller enterprises, especially SMEs, in economic development (Pavitt, Robson et al., 1987; Acs and Audretsch, 1988; Keeble, 1996). While these references contributed to an economy in general, I firstly want to present the economic value of micro- and small-to-medium enterprises (MEs and SMEs) **(topic i)** for the Austrian software industry. Secondly, the article focuses on differences observed between MEs, SMEs and large enterprises (LEs) for the following two important areas of software companies: Differences of software engineering process characteristics between MEs, SMEs and LEs as perceived by the management of Austrian software companies **(topic ii)**. And finally, differences in the utilization rates of new information and communication technologies (ICT) in the companies' product and service portfolios **(topic iii)**.

METHODOLOGY

The methodology employed to investigate these research topics is an empirical study of the Austrian computer software industry, which was carried out in the year 2000. The results shown in this paper represent only a part of the wider field of research topics considered by the undertaken empirical survey.

For both, the preliminary (for screening purposes) and the main analysis, the design of a questionnaire which was validated in several pre-tests was necessary. For the preliminary phase random sampling was employed and the 600 chosen companies were contacted by telephone. The achieved response rate was 70.4. On completion of the preliminary analysis structured face-to-face interviews followed in the main step of analysis, which based on a stratified and disproportional sample with subgroups according to company size. The rate of return for the second step of the study was 55.6%. The non-response analysis revealed no significantly different characteristics between non-respondents and respondents. Of the 174 data sets received, 91 belonged to MEs, 50 to SMEs and 33 to LEs.

EMPIRICAL RESULTS

Economic Importance

While Austria's MEs and SMEs account for 25% of the whole target populations' sales (including non-software), the contribution to R&D investments (49.08%) and especially to employee education and training (88.0%) investments is much higher (see Table 1). This high contribution to employee education and training of smaller software organizations in Austria shows their significant role in building up knowledge resources. LEs often obtain these resources by buying and integrating technology from smaller organizations or by utilizing the high mobility of human resources (Porter, 1990) and thereafter embracing the proportion of exogenous organizational knowledge which is embedded in the minds of the individual employees. Thus, the value of MEs and SMEs in terms of knowledge contribution to the Austrian software industry can be rated as very high.

Austria's software companies employ a workforce of approximately 40.000 software specialists on a permanent basis and 13.000 as software freelancers, not fully integrated in the company. SMEs employ 31.8% of the permanent software workers, LEs employ 63.4%. Both categories, SMEs and LEs, employ the same share of freelancers for software related tasks (44%). But MEs and SMEs rely more intensively on their non-permanent work force than LEs. The empirical data showed a strong overbalance of smaller software enterprises in Austria: Micro-enterprises (ME) account for 55.7% of the Austrian software organizations. 32.2% can be attributed to SMEs and 12.1% to large enterprises (LE). Classification was performed following the definition proposed by the European Community (EC, 1996) (see Table 1). In Austria the average firm size has declined in line with smaller firms entering the industry.

Inquired Software Process Criteria

The development of software is known to be a complex task and routinely breaches the effort, quality and functionality targets (Van Genuchten, 1991; Kautz and Larsen, 2000). This work seeks to reveal the current focus of the Austrian software industry in seeking to overcome the limited success of software projects as reported in academic literature.

During the interview, the companies assessed 14 different variables according to their perceived application in their software engineering processes. Therefore only companies which provide either packaged or custom software were considered for analysis in this section (144 enterprises).

The questioned factors were divided into two different groups: programming languages and criteria applicable to the software engineering process as a whole. The data showed that object-oriented program languages are most commonly used and that companies have recognized project management tech-

Table 1. Distributions of industry characteristics

Size	Employees	Turnover (Mio. •)	In-dependency[1]	No. of Companies (rel.)	No. of Companies (abs.)
ME	1-9	< 7	< 25%	**55.7%**	1.082
SME	10-249	< 40	< 25%	**32.2%**	625
LE	> 250	> 40		**12.1%**	235
Total				100%	1.941

[1] Capital share in external ownership.

Size	Distribution of Sales	Distribution of R&D Expenses	Distribution of Employee Education and Training Investments
ME	4.0 %	5.6 %	50.5 %
SME	20.6 %	43.4 %	37.7 %
LE	75.4 %	50.9 %	12.0 %
	100 %	100 %	100 %

Total sales p.a. (including non-software related sales): • 11 billion
Software-related sales p.a.: • 5 billion

All data are based on own estimation referring to the year 1999

niques including a unified process and project controlling as the most important aspects of the software engineering process. To improve software development, software managers achieve greater leverage from the management of people and the cross-functional processes than with the use of CASE tools, which were rated as relative unimportant.

To test the independence of responses between MEs, SMEs and LEs, the Kruskal-Wallis H-Test was applied, which is a non-parametric equivalent to one-way ANOVA. The strength of a relationship was analyzed with Spearman rank correlation coefficients, which is used when ordinal scaled variables (in this case the size of the company) are involved. The study identified six out of the 14 criteria that showed differences in how they were rated by managers between company sizes (see Table 2). The highest correlated relationships (either positive or negative) with high significances were "Case-Tools" and "Distributed Object System Technology (CORBA, COM/DCOM)". The perceived importance of all identified characteristics correlates positively with the size of the organization, i.e., the importance increases with the size of the organization.

To examine the effect demonstrated by the six criteria as a whole a multiple discriminant analysis (MDA) based on the split-sample or cross-validation approach (Green and Carrol, 1978; Perreault, Behrman et al., 1979) was applied. The results of MDA show that using these six factors in a simultaneous estimation approach, 69.8% of all cases in the analysis sample could be correctly grouped in MEs, SMEs and LEs, while 54.1% of all cases in the holdout sample could be correctly classified. The calculated discriminant functions are statistically significant (p=0.05), as measured by the chi-square statistic, and the first function accounts for 94.4% of variance explained by the two functions. This also affirms the significance of the six variables for classifying the company's size. Using the group sizes for the reduced sample, the proportional chance criterion (Hair, Anderson et al., 1998) is 0.424. Comparing this chance criterion with the prediction accuracies presented shows that they are acceptable.

Table 2. Identified discriminating software process characteristics

No.	Variable	Mean (MEs)	Mean (SMEs)	Mean (LEs)	Mean (all)	Sig-nificance (H-Test)	Correlation Coefficient (Spearman)	Significance (Spearman)
1	CASE-Tools	2.00	2.79	3.29	2.42	0.000	0.378	0.000
2	Distributed Object System Technology (CORBA, COM/DCOM)	1.94	2.64	3.33	2.34	0.001	0.368	0.000
3	Software Project Management Practices	3.47	4.22	4.33	3.83	0.000	0.347	0.000
4	Software Project Controlling	3.26	3.84	3.83	3.53	0.008	0.307	0.000
5	Unified Modeling Language (UML)	1.60	2.01	2.48	1.83	0.007	0.285	0.001
6	Formal Software Testing Routines	3.20	3.67	3.79	3.43	0.037	0.193	0.024

Variables rated by managers on a scale between one (not important) and five (very important) as perceived in their own organizations

Table 3. Identified discriminating ICTs

No.	Variable	Mean (MEs)	Mean (SMEs)	Mean (LEs)	Mean (all)	Sig-nificance (H-Test)	Correlation Coefficient (Spearman)	Significance (Spearman)
1	Digital signatures & auth.	1.72	2.29	2.39	1.99	0.002	0.263	0.001
2	New encryption mechanisms	1.68	2.08	2.42	1.90	0.013	0.260	0.001
3	WAP	1.45	2.00	2.12	1.71	0.003	0.229	0.003
4	New HTML-extensions	2.47	2.98	3.36	2.74	0.003	0.219	0.004
5	Bluetooth	1.21	1.58	1.09	1.31	0.000	0.195	0.011

Variables rated by managers on a scale between one (not important) and five (very important) as perceived in their own organizations

ICT Utilisation

The inquired information and communication technologies (ICT) can be divided into the following groups: security and e-commerce ("new encryption mechanisms", "Digital signatures and Authentication", "smart cards"), convergence of media and ICT ("new multimedia standards" such as the **m**oving **p**icture **e**xperts **g**roup-4 standard), Internet ("new HTML extensions" such as XML or CSS2 and "WAP") and new communication techniques ("**v**oice **o**ver **IP"**, "bluetooth"). The utilization of these technologies in the design of the companies' ICT products and services had to be rated by managers of Austrian software companies on a scale from one (not important) to five (very important) as perceived in their own organization. Another inquired variable corresponded to the use of new technologies in general. For the data analysis in this section the non-software developing companies were allowed back into the sample resulting in the original number of 174 data sets.

The data showed that although new technologies in general were utilized by the Austrian software companies regularly, the specific ICT technologies inquired were not classified as very relevant. An exception are the HTML extension such as XML, CSS2 or VRML. On second place follow the security technologies which need to be considered with every e-commerce application.

To find differences between MEs, SMEs and LEs, again first the Kruskal-Wallis H-Test and second, Spearman rank correlation coefficients were analyzed (see Table 3) prior to the MDA analysis. Again, the calculated discriminant functions are statistically significant (p<0.01) and the first function accounts for 82.1% of the variance explained by both functions. The comparison with the proportional chance criterion (which is 43% when including all companies in the analysis) yields a acceptable prediction accuracy only for the analysis sample (57.7%). The cases could not be successfully classified in the holdout sample (42.7%).

CONCLUSION

The median firm operating in the Austrian software industry has become smaller through time. Although MEs and SMEs together contribute for only a quarter of the whole industry sales, they already account for nearly half of the R&D investments and nearly 90% of costs attributed to employee education and training in the Austrian software industry showing the value of MEs and SMEs in terms of knowledge contribution. It seems that the Austrian software companies have a stronger focus on software project management practices than on technology-driven approaches to strive for high-quality software development. The statistical analyses employed showed several factors differing between different sized companies out of which the importance of Case-Tools is valued most differently, resp. highest by LEs. According to the empirical findings the inquired new IT technologies are more often utilized for products and services in larger enterprises.

REFERENCES

Acs, Z. J. and D. B. Audretsch (1988). "Innovation in large and small firms: an empirical analysis." *American Economic Review* 78(4).

EC (1996). Empfehlung der Kommision betreffend die Definition der kleinen und mittleren Unternehmen. Brussels, Commission of the European Community.

Green, P. E. and J. D. Carrol (1978). *Mathematical Tools for Applied Multivariate Analysis.* New York, Academic Press.

Hair, J. F., R. E. Anderson, et al. (1998). *Multivariate Data Analysis*. London, Prentice Hall.

Kautz, K. and E. A. Larsen (2000). "Diffusion theory and practice - Disseminating quality management and software process improvement innovations." *Information Technology & People* 13(1): 11-26.

Keeble, D. (1996). Small Firms, Innovation and Regional Development in Britain in the 1990s, ESRC Centre for Business Research.

Pavitt, K. L. R., M. Robson, et al. (1987). "The size distribution of innovating firms in the UK: 1945-83." *Journal of Industrial Economics* **35**(3).

Perreault, W. D., D. N. Behrman, et al. (1979). "Alternative Approaches for Interpretation of Multiple Discriminant Analysis in Marketing Research." *Journal of Business Research* 7: 151-173.

Porter, M. (1990). *The competitive advantage of nations*. London and Basingstoke, The Macmillan Press LTD.

Van Genuchten, M. (1991). "Why is software late? An empirical study of reasons for delay in software development." *IEEE Transactions on Software Engineering* 17(6): 582-590.