Simulation in the Expansion of SMEs through the Adoption of ICTs: 
An Empirical Study of SMEs in Greece

CHRISTINA BENEKI
Department of Business Administration
Technological Educational Institute of Ionian Islands
28200 Lixouri, Kefalonia
GREECE
benekic@teiion.gr

AVRAAM PAPASTATHOPOULOS
Department of Business Administration
University of Patras
26500 Rio, Patras
GREECE
apapast@hotmail.com

MICHAEL TSAGRIS
Department of Statistics
Athens University of Economics and Business
76, Patission Str., 10434 Athens
GREECE
mtsagris@yahoo.gr

Abstract: Bootstrap and jackknife resampling methods are used to determine to what extend the high cost of integration between existing and new Information and Communications Technologies-Systems affect the sensitive SME sector for approaching new and remote market segments and how much this might vary due to many replications of a trial.

Key-Words: ICTs, SMEs, Barriers, ICT strategy, Bootstrap, Jackknife

1 Introduction
One of the main factors that influences the success or failure of SMEs is technology. The continuous rise in the use of ICTs, as well as their importance for the modern enterprise, is presented in the study conducted by OECD [10]. More specifically, it mentions that SMEs have gradually recognized the positive impact that ICTs, such as computer terminals, e-mail, Internet and their applications can have on their business. Many types of business software can improve information and knowledge management within the firm, leading to more efficient business processes and better firm performance.

At firm level, ICT and its applications can make communication within the firm faster and make the management of the firm’s resources more efficient. Seamless transfer of information through shared electronic files and networked computers increases the efficiency of business processes such as documentation, data processing and other back-office functions (e.g. organizing incoming orders and preparing invoices). Increasingly sophisticated ICT applications such as DSS (Decision Support System), ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) allow firms to store, share and use a variety of models to analyze their data or condense large amounts of data into a form in which decision makers can analyze them [15].

At inter-firm level, the Internet and e-commerce have great potential for reducing transaction costs and increasing the speed and reliability of transactions. They can also reduce inefficiencies resulting from lack of co-ordination between firms in the value chain. Internet-based B2B interaction and real-time communication can reduce information asymmetries between buyers and suppliers and build closer relationships among trading partners [9].

On the other hand, it is widely recognized that there
are major hurdles and problems facing SMEs wishing to implement ICTs. Implementing new technologies is a problem for 17% of SMEs in the EU. In no Member States more than about one third of SMEs consider implementing new technology to be a constraint [7]. In most developed countries, the problems faced by SMEs are more or less similar in nature. The major problems and constraints faced by them are in the field of policy and legal framework, finance, entrepreneurship, management, socio-cultural values and of course technology.

For the categorization of the SMEs, what was used was the definition (table 2) provided by the European Committee [6]. The complete definition of small and medium sized enterprises is given, after having determined that the basic condition for an enterprise to be recognized as a small and medium one is to respect the limits regarding Staff headcount and financial ceilings (annual turnover or annual balance sheet). The definition categorises SMEs in the following three categories:

<table>
<thead>
<tr>
<th>Enterprise Category</th>
<th>Headcount (unchanged)</th>
<th>Annual Turnover</th>
<th>Annual Balance Sheet Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium-sized</td>
<td>&lt; 250</td>
<td>&lt; 50 million €</td>
<td>&lt; 43 million €</td>
</tr>
<tr>
<td>Small</td>
<td>&lt; 50</td>
<td>&lt; 10 million €</td>
<td>&lt; 10 million €</td>
</tr>
<tr>
<td>Micro</td>
<td>&lt; 10</td>
<td>&lt; 2 million €</td>
<td>&lt; 2 million €</td>
</tr>
</tbody>
</table>

Table 1: Definition of SMEs

In this paper, we want to determine to what extend the high cost of integration between existing and new Information and Communications Technologies-Systems affect the SMEs for approaching new and remote markets and how much this might vary due to many replications of a trial.

The remainder of the paper is organized as follows. Section 2 discusses the relevant literature. Data selection and research methodology are described in Section 3. Section 4 provides analysis and interpretations of the empirical results and Section 5 concludes the paper.

2. Literature review

There is a wide range of reasons why SMEs do not make more active use of the ICTs. Reasons vary widely among sectors and countries and are most commonly related to lack of applicability to the business, preferences for established business models, and the kinds of electronic transactions SMEs are involved in or wish to introduce (B2B or B2C). According several studies [10], [12], [14], common barriers include:

- unsuitability for the type of business;
- enabling factors (availability of ICT skills, qualified personnel, network infrastructure);
- cost factors (costs of ICT equipment and networks, software and re-organization, and ongoing costs); and
- security and trust factors (security and reliability of e-commerce systems, uncertainty of payment methods, legal frameworks).

2.1 Cost factors (costs of ICT equipment and networks, software and re-organization, and ongoing costs)

The high initial set-up costs and perceived on-going costs of ICT and e-business can act as a barrier to take-up among SMEs. Most SMEs will not adopt e-commerce if the benefits do not outweigh the costs of developing and maintaining the system. The issue is costs relative to benefits expected, not cost itself. Nevertheless, SMEs are generally concerned about the costs of establishing and maintaining e-commerce since they generally suffer from budget constraints and are less sure of the expected returns on the investment. Some SMEs cannot afford to adopt sophisticated ICT solutions because they are not able to integrate this new provision with their existing provision. In this case, the existing information and communication technologies are a formidable barrier to progress [14].

3. Research Methodology

A joint methodology of fully-structured questionnaire and in-depth interviews was selected as the primary research instrument in order to gain as broad a view as possible of the issues surrounding application of ICT, amongst a spectrum of SMEs from 4 out of 51 Greek geographical areas (States/provinces) which fulfilled the criteria of GDP-sharing, working population and total number of population. A total of 100 companies were selected and letters were sent out requesting an interview, while follow-up telephone calls by the researcher negotiated access to each business. Fifty four SMEs responded positively. The main reason why the authors have attempted to use a combination of techniques was to minimize bias and error and overcome any ambiguities.
The survey questionnaire was divided into four parts. Part 1 deals with the adoption and use of ICTs and Part 2 covers questions addressed to evaluate the degree of emphasis placed on strategic and operational planning of ICTs and whether the strategic process was systematic and formal. Part 3 covered the financial information and the last part was based on general information about SMEs.

Personal interviews were conducted with the person deemed to be most knowledgeable on the developments of ICTs within the firm. For that reason, the interviewees ranged from director or owner-manager and IT personnel to general managers. Only one interview per company was conducted. A mix of closed and open-ended questions was included to conduct the structured interviews. This provided a collection of quantitative and qualitative data, and enabled comparisons based on rating, ranking and individual contextual analysis. On average, the interviews lasted one hour and 15 minutes based on a fully structured questionnaire.

A stratified random sample of SMEs was drawn from four industry sectors according to classification of economic activity by NACE (rev. 1.1). The criteria of total selection of industry sectors and SMEs according to their two-digit NACE code allocation were attendance index of SMEs in each industry sector and contribution index of each industry sector in Gross Value Added and E-Business Index. The data for the two first indices were found in National Statistical Service of Greece and ICAP databases while the last Index was adopted from the European E-Business Report 2003 [11].

### 3 Problem Analysis

The association amongst SMEs which approach new markets with the cost of integration between existing and new ICTs (COSTINT) and implement an ICT strategy (ICTSTR) was examined through a logistic regression model. The logit models theory can be found at Cramer J.S [3]. The form of the model was the following:

\[
\log\left(\frac{p_i}{1-p_i}\right) = -1.107 + 1.493 \times COSTINT + 1.5 \times ICTSTR
\]

where

<table>
<thead>
<tr>
<th>COSTINT</th>
<th>1, if the financial barrier affected the approach to new markets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0, if the financial barrier did not affect the approach to new markets</td>
</tr>
<tr>
<td>ICTSTR</td>
<td>1, if SMEs implement an ICT Strategy</td>
</tr>
<tr>
<td></td>
<td>0, if SMEs do not implement an ICT Strategy</td>
</tr>
</tbody>
</table>

and \( p_i \) denotes the probability of approaching new markets. The fit of the model is not rejected (p-value = 0.233). The significance of the independent variables was tested via the Wald statistic. The exponent of the COSTINT coefficient [\( \exp(1.493) = 4.45 \)] indicates the odds ratio for the financial barrier. That is, the odds of approaching new markets affected by this financial barrier are 4.45 times the odds for a company that has not affected by this barrier. The exponent of the ICTSTR coefficient [\( \exp(1.5) = 4.48 \)] indicates the odds ratio for the financial barrier. That is, the odds for a firm, which has a setup strategy, to approach new markets are 4.48 times the odds for a company that has not a setup an ICT-Strategy. In order to estimate the probability of approaching new markets, one can straightforward solve the equation (1) with respect to \( p_i \), that is:

\[
p_i = \frac{\exp(-1.107 + 1.493 \times COSTINT + 1.5 \times ICTSTR)}{1 + \exp(-1.107 + 1.493 \times COSTINT + 1.5 \times ICTSTR)}
\]

The validation of the logit model was carried out via non-parametric bootstrap and jackknife resampling methods. Resampling methods stem from Monte Carlo simulations, but differ from them in that they are based upon some real data; Monte Carlo simulations, on the other hand, could be based on completely hypothetical data. However, the bootstrap and jackknife approaches offer an advantage over Monte Carlo simulation. Monte Carlo assumes that the parameters of the population are known whereas bootstrap and jackknife need no assumptions about the distribution of the population or its parameters. The main idea of these methods is that the sampling distribution can be estimated by resampling a given set of data and calculating the parameter of interest for each synthetic sample.

The non-parametric bootstrap rationale is the following: The original data \((x_1, x_2, ..., x_n)\) is a sample from an unknown probability distribution \(F_\theta(x)\). Let \(\hat{F}\) be the usual empirical distribution function, having mass \(1/n\) at each observed \(x_i\). Let \((x_1^*, x_2^*, ..., x_n^*)\) be a random sample chosen with replacement from \(\hat{F}\). Simulation is used to estimate the distribution of \(\hat{\theta}^* = \hat{\theta}(x_1^*, ..., x_n^*)\). After \(B\) replications of this mechanism, one has an empirical distribution of \(\hat{\theta}^*_b\) (\(b=1, ..., B\)) values which serve as an estimate of the unknown sampling distribution of the
statistics \( \hat{\theta} \). The bootstrap estimate of \( \theta \) is then given by \( \hat{\theta} = \frac{1}{B} \sum_{b=1}^{B} \hat{\theta}_b \). The differences between the initial estimates and the means of the bootstrap estimates served as the estimates of bias for each of the true parameters.

The basic idea behind the jackknife estimator lies on systematically recomputing the statistic estimate leaving out one observation at a time from the sample set. Hence, the jackknife estimate of \( \theta \) is given by the mean of \( \hat{\theta}_{(i)} = \hat{\theta}(x_1, x_2, ..., x_{i-1}, x_{i+1}, ..., x_n) \), \( \hat{\theta} = \frac{1}{n} \sum_{i=1}^{n} \hat{\theta}_{(i)} \). The estimated bias however, is given by the formula [8]: \( \text{bias}_{\text{jack}} = (n-1)(\hat{\theta}_{(i)} - \hat{\theta}) \).

Each method produces either B or n estimates of \( \theta \) which are used to estimate the distribution of \( \theta \), denoted by \( F_{\theta}(x) \). The 95% confidence interval for the true value of the parameter \( \theta \) can be constructed by \( [\hat{G}_{\theta}^{-1}(a), \hat{G}_{\theta}^{-1}(1-a)] \), where \( \hat{G}_{\theta}(t) = \frac{\# \{ \hat{\theta}_b \leq t \}}{B} \), for the bootstrap method. The same is true for the jackknife method by substituting B with n (the sample size). Swanepoel and Frangos [13] investigated the use of bootstrap for the construction of confidence intervals for the beta coefficient in the logistic regression. For more information on these two techniques, one can look at Efron [4], Efron and Tibshirani [5], Miller [8] and Chernick [2].

The following steps were carried out in S-PLUS 8. First, we generated \( B = 1,000 \) bootstrap samples. Booth and Sarkar [1] examined the adequate number of samples required for the estimation of the standard error of a statistic and they showed 800 bootstrap samples work fine for this purpose. In fact, a larger bootstrap replication \( B = 10,000 \) produced similar results. The jackknife method was also applied and the results favored for this latter method. The bootstrap and jackknife estimates of the coefficients were close to the original estimates of the initial sample.

### Table 2: Estimates of the coefficients

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Classical</th>
<th>Bootstrap</th>
<th>Jackknife</th>
</tr>
</thead>
<tbody>
<tr>
<td>( b_0 )</td>
<td>-1.107</td>
<td>-1.287</td>
<td>-1.109</td>
</tr>
<tr>
<td></td>
<td>(-2.352, 0.139)</td>
<td>(-2.876, 0.0125)</td>
<td>(-1.402, -0.998)</td>
</tr>
<tr>
<td>( b_1 )</td>
<td>1.493</td>
<td>1.77</td>
<td>1.496</td>
</tr>
<tr>
<td></td>
<td>(0.188, 2.798)</td>
<td>(0.246, 3.627)</td>
<td>(1.369, 1.743)</td>
</tr>
<tr>
<td>( b_2 )</td>
<td>1.5</td>
<td>1.685</td>
<td>1.503</td>
</tr>
<tr>
<td></td>
<td>(0.167, 2.883)</td>
<td>(0.178, 2.942)</td>
<td>(1.332, 1.748)</td>
</tr>
</tbody>
</table>

### Fig.1 Histogram of the replicates of the ICTSTR coefficient

### Fig.2 Histogram of the replicates of the COSTINT coefficient

### Fig.3 Histogram of the replicates of the constant

Proceedings of the 9th WSEAS International Conference on SIMULATION, MODELLING AND OPTIMIZATION

ISSN: 1790-2769

3 Conclusion

In this paper is presented an empirical study of the effect of the “high cost of integration between existing and new Information and Communication Technologies” and the existence of a specific strategy for the adoption and use of ICTs on the potential to SMEs for approaching new and remote markets. The potential for expansion of the SME was evaluated with the help of a model of binomial logistic regression, where the dependent variable is the potential, for a SME, to approach a new market, and where the independent variables are the high cost of integration between existing and new ICTs for a SME and the presence of a specific strategy for the use of ICT.

The two simulation methods which were used, reveal that the replications produced results that were close to the original estimates of the initial sample. These findings can be explained, in terms of business, that financial constraints and rational planning significantly affect the process of SMEs to approach new commercial areas. That means, the SMEs comprehensively consider the cost of implementation of a new information and/or communication systems into their existing systems. Similarly, the expansion process of SMEs is closely related to the adoption of an ICT-Strategy, which takes into account the new possibilities arising from the use of ICTs.

Finally, the above findings imply that there is a strong need for SMEs to develop a comprehensive strategy for the adoption of ICTs and taking into account the cost of new systems which are incorporated into its business functions. Given, the widespread use of ICTs and the need of SMEs for continuous evolution, the findings in this paper suggest that the key for small firms to approach new markets should rely on the development and implementation of a specific strategic planning. For this reason, the future research should focus on those qualitative elements that must compose a technological business strategy.

References: