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A COMPARISON OF PRE AND POST MODERN PORTFOLIO THEORY USING RESAMPLING

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ABSTRACT

This article introduces the Resampling approach to Portfolio modelling, targeted at reducing the effect of estimation error present in any practical implementation of a Portfolio Model. Resampling is a method used in portfolio modelling to try to obtain better out of sample performance for given input model parameters. In the real world, where the possibility of estimating errors for future model forecasts certainly exist, it is necessary to consider the error component in building portfolios. Resampling does this by recombining the input parameters required for a portfolio model. In this paper an application of Resampling is performed using a sample of equities from different stock markets. The results are presented for Tracking Error Minimization, Mean Absolute Deviation Minimization (MADM) and Shortfall Probability Minimization Models. The innovation in this study lies in the comparison made with different portfolio models. Unlike previous studies, the evidence shows that Resampling applied to the Markowitz model does not generate better out of sample performance. However, the benefits of Resampling applied to the Post Modern Theory model are remarkable.

KEYWORDS: Technical Analysis, Post Modern Portfolio Theory, Resampling.

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INTRODUCTION

In order to improve the stability of the out-of-sample performance of a portfolio generated by a process of optimization, economic theory and operational practice have developed techniques for improving the estimation of portfolio model parameters. In this article we introduce Resampling and examine the effectiveness of this technique when applied to the Markowitz model and certain Post Modern Theory models. Resampling is a technique that is based on the simulation of equity returns using Monte Carlo methods. A well-understood fact of asset allocation is that the traditional portfolio optimization algorithm is too powerful for the quality of the input data. The problem is that optimizers are extremely sensitive to minor changes in assumptions. Even small changes in optimization inputs often lead to large changes in optimized portfolios. The Markowitz Model optimizer tends to select the assets with the most attractive features (high returns and low risk and/or low correlations) and to avoid the ones with the worst features when inputs are measured with error. In this sense the optimization algorithm always results in a corner solution and tends to "error-maximize" investment information. This results in portfolios that are too close to a given set of inputs and that are unlikely to perform well in the future. Small changes in the inputs typically result in very different optimal portfolios. As a result users often include many constraints in order to stabilize the optimization. In this sense financial operators should never run an optimizer only once and be satisfied with the results. They should run the optimizer a number of times with differing assumptions. By doing so it is possible to incorporate uncertainty into an optimization algorithm.

Recently, a new concept called "Resampled Efficiency" has been introduced into the asset management world to help deal with estimation errors. The first author involved in diffusing this new statistical approach has been Michaud (1998). Also Markowitz, the father of Modern Portfolio theory, has dealt with this topic in a recent study (Markowitz, Usmen, 2003). Resampling methods are widely used in modern statistics. Monte Carlo simulation is used to compute many statistically similar alternatives. In a portfolio context, risk and return input data estimates are never known with perfect certainty. Resampling efficient frontier optimization generalizes classical mean-variance optimization, incorporating the investor's level

of uncertainty in the estimates. In this sense Resampled Efficiency provides a wide range of alternative optimal portfolios that are consistent with risk-return estimates. Resampling does this by generating hundreds of efficient frontiers using small changes with regard to initial input parameter estimates.

In a strict sense Resampled Efficiency can be seen as an averaging process that processes all the alternative efficient frontiers into a new efficient frontier and a set of optimized portfolios. On the other hand each portfolio on the Resampled efficient frontier is the result of averaging a number of statistically equivalent efficient portfolios. The resulting process is more stable and produces more reliably effective optimal portfolios because they are optimal with regard to the many ways in which assets and markets may perform in the period the investment is held.

It is helpful to be clear about the reasons why a financial operator, or even a simple investor would consider a Resampling approach as his way of portfolio management. It is also beneficial to identify the contribution of Resampling to final performance with regard to different portfolio models. The remainder of the paper is organized as follows. After a brief literature review in Section 1, Section 2 provides the theoretical underpinnings of the Resampling methodology. In Section 3 a brief description of some models of the Post Modern Theory are provided, and the mathematical structure of objective functions of all the models are presented. In Section 4 data and results of the application are explored, to identify the effectiveness of Resampling. The applications involve a comparison between a Markowitz approach and Post Modern Portfolio theory approach, and the effectiveness of Resampling. Section 5 provides some concluding comments.

LITERATURE REVIEW

Classical optimizers assume 100% certainty in information input, however investment information is typically uncertain. Markowitz mean-variance efficiency is a cornerstone of modern finance for asset management. Given the presumption that rational investors make investment decisions based on risky assets' expected return and risk; with risk measured as variance, a portfolio is considered mean-variance efficient if it has the minimum variance for a given level of portfolio expected return, or if it has the maximum expected return for a given level of portfolio variance. The quadratic programming optimization algorithm, which is the classical way to apply Markowitz's methodology, is too sensitive to the quality of input parameters. The result produces a maximization of the estimation error. If unchecked, this phenomenon skews the optimizer towards extreme weights that tend to perform poorly when applied to real data. In the case of the investment behaviour of portfolio optimizers, the evidence came more than twenty years ago, in a series of papers authored by two financial economists, J.D. Jobson and Bob Korkie (1981). They showed mathematically and statistically that optimizers have, on average, little investment value and that equal weighted portfolios are often far superior to optimized portfolios.

With regard to sample variance and covariance matrix estimate error reduction, a solution that has been proposed is to shrink the sample covariance matrix by changing its most extreme elements with more moderate values. Ledoit and Wolf (2004) proposed an improved estimator of the covariance matrix based on the statistical principal of shrinkage. The idea is to find an optimal linear combination of the sample covariance matrix and a highly structured estimator, which assumes that the correlation between the returns of any two stocks is always the same. In their empirical study, Ledoit and Wolf demonstrated that shrinkage approach provided a significantly higher realized information ratio of the active manager compared to the sample covariance matrix.

An alternative solution is the Resampled Efficiency described in Michaud (1998), invented and patented by Richard Michaud and Robert Michaud. The method is based on Resampling optimization inputs. This is a Monte Carlo simulation procedure to create alternative optimization inputs that are consistent with the investor's level of certainty in the estimates. Some authors wondered if there is a general theoretical

justification to the Algorithm at the base of Resampling approach. To shed some light on this question, it is helpful to realize that the algorithm can be considered a special case of the statistical technique of bagging. Bagging is an acronym for "bootstrap aggregating'' and was invented by the statistician Leo Breiman (1996). The general situation is as follows. A predictor (or estimator) θ is computed on observed data. Due to the nature of this predictor, small changes in the data set can lead to significant changes in the predictor values: thus the predictor is unstable. As a consequence, it is deemed unreliable for practical use. Bagging aims to remedy this situation as follows. From the observed data a Resampling approach is conducted via bootstrap and, in this way, the predictor on the bootstrap data is computed, resulting in θ*. Call the bagged estimator θ*. This process is repeated many times and the resulting values θ* are 'aggregated' by averaging them. The hope is that θ* has a better out-of-sample performance than the original estimator θ. But Breiman (1996) proves that his result is no universal guarantee.

Generally speaking Resampled Efficiency is always preferable to a Mean Variance approach because investors are never 100% certain of their estimates. Again, generally speaking, Resampled Efficiency optimized portfolios are less risky as they are optimal, relative to the many ways in which assets and markets may perform, in the investment period. In the case of long-only constraints, Resampled Efficiency leads to more-diversified portfolios, which, as presented by Michaud (1998), are well known to beat simple Markowitz portfolios in out-of-sample tests in a way that is statistically significant. Michaud's portfolios tend to be more diversified and more stable over time than asset allocations produced by traditional optimizers. A recent study by Markowitz and Usmen (2003) found that the investment performance of Resampled Efficiency optimized portfolios (Michaud 1998) is superior to that of Markowitz (1952) mean-variance (MV) optimized portfolios, also in the case in which sophisticated Bayesian estimates of risk and return are introduced. The Bayesian procedure in Markowitz and Usmen (2003) is a very sophisticated use of Bayesian, Monte Carlo, and numerical analysis methods for optimization input estimation. In a test of 10 scenarios, Markowitz found that the Resampling methodology is superior to a traditional optimizer 10 out of 10 times. In a second test, Markowitz compared the entire efficient frontier generated by the traditional optimizer with one generated by the Resampling methodology. In this case Michaud's methodology added 57 basis points over the traditional optimizer in the first test but just 12 basis points in the second test.

Ledoit and Wolf (2004) in their work performed a test on Resampling methodology effectiveness and they found that the extent to which the result can be generalized is unclear. Portfolio Resampling carries with it some unwanted features. In particular results exhibit deteriorating Sharpe ratios (caused by higher volatility) and additionally, the efficient frontiers may exhibit turning points (a move from concave to convex). Resampling can be combined with shrinkage. However, the two authors cannot find evidence that this combination offers any further improvement beyond 'pure' shrinkage.

A theoretical investigation of Resampled Efficiency is provided by Scherer (2002). In this setting, the portfolio manager aims at an optimal 'absolute' portfolio rather than at outperforming an index. The main findings of Scherer (2002) are two. Firstly, that in the absence of lower and upper bounds on the vector of portfolio weights, Resampling produces results close to those you could obtain from a sample covariance matrix. Secondly, that in the presence of lower and upper bounds on the vector of portfolio weights, Resampling leads to more diversified (active) portfolios compared to the sample covariance matrix. As a result, Resampling improves out-of-sample performance.

According to Ledoit and Wolf (2004) Markowitz efficiency is not the relevant benchmark for Resampled Efficiency whereas Bayesian alternatives, which have a strong foundation in decision theory, are. Therefore, a significant field for future research is, above all, how Resampling can be compared or even integrated with Bayesian alternatives. In fact Bayesian estimation and other methods for improving the reliability of risk and return estimates are not mutually exclusive with Resampled Efficiency. In the future, best practice may require more sophisticated statistical estimation procedures and Resampled Efficiency.

RESAMPLING

Resampling is an operational solution belonging to the heuristic category of asset allocation approaches. It is based on Monte Carlo simulation and a stochastic interpretation of the return-variance approach. The underlying idea is as follows: input parameters for portfolio optimization are derived from representative historic returns of a single realized event of the underlying stochastic process implying that history permits the observation of only one path of return evolution.

The first applications of Resampling, in financial theory, were due to the CAPM model as later developed by Markowitz. With Markowitz, the problem of efficient frontier instability ex post mainly depends upon an excessive concentration of efficient portfolios. Resampling promotes a logic that allows for more diversified portfolios incorporating, in contrast with Markowitz optimization, the erratic component in the portfolio construction phase.

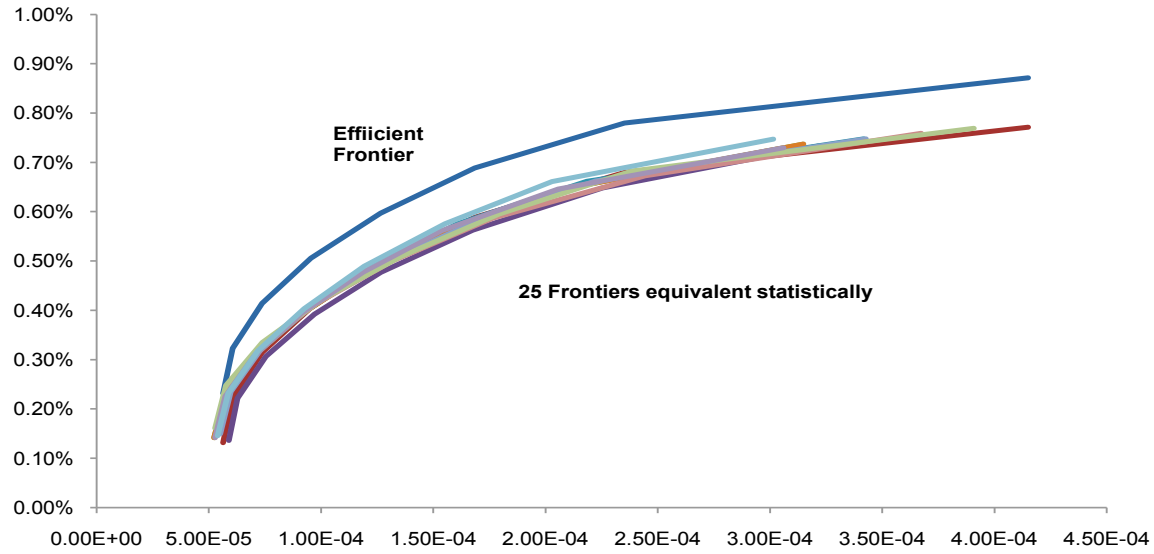
We can articulate the Resampling process in different phases:

1. A vector E (r) is estimated in n components (in which n is the number of securities under consideration), which include estimates of expected returns from the securities under consideration. In addition a vector σ is estimated with *n* standard deviations, and the matrix *n x n* of correlation between asset returns.
2. Starting from the parameters estimated in the first round, a Monte Carlo simulation is performed in which E $(r)_{sim}$ (that is a vector of simulated returns), σ_{sim} (simulated vector of standard deviations), and finally the simulated correlation matrix, ρ_{sim} are identified. The simulation process is not entirely random; in fact it is expected to "tie" the simulated parameters to historic parameters that have been observed. Assume that for security A we have E (r) = 3% and σ = 10%. Therefore, the generation of simulated trajectories of returns is bound by the assumptions made about the standard deviation and the mean value. The process of Resampling therefore requires the joint extraction of N returns, to be repeated a number of times H, from a multivariate normal distribution with parameters (mean, variance and covariance) coinciding with historical values. Of course, with increasing numbers of simulations, values obtained converge to the mean value and estimated standard deviation. For example, after 1000 simulations 2.83% has been obtained as the average value and 10.27% as the standard deviation. The number of simulations is a function of the degree of confidence about the observed estimates. Selecting the input obtained in phase 3, it moves to a process of optimization, such as Markowitz, from which we get a frontier statistically equivalent to that which we would have obtained if we had estimated optimized inputs in the first phase.
3. Repeating phase 2 H times, we obtain statistically equivalent H frontier. It is noted that, for construction, all statistically equivalent portfolios are located below the efficient frontier. If the weighting vector of a mean variance efficient portfolio is optimal for the original set of inputs it is natural that the allocations of portfolios simulated, reassessed with the same information set, are not so optimal (see Figure 1).

For each of the H simulations, it is possible to identify Z portfolios statistically equivalently close to the frontier. Each portfolio was given a ranking in a list. This produces for each ranking position, H portfolios all with the same average return but with different standard deviation and different composition.

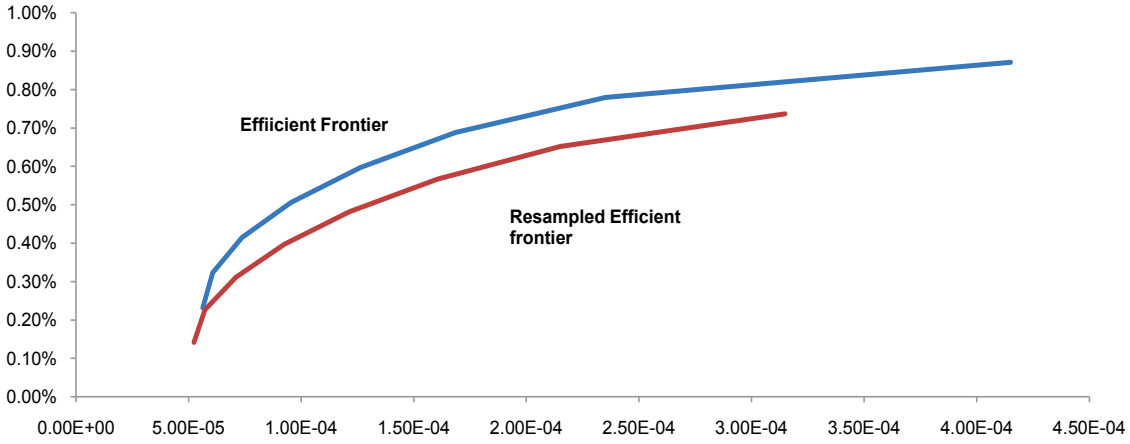
Taking the average weight that each security has in the portfolios with a certain ranking for the H simulations, we obtain a portfolio (portfolio 1 for example) named “Resampled”; repeating the same process for all other positions in the ranking will produce the Resampled frontier (see Figure 2).

Figure 1: Efficient Frontier and 25 Statistically Equivalent Efficient Frontiers



In this figure we compare efficient frontier and a set of statistically equivalent frontier. It is noted that, for construction, all statistically equivalent portfolios are located below the efficient frontier.

Figure 2: Efficient Frontier and Resampled Efficient Frontier



In *this figure we compare efficient frontier and Resampled efficient frontier. It is noted that, for construction, all Resampled efficient frontier are located below the efficient frontier.*

The frontier Resampled is nothing but an average of the weights of the portfolios of the efficient frontiers, which in turn were generated from input obtained from the simulation processes. The Resampling frontier will be more diversified relative to the efficient frontier. This is unlike Markowitz, in which the process of optimization leads to the identification of a particular dominant asset compared with others. From the composition of the H statistically equivalent frontiers, the same asset can also be dominated by other assets, and as a consequence creates less concentrated portfolios. The reasoning above shows a limit of the Markowitz approach known as "counter-intuition". Resampling and Bayesian approaches differ in the way they take into account estimation risk. In the first case, the intervention is directed to the most exposed input to this source of risk, namely the vector of average empirical yields. Otherwise, in the second case no correction is made, as there is the conviction to repair.

POST MODERN PORTFOLIO THEORY

It is possible to divide portfolio models, at least chronologically, into two families: the 'traditional models' (CAPM, Markowitz), which constitute the modern theory of portfolio choices, and the so-called 'post-modern' models (MADM, TEV, Elton-Gruber, SPM). All the quantitative modelling of first generation portfolio theories have in common an assumption of normality in the frequency distribution of portfolio returns. That assumption has proved forced, and does not correspond to the distributions of security returns observed in real markets. One of the assumptions on which the portfolio theory of G. Sortino is based, is recognition of the non-normal distribution, resulting in a greater use of processes that seek to express a better stability of parameters, and a more correct weightings distribution. A brief account, of some models of the so called Post Modern Theory, follows.

The Tracking Error Minimization Model (TEM) is a parametric model based on two factors: the expected return and the variance of the differential between the performance of the portfolio and the performance of the benchmark, which is the square of the Tracking Error Volatility. The objective is to seek the weight to assign to each asset in the portfolio. This is done to obtain the minimum portfolio tracking error with the constraints that the expected returns to be achieved are equal to or below a preset level, and that the weightings of the activities are positive and have sums equal to one. A generalization of the structure of the constraints is also permitted, in the sense that the presence of arbitrary linear constraints on the structure of the portfolio or lower (upper) bound is permitted. The objective function to minimize is:

$$Min\ variance\ \sum(\omega_i \cdot r_i) - \sum(\chi_i \cdot r_i) \tag{1}$$

where:

χ_i = *fraction of the benchmark portfolio held in asset* i.

$\sum(\chi_i \cdot r_i) = r_t$ *(benchmark return)*

ω_i = *asset* i*'s weight by optimization process*

The Mean Absolute Deviation minimization Model (MADM) is a non-parametric model, based on the idea of finding a benchmark, against which a predetermined over-performance is required. It seeks to achieve a certain return while at the same time, not departing too much from the chosen benchmark. The distance from the benchmark is adopted as the risk measure. This risk is measured as the absolute median difference calculated over a predetermined period of time. The goal is to find the weight to assign in the portfolio to each security, with the condition of minimum absolute mean deviation. The security return, or better the portfolio return, expected to be achieved is equal to or less than a value set in advance. Moreover, the weights of all activities must be positive and of sum equal to one. It also permits the presence of arbitrary linear constraints in the structure of the portfolio. The model does not take into account hypotheses on the shape of the distribution of returns. The only implicit assumption is that the return distribution, observed in the past, remains in the future. The objective function to minimize is:

$$Min_{\omega} \sum \left| \sum(\omega_i \cdot r_i) - \sum(\chi_i \cdot r_{it}) \right| \tag{2}$$

where:

r_i = *asset* i*'s return*

ω_i = *asset* i*'s weight by optimization process*

χ_i = *fraction of the benchmark portfolio held in asset* i.

$\sum(\chi_i \cdot r_{it}) = r_{bt}$ = *benchmark return*

Remaining with models designed to optimize performance against a benchmark, the Shortfall Probability Minimization (SPM) model aims to reduce the probability of occurrence of a portfolio underperformance against a benchmark. The probability of shortfall is estimated over time, by relating the number of periods in which there was a shortfall to the total over the time periods preselected.

The aim of the model of minimizing the shortfall probability is therefore to find the weight assigned to each financial instrument so that in a given timeframe the shortfall frequency is minimal. This occurs with the constraint that the expected return is equal to or less than a value to be assigned, and the sum of the weightings is equal to one. Other restrictions can also be imposed on the linear weights of financial assets. In this model, as with the previous, the only assumptions on the distribution of returns made are that, they are the product of a stationary process. In this way the past contains useful information for future distribution. The objective function to minimize is:

$$\min_{\omega} \sum_{t=1}^{M} \frac{I_t}{m} \tag{3}$$

Where:
It = dichotomic variable, which assumes value equal to 1, in the event that at time t, shortfall occurs, otherwise it assumes value equal to 0.
m = number of sample periods in the time domain considered.

DATA AND RESULTS

The database studied consists of blue chip firms from three financial indices: the Eux50 (DJ Euro Stoxx 50) index, the U.S. Sp100 index and finally the SPMIB40 index. For each security the weekly series consisting of 383 observations is considered. The relative time period: from 07/01/2000 to 04/05/2007 is evaluated relative to an of sample period from 21/11/2003 to 04/05/2007. For each index a "rolling" estimate logic was used, or rather, the different outputs of the various models and different techniques used were calculated by moving forward one period at a time.

As shown in the Section 1, the Resampling uses Monte Carlo simulation which uses a generation of random numbers, within the range 0 and 1, of a uniform distribution. Each number obtained, by each random generation in the interval [0-1], is associated with an area within a standardized normal distribution, N~ (0,1), which corresponds to a particular value on the x-axis. For any N ~ (μ, σ), it is possible to identify that value on the x-axis which generates this area (by inverse function of a normal distribution). In this way, there will be a match between random number and x-axis value of a normal distribution. In practice for each security that is a component of the index considered, an average value and standard deviation of historical returns is calculated. Parameters obtained, for every security, represent input data for a N ~ (μ, σ) distribution.

Operationally, for each security, 200 random numbers and then 200 returns were considered. For example in the case of the Eux50 index, the definition of the simulated return matrix refers to a matrix *200 x 50* (50 being the number of securities within the index) for each period (in total there are 181 out of sample periods). The repeating of the return simulation is considered with the simulated returns repeated 100 times. From the simulated returns, a matrix of simulated returns is computed, from which a frontier is obtained that is statistically equivalent. The frontier is created using the mean value for each one of the securities from the simulated return matrix and the covariance of the time series of simulated returns.

In the application run on the dataset under consideration, 100 statistically equivalent frontiers (and thus 100 arrays of *200 x n* random numbers, where *n* is the number of securities included in the index) were

generated. From 100 frontiers simulated a single frontier was produced. The procedure involved calculating, for 10 expected returns, the average of the weightings (relative to the fixed returns) of 100 statistically equivalent frontiers.

This article proposes a comparison, with reference to the Resampling technique, between the Markowitz model and Post Modern Theory models; specifically: TEV, MADM, and SPM. Unlike the Markowitz model, for Post Modern Theory models, the statistically equivalent frontiers have not been calculated. Instead for every simulated return matrix referring to a specific period (100 for each period), the optimal weight vector was calculated. With reference to the selected period, the optimal weighting vector is given from the weighting average of the optimal vectors obtained from each simulated matrix.

For each index considered (Eux50, Spmib40, Sp100) eight models are calculated. Statistics for each model are described as follows: Compound return, Rap measures (Sharpe ratio, Sortino Index, Information Ratio), Risk measures (Tem, Tev, Standard Deviation, Down Side Risk); test of statistical significance for the difference between mean returns of models and benchmark, and test of statistical significance for equality between variance returns of models and benchmark. At the top of the second and third column of each table is the name of the adopted model:

- Markowitz application of the Markowitz model, using the conditions that investors cannot hold securities in negative amounts and cannot short sell. In this case the best portfolio is the one lying on point of tangency between the efficient frontier and the Security Market Line.
- Resampling Markowitz, application of Resampling to the Markowitz model;
- MADM Resampling, application of Resampling to the Mean Absolute Minimization model (MADM);
- TEV Resampling standing for application of Resampling to the Tracking Error Minimization Volatility (TEV) model;
- SPM Resampling standing for Resampling in Shortfall Probability Minimization model (SPM) context.

In the first column of the tables shown below you can find, the total return, that is the maturity yield (compound return) of the model, calculated by assuming a starting capital of 100 compound interest calculated with weekly observations. We have calculated the model return for each period, using the hypothesis of investing in stocks suggested by the best vector of the model weights. The weekly return of the model was calculated by multiplying the best weights vector with real returns of stocks. This renders a different performance (actual/realized) from the performance estimated by the model. This difference is commonly called a discrepancy, similar in concept to the definition of instability of efficient portfolios. In this analysis no transaction costs have been taken into account. Using the Markowitz model the Resampling technique did not overperform with regard to the reference model (that is the Markowitz model without Resampling), for all the three considered indexes even though the compounded return is high, respectively 94% against 128%, for the Sp100 index, 21% against 31% for the Ex50 index, and 93% against 183% for the Spmib40 index.

The application of the Resampling technique to Post Modern Theory produced benefits (except in the case of the TEV model for the Sp100 index) in terms of compound return as determined by comparing the reference model to the ones the Resampling technique is applied to. In fact the MADM returned 42% for the US Sp100 index and 43% for MADM Resampling. The same results were produced for the Ex50, 34% index without Resampling against 38% in cases where the technique was applied, and 95% for the MADM through Resampling for the SpMib40 index against 162% for the simple MADM. The TEV model gave, for the three indexes, Sp100, Ex50 and Spmib40, 74%, 64% and 140% respectively, against 68%, 100% and 212% of the TEV with Resampling. The benefits achieved, through the Resampling

technique for the SPM model, were even higher; in fact according to the index considered, the best performance was from a minimum of about 78% to a maximum of over 196%.

An analysis of risk adjusted performance showed that the difference observed for the compound returns (in the use of the model) decreased. For example, in the use of the Sharpe indicator, the model excess return is compared to return standard deviation. So we can deduce that the models which have produced the best returns, are also the riskiest ones as defined by the standard deviation. It is symptomatic to observe how the difference in basis points, between the Markowitz and the TEV models, for the Spmib40 index, equivalent to over 40 points, might persuade the choice of the first model. On the contrary, if we analyse performances in the light of the Sharpe, the choice will lead to the second model. See the first and third panels in Table 3.

In fact, if we consider Table 3 again, we can observe how the Markowitz model standard deviation of 3.6%, is higher compared to the TEV model standard deviation of 2.7%. Yet if we analyse the results in the light of the Sharpe index, again Resampling technique has not improved the simple model performance. With regard to the Resampling method applied to post modern models, we get improvements in the Sharpe index in 100% of the cases against 89% improvements for the compound returns (8 cases out of 9).

The Information Ratio value is shown in Table 1 to 3 for each model related to the period 2004-2007. We cannot compare models in the case of Information Ratio, with different starting benchmarks, as the information ratio related to each model is influenced by the effects of its own reference benchmark. The Resampling technique, applied to post-modern models, enables us to improve the reference models 7 times out of 9, or in the 78% of cases, (Tables 1 to 3). In the case of the Markowitz model (once again) there are no benefits.

Next the Sortino index which uses as a measure of the Downside risk, is considered where the minimum acceptable return is represented by the risk free return. The Sortino index shows the percentage of over performance per unit of Downside Risk. In all cases the Resampling method improves the Markowitz model (first panel of tables 1 to 3). For Post Modern Theory models it improves about 56% of all cases (5 times out of 9), with particular difficulty with the MADM model and the Sp100 index. With regard to risk measures, such as Downside risk and Standard Deviation, the Resampling method improves almost exclusively in the TEV model.

Table 1 - Sp100 Model Results

	Sp100		
	Markowitz	**Markowitz Resampling**	**Difference**
Total Return	128.24%	94.61%	33.62%
Sharpe	13.07%	11.96%	1.12%
Sortino	1.76%	2.02%	-0.26%
Informatio Ratio	13.36%	12.43%	0.93%
Tev	3.24%	2.62%	0.62%
Standard Deviation	3.67%	3.12%	0.55%
Dsr	2.66%	2.32%	0.34%
	MADM	**MADM Resampling**	**Difference**
Total Return	42.16%	42.76%	-0.60%
Sharpe	5.88%	7.68%	-1.80%

	Sp100		
Sortino	1.63%	1.62%	0.01%
Informatio Ratio	5.32%	7.44%	-2.12%
Tev	3.36%	3.27%	0.09%
Standard Deviation	3.84%	3.78%	0.06%
Dsr	2.88%	2.89%	-0.02%
	TEV	**TEV Resampling**	**Difference**
Total Return	74.36%	68.86%	5.50%
Sharpe	9.51%	8.82%	0.69%
Sortino	1.90%	1.79%	0.11%
Informatio Ratio	9.86%	8.99%	0.87%
Tev	2.77%	2.88%	-0.11%
Standard Deviation	3.36%	3.47%	-0.11%
Dsr	2.46%	2.62%	-0.15%
	SPM	**SPM Resampling**	**Difference**
Total Return	-23.86%	53.99%	-77.84%
Sharpe	-2.55%	8.12%	-10.67%
Sortino	1.42%	2.22%	-0.81%
Informatio Ratio	-3.39%	7.49%	-10.89%
Tev	4.50%	2.53%	1.97%
Standard Deviation	4.15%	2.91%	1.24%
Dsr	3.31%	2.10%	1.20%

In this table we report results, for the applications of the Markowitz Model and Post Modern Theory Models for Sp100 Index over a sample period from 21/11/2003 to 04/05/2007.

Table 2 - Ex50 Model Results

	Ex50		
	Markowitz	**Markowitz Resampling**	**Difference**
Total Return	31.33%	21.75%	9.58%
Sharpe	6.30%	4.34%	1.96%
Sortino	17.55%	18.30%	-0.74%
Informatio Ratio	-8.13%	-13.83%	5.70%
Tev	1.60%	1.26%	0.34%
Standard Deviation	2.00%	1.89%	0.11%
Dsr	1.46%	1.40%	0.06%
	MADM	**MADM Resampling**	**Difference**
Total Return	34.02%	38.28%	-4.26%
Sharpe	5.92%	7.60%	-1.68%
Sortino	14.01%	17.21%	-3.19%
Informatio Ratio	-5.76%	-6.86%	1.11%
Tev	1.86%	1.46%	0.40%
Standard Deviation	2.52%	2.05%	0.47%
Dsr	1.83%	1.49%	0.34%

	Ex50		
	TEV	**TEV Resampling**	**Difference**
Total Return	64.59%	100.42%	-35.82%
Sharpe	11.58%	18.69%	-7.11%
Sortino	16.22%	18.26%	-2.04%
Informatio Ratio	-0.05%	8.51%	-8.57%
Tev	1.55%	1.20%	0.34%
Standard Deviation	2.20%	1.92%	0.28%
Dsr	1.58%	1.40%	0.18%
	SPM	**SPM Resampling**	**Difference**
Total Return	51.84%	248.28%	-196.45%
Sharpe	8.42%	25.78%	-17.36%
Sortino	14.03%	13.43%	0.60%
Informatio Ratio	-1.79%	20.64%	-22.44%
Tev	1.99%	2.06%	-0.08%
Standard Deviation	2.62%	2.65%	-0.03%
Dsr	1.82%	1.91%	-0.08%

In this table we report results, for the applications of the Markowitz Model and Post Modern Theory Models for Ex50 Index over a sample period from 21/11/2003 to 04/05/2007.

Table 3 - Spmib40 Model Results

	SpMib40		
	Markowitz	**Markowitz Resampling**	**Difference**
Total Return	183.57%	93.97%	89.60%
Sharpe	16.66%	13.89%	2.76%
Sortino	9.59%	13.33%	-3.75%
Informatio Ratio	11.12%	5.31%	5.80%
Tev	3.20%	2.15%	1.06%
Standard Deviation	3.58%	2.55%	1.03%
Dsr	2.51%	1.80%	0.70%
	MADM	**MADM Resampling**	**Difference**
Total Return	94.59%	162.42%	-67.83%
Sharpe	12.51%	18.91%	-6.40%
Sortino	11.51%	11.68%	-0.17%
Informatio Ratio	5.13%	12.24%	-7.10%
Tev	2.46%	2.36%	0.10%
Standard Deviation	2.93%	2.80%	0.13%
Dsr	2.09%	2.06%	0.03%
	TEV	**TEV Resampling**	**Difference**
Total Return	140.37%	212.29%	-71.91%
Sharpe	17.75%	21.69%	-3.93%
Sortino	12.27%	11.44%	0.83%

	SpMib40		
Informatio Ratio	10.72%	15.59%	-4.87%
Tev	2.21%	2.49%	-0.28%
Standard Deviation	2.69%	2.90%	-0.21%
Dsr	1.96%	2.10%	-0.14%
	SPM	**SPM Resampling**	**Difference**
Total Return	115.39%	199.80%	-84.41%
Sharpe	12.67%	19.38%	-6.71%
Sortino	9.83%	10.36%	-0.52%
Informatio Ratio	6.55%	13.53%	-6.97%
Tev	3.05%	2.76%	0.28%
Standard Deviation	3.47%	3.17%	0.30%
Dsr	2.45%	2.32%	0.12%

In this table we report results, for the applications of the Markowitz Model and Post Modern Theory Models for SpMib40 Index over a sample period from 21/11/2003 to 04/05/2007.

Up till now we have presented heuristic evidence of Resampling processes. Next, we deal with the statistical significance of results obtained from the models presented above. In order to verify the significance of positive track error, between results of different models, we use a statistical test based on the difference between two mean values. Let us consider two populations (X, Y) independent and normally distributed. Let us also consider two samples of *n* independent observations from the two normal populations (X1,…Xn) and (Y1,…,Yn). We want to test:

H0: $\mu x = \mu y$ against H1: $\mu x \neq \mu y$.

These hypotheses can equivalently be written as:

H0: $(\mu x - \mu y) = 0$ against H1: $(\mu x - \mu y) \neq 0$

Consider the standard distribution of the variable $(\overline{X} - \overline{Y})$ we obtain test statistic (with hypothesis that the two populations have identical variance):

$$z = \frac{(\overline{X} - \overline{Y}) - (\mu_x - \mu_y)}{\sqrt{\frac{\sigma_x^2}{n_x} + \frac{\sigma_y^2}{n_y}}} \tag{4}$$

under H0: $(\mu x - \mu y) = 0$ we obtain:

$$z = \frac{(\overline{X} - \overline{Y})}{\sqrt{\frac{\sigma_x^2}{n_x} + \frac{\sigma_y^2}{n_y}}} \tag{5}$$

In most of cases the common population variance is not known, so in this case we can refer to unbiased variance estimator $s^{2,}$ defined by:

$$s^2 = \frac{\sum_{i=1}^{n_x}(X_i - \overline{X})^2 + \sum_{i=1}^{n_y}(Y_i - \overline{Y})^2}{n_x + n_y - 2} \tag{6}$$

Under H0 the test statistic is given by:

$$t = \frac{(\overline{X} - \overline{Y})}{\sqrt{\frac{s^2}{n_x} + \frac{s^2}{n_y}}} \tag{7}$$

this has a t distribution with *nx* + *ny* - *2* degrees of freedom. In this case test critical values are given by:

$$(\overline{X} - \overline{Y})\,\mathrm{I} = -t_{\alpha/2}\sqrt{s^2/n_x + s^2/n_y} \tag{8}$$

$$(\overline{X} - \overline{Y})\,\mathrm{S} = t_{\alpha/2}\sqrt{s^2/n_x + s^2/n_y} \tag{9}$$

In the case in which the two sample variances are different, before conducting a test on mean values, we have to verify the hypothesis by a test for variance equality. This is done using a test based on the F statistic with Fisher distribution.

In the case in which test F is statistically significant the variables X and Y, from which the two samples are drawn, may not have the same variance. In this case we have to use two unbiased variance estimators s^2_x and s^2_y defined by:

$$s_x^2 = \sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{n_x - 1} \tag{10}$$

$$s_y^2 = \sum_{i=1}^{n} \frac{(Y_i - \overline{Y})^2}{n_y - 1}. \tag{11}$$

The test statistic in this case will be:

$$t = \frac{(\overline{X} - \overline{Y}) - (\mu_x - \mu_y)}{\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}} \tag{12}$$

A test of the difference between the two return means, one from the model and the other the benchmark, deals with a crucial topic in finance. That is, considering two populations X and Y, we try to establish if they have identical means. In other words, we try to understand if, on average, investing in the model or in the benchmark are equivalent. Considering the full period, 21/11/2003 to 04/05/2007 examining model (X) and benchmark (Y) returns, we find that in all cases except two, we cannot reject H0, at the 0.05% significance level. Thus we conclude that on the basis of the samples observed, identical means between model and benchmark returns are present in the majority of cases. For Ex50 index the null hypothesis is

rejected at the 0.05% significance level only in one case corresponding to SPM with Resampling. For SpMIb40 index the null hypothesis is accepted in all of the cases considered. For Sp100 index the null hypothesis is rejected at the 0.05% significance level, only in one case corresponding to SPM without Resampling. With regard to the test of variance equality between model and benchmark, only in 11% of all cases we can accept the null hypothesis of equality of variances between the two populations. In the remaining of 89% of the cases, the test suggests a difference between the variances of the two populations.

CONCLUSION

This article examines the approach to Portfolio modelling called Resampling, which reduces the effect of estimation error present in any practical implementation of a Portfolio Model. Resampling is a method used in portfolio modelling to try to obtain better out of sample performance for given input model parameters and in this way better measures of performance. Applying Resampling methods to blue chip portfolios of 3 different stock markets (Italian Equity Market, European stock Exchange and New York Stock Exchange) we compared the results for the Markowitz model and the so called Post Modern Portfolio Theory models (in particular Tracking Error Minimization Model (TEV), Mean Absolute Minimization Model (MADM), and Shortfall Probability Model (SPM)). With regard to the Markowitz model, in terms of compound return, the Resampling method did not over perform the reference model. The application of the Resampling method to Post Modern Portfolio Theory models produced benefits in all cases considered except for one (TEV Resampling for the Sp100 index). In particular benefits were notably evident for the SPM model where the performance improves from 78% to over 196% depending on the index considered.

An analysis of indicators taking into account the risk showed that the Resampling method applied to Post Modern Portfolio Models improved the Sharpe Index in 100% of the cases. However, there were no benefits for the Markowitz model. When we examine the information ratio values the Resampling method produced benefits only for about 78% of the post modern portfolio theory cases. Examining the Sortino index results we obtained contrasting results, whereas there are smaller benefits, for the Post Modern Theory and bigger ones for the Markowitz model. Our conclusion is that there is general evidence to show that Resampling methods produce better stability in the input of the models. As such, they are capable of generating substantial improvements both for compound return and for RAP performance measures, but only for post modern portfolio theory models. When considering Downside Risk and Standard Deviation, the Resampling method only improves the TEV model. So it is evident that this method is useful for obtaining better returns but not proportional stability of the same returns. The statistical significance of the positive tracking errors obtained from the models indicates that these results should be taken with caution. This caution is warranted because the equality tests of average returns, from models with or without Resampling method, lead to rejection of the null hypothesis in 25% of all cases. In short, though the benefits of Resampled Efficiency optimality are not clear, Resampling remains an interesting heuristic to deal with the important problem of error minimization.

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BIOGRAPHY

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JOB SECURITY AND PERSONAL INVESTMENT PORTFOLIO

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ABSTRACT

This paper incorporates human capital into the well-established portfolio theory by allowing for job security in personal portfolio choice. Our model predicts that young people hold more cash to hedge against risk associated with human capital (layoff risk). As people age, layoff risk decreases, and consequently, they invest in more risky assets – stocks in their portfolios. However, as people approach retirement, their human capital diminishes, and they become more risk averse. Hence, they hold more cash again. Our model provides a plausible explanation for the observed investment behavior of people who reveal humped shape stock holdings over the life cycle. Our results suggest that financial advisors should take into account different levels of job security when giving financial advice to different individuals.

JEL: G11; G23

KEYWORDS: Job security, personal portfolio, human capital

INTRODUCTION

In the past decade, self-directed retirement plans (e.g. 401(K)s, IRAs, etc.) have become the norm for people saving for their retirement. However, many participants in these retirement plans know little about personal investment. As such, professional financial advice is important in helping participants make sensible choices. Professional financial advisors popularly advise young people to invest in stocks, and gradually increase their investment in fixed income as they approach retirement. For example, Fidelity Investments and the Vanguard Group both recommend that the fraction of assets invested in equities should increase with one's wealth and decline with one's age.

However, empirical evidence shows that such professional advice contradicts people's investment behavior. The observed investment pattern is a humped shape for stocks. That is, people's investment in stocks gradually increases from a young age to middle age, and then tapers off. Investment in cash is the opposite: it gradually decreases from a young age to middle age, and then goes up.

An important question is: what causes professional advice to deviate from people's investment behavior? A possible reason is that such advice takes little consideration of human capital and its associated risk. Human capital is a major component of personal assets. Especially, it may be the only asset for most young people who are just starting their career. If this crucial element is ignored in making portfolio choices over the life cycle, the portfolio may not be optimal.

In contrast to previous studies, our study provides an alternative to quantify human capital and its associated risk by incorporating job security into portfolio theory to explore people's investment behavior. We first model human capital (income from job) as a financial asset. Next, we derive the covariance of the financial asset proxy for human capital with the mutual fund that the person would invest in. In our model, the risk associated with human capital is layoff risk, which is a major risk related to personal portfolio choice. Hence, how to diversify or hedge away this risk is an important issue in personal portfolio choice over the life cycle. By incorporating this human capital risk into portfolio

choices, we provide an optimum strategy for making personal investment decisions. The optimum strategy shows that people hold less risky assets at a young age to hedge against high human capital risk (layoff risk). As people age, human capital risk declines and people hold more risky assets. However, as people approach retirement, their human capital diminishes and risk aversion increases, resulting in an increase in the holding of risk-free assets. Our results thus provide a plausible explanation for the puzzle of why people's investment behaviors do not follow the pattern recommended by professionals.

This paper is organized as follows: Section 2 reviews the relevant literature. Section 3 develops a discrete model that incorporates job security into personal portfolio selection and presents the major results of the model. Section 4 extends the model and further discusses its implications. Section 5 concludes the paper.

LITERATURE REVIEW

Since Markowitz (1952, 1959) laid the groundwork for optimizing investment portfolios based on the tradeoff between risk and return, where risk is proxied by the volatility of the return on the underlying assets, professional financial advisors have used portfolio theory extensively to advise personal portfolio choices. A known rule of thumb is that the percentage of one's portfolio to invest in equities should be 100 minus one's age (see, Bodie and Crane, 1997). However, studies show that such professional advice is problematic. For example, Bodie (2002) points out that such advice is logically flawed and dangerously misleading because it does not allow for insurance against a market decline. In addition, empirical evidence shows that such professional advice contradicts people's investment behavior. For instance, the Survey of Consumer Finances (see Table 1) shows that people do not follow investment advice professionals claim to be optimal (Heaton and Lucas, 2000). The observed investment pattern is a humped shape for stocks. People's stock holdings increase from the young (<35) to the middle aged (<64) and then decrease as retirement approaches (>64). Furthermore, Heaton and Lucas find that the share of stock holdings is negatively related to the level and variability of the growth rate of proprietary income. Similarly, a survey on TIAA-CREF participants by Bodie and Crane (1997) shows that controlling for the effects of age and wealth, substantial differences still exist among individuals in the fraction of their total assets invested in equity. Factors reflecting the value and riskiness of human capital help explain these differences.

Table 1: Portfolio Shares Relative to Liquid Assets by Age

Assets	Age	<35	35-49	50-64	>64
			1989		
Stocks		0.394	0.465	0.454	0.360
Bonds		0.154	0.137	0.176	0.196
Cash		0.452	0.398	0.370	0.444
			1992		
Stocks		0.474	0.534	0.540	0.420
Bonds		0.114	0.130	0.160	0.199
Cash		0.412	0.336	0.300	0.381
			1995		
Stocks		0.550	0.590	0.600	0.494
Bonds		0.113	0.116	0.119	0.138
Cash		0.337	0.294	0.281	0.368

Source: Heaton and Lucas (2000), Journal of Finance 60, p. 1163-1198.

While the empirical evidence shows that human capital is an important factor in portfolio choices, the challenge is how to quantify human capital and risk associated with it. For example, Bodie et al. (1992) use the earning power from labor to proxy for human capital. Their model indicates that the fraction of an individual's financial wealth optimally invested in equity should "normally" decline with age. Lupton (2001) and Merton (1971) develop models to find that constant labor income substitutes for bonds in a financial portfolio. Gomes and Michaelides (2005) develop a life-cycle model with calibrated uninsurable

labor income risk and moderate risk aversion. They show that the model can simultaneously match stock market participation rates and asset allocation decisions conditional on participation. Cocco et al. (2005) solve numerically for optimal portfolio and savings decisions considering an investor facing mortality risk, borrowing and short-sale constraints, and receiving labor income. Their model shows that an investor reduces her proportional stock holdings in the process of aging, and that labor income loses importance as an investor ages. Polkovnichenko (2007) considers stochastic uninsurable labor income and predicts a much more conservative portfolio when there is a slim chance of a severe income shock. Bodie and Treussard (2007) suggest that if a safe fund matched to the investor's time horizon is included in addition to the target-date funds (TDF), investors who differ from the natural TDF holder in their risk aversion or exposure to human capital risk would realize optimal strategy. By allowing for the mutual relation between labor supply (earnings) and portfolio choice over a life-cycle, Gomes et al. (2008) show that variable labor supply materially alters preretirement portfolio choice by significantly raising optimal equity holdings. Post retirement, however, the optimal equity share increases as households spend down their financial assets, leaving bond-like pension benefits to increasingly dominate household resources.

Although previous studies consider human capital in constructing portfolios, their theoretical prediction of people's investment behavior is not completely consistent with the empirical evidence (e.g. Heaton and Lucas, 2000). In this paper, we provide an alternative approach to quantify human capital and its associated risk in personal portfolio selection by considering job security. We contribute to the literature in that our model prediction of people's investment behavior is consistent with the observed pattern. As such, our results provide insightful implications to professional financial advisors that they should consider different levels of job security when they advise clients on personal portfolio choices.

MODEL

Modeling of Human Capital

In this study, we analyze people's investment behaviors by studying an employee of a corporation. The corporation issues common stocks that trade on the market. We define personal human capital as the present value of the individual's future income. We assume the person has already optimized her human capital. Namely, the person has invested in her education and other trainings such that the marginal cost of education is equal to the expected marginal gain in her income. Therefore, the average return on human capital is higher than the marginal return. The direct consequence of this argument leads to the following lemma:

***Lemma 1*:** The expected average rate of return on personal human capital, R_L^P, is greater than the rate of return on any mutual fund with the same level of risk, R_M.

The rationale behind Lemma 1 is that if $R_L^P < R_M$, the opportunity cost of *not* working is small and one would find it advantageous to use the profits from the mutual fund's gains to pay for more trainings and education, which contradicts our assumption that the person has already optimized her human capital. We next define risk of human capital as layoff risk. We model the value of human capital as a jump process, which is characterized as the layoff probability, λ, and the recovery rate, δ. If a person is not laid off in period 1, the value of her human capital will be her human capital in the next period, H_1 plus her wage income, I_1. Her rate of return on human capital is

$$R_{Lu} = \frac{(I_1 + H_1) - H_0}{H_0}. \quad (1)$$

However, if she is laid off, she can only recover a portion of the value of her original human capital due to income losses over the jobless period, loss of benefits, and settling in a job with less income. Her human capital loss would be $(1-\delta)(I_1+H_1)$. Her rate of return on human capital is

$$R_{Ld} = R_L \left| t^* \in \{0, t_1\} = \frac{\delta(I_1 + H_1) - H_o}{H_o} = \delta(1 + R_{Lu}) - 1. \right. \tag{2}$$

Combining equations (1) and (2), we can express the expected rate of return on her human capital as

$$R_L^p = E_t^P(R_L | F_0) = R_{Lu} - (1-\delta)\lambda - \mathrm{O}(\lambda R_{Lu}) \tag{3}$$

where O(z) stands for the term with the same or higher order of z. The variance of her human capital return can be computed as

$$\begin{aligned} \mathrm{var}(R_L) &= \left[\left(R_L \left| t^* > t_1\right.\right) - R_L^P\right]^2 (1-\lambda) + \left[\left(R_L \left| t^* \in \{0, t_1\}\right.\right) - R_L^P\right]^2 \lambda \\ &= (1 + R_{Lu})^2 (1-\delta)^2 (1+\lambda)\lambda. \end{aligned} \tag{4}$$

Equation (4) indicates that the higher the layoff risk and the lower the recovery rate, the more volatile the human capital returns.

Covariance between the Firm's Stock and the Mutual Fund

Since human capital is an important component in a personal portfolio, we have to understand the covariance between human capital and the person's other assets in the portfolio to set up an optimal portfolio. Unfortunately, there is no direct link between these two asset processes. Therefore, we first compute the covariance between the stock of the firm that hires the person and the mutual fund that the person may choose for her portfolio. Next, we link human capital to the stock of the employer. In this way, the relation between human capital and the mutual fund is built and the covariance between the two is computed.

We denote x as a publicly traded stock, S, (or a mutual fund M). The stock price can either move up from x_o to a new level $u_x x_o$ or down from x_o to a new level $d_x x_o$. Let $u_x = e^{\sigma_x \sqrt{\Delta t}}$ and $d_x = e^{-\sigma_x \sqrt{\Delta t}}$, where σ is the volatility of the firm's stock (or mutual fund) and Δt is the length of the period (see Cox, Ross, and Rubinstein, 1979). The probability of an up movement in price, π, is given by

$$\pi_x = \frac{e^{\mu_x \Delta t} - d_x}{u_x - d_x}. \tag{5}$$

There are four possible states, $u_S u_M$, $u_S d_M$, $d_S u_M$, and $d_S d_M$ with probability x_1, x_2, x_3, and x_4 respectively, (see Figure 1). Thus, the covariance between the expected rate of return of the stock and that of the mutual fund is

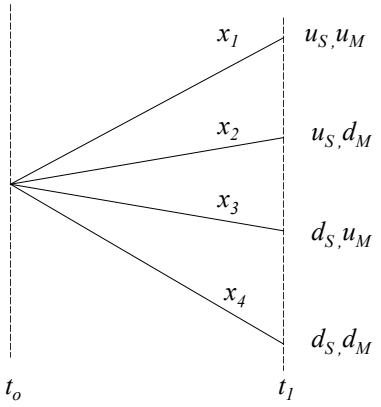
$$\begin{aligned} \mathrm{cov}(R_S, R_M) = \sigma_{SM} &= \left(u_S - e^{\mu_S \sqrt{\Delta t}}\right)\left(u_M - e^{\mu_M \sqrt{\Delta t}}\right) x_1 + \left(u_S - e^{\mu_S \sqrt{\Delta t}}\right)\left(d_M - e^{\mu_M \sqrt{\Delta t}}\right) x_2 \\ &+ \left(d_S - e^{\mu_S \sqrt{\Delta t}}\right)\left(u_M - e^{\mu_M \sqrt{\Delta t}}\right) x_3 + \left(d_S - e^{\mu_S \sqrt{\Delta t}}\right)\left(d_M - e^{\mu_M \sqrt{\Delta t}}\right) x_4 \end{aligned} \tag{6}$$

and $x_1 + x_2 = \pi_S$, $x_1 + x_3 = \pi_M$, $x_1 + x_2 + x_3 + x_4 = 1$, which yield

$$x_1 = \frac{\sigma_{SM}}{\left(e^{\sigma_S \sqrt{\Delta t}} - e^{-\sigma_S \sqrt{\Delta t}}\right)\left(e^{\sigma_M \sqrt{\Delta t}} - e^{-\sigma_M \sqrt{\Delta t}}\right)} + \pi_S \pi_M. \tag{7}$$

If the high order terms of Δt are ignored, equation (7) is reduced to $x_1 = \sigma_{SM} + \sigma_S \sigma_M$. The reduced equation (7) shows that the probability of the stock and mutual fund going up simultaneously depends on the covariance between the expected returns of the two and the volatility of each one.

Figure 1: Movement of Stock and Mutual Fund Returns



This figure shows that the probability of both the stock and the mutual fund going up is x_1, the probability of the stock going up and the mutual fund going down is x_2, the probability of the stock going down and the mutual fund going up is x_3, and the probability of both the stock and the mutual fund going down is x_4.

Covariance between Human Capital and the Mutual Fund

To link human capital to the stock of the employer, we assume that the layoff would occur if the stock of the firm were down. If x_o goes down to dx_o, there is a probability $\lambda/(1-\pi_S)$ that the firm will lay off employees. The covariance between the return on human capital and that on the mutual fund is

$$\begin{aligned}\operatorname{cov}(R_L, R_M) = \sigma_{LM} = &\left(u_M - e^{\mu_M \Delta t}\right)\left(R_{Lu} - R_L^P\right)x_1 + \left(d_M - e^{\mu_M \Delta t}\right)\left(R_{Lu} - R_L^P\right)x_2 \\ &+\left(u_M - e^{\mu_M \Delta t}\right)\left(R_{Lu} - R_L^P\right)x_3\left(1 - \frac{\lambda}{1-\pi_S}\right) + \left(u_M - e^{\mu_M \Delta t}\right)\left(R_{Ld} - R_L^P\right)x_3\frac{\lambda}{1-\pi_S} \\ &+\left(d_M - e^{\mu_M \Delta t}\right)\left(R_{Lu} - R_L^P\right)x_4\left(1 - \frac{\lambda}{1-\pi_S}\right) + \left(d_M - e^{\mu_M \Delta t}\right)\left(R_{Ld} - R_L^P\right)x_4\frac{\lambda}{1-\pi_S}.\end{aligned} \tag{8}$$

Equation (8) can be simplified as $\sigma_{LM} = \alpha\sigma_{SM}$, where $\alpha = \dfrac{(1+R_{Lu})(1-\delta)\lambda}{e^{\sigma_S\sqrt{\Delta t}} - e^{\mu_S \Delta t}}$. The simplified equation (8) shows that the covariance between the return of human capital and that of the mutual fund is determined by the covariance between the return of the firm's stock and that of the mutual fund.

Personal Portfolio Choice

After figuring out the covariance between the return of human capital and that of the mutual fund, we set up the personal portfolio. We assume that the personal portfolio is composed of human capital, real estate, and the mutual fund (stocks and bonds). The variance matrix of the return on the assets in the portfolio is given by

$$\begin{bmatrix} \sigma_L^2 & \sigma_{LH} & \sigma_{LM} \\ \sigma_{LH} & \sigma_H^2 & \sigma_{HM} \\ \sigma_{LM} & \sigma_{HM} & \sigma_M^2 \end{bmatrix}$$

where $\sigma_i^2, i = L, H, M$ stands for the variance of the return of human capital, real estate, and the mutual fund, respectively. σ_{LH} is the covariance between the return of human capital and that of real estate. σ_{LM} is the covariance between the return of human capital and that of the mutual fund. Lastly, σ_{HM} is the

covariance between the return of real estate and that of the mutual fund. The return and the variance of the portfolio are given by

$$R_p = w_L R_L + w_H R_H + w_M R_M$$
$$\sigma_p^2 = w_L^2\sigma_L^2 + w_H^2\sigma_H^2 + w_M^2\sigma_M^2 + 2w_L w_H \sigma_{LH} + 2w_H w_M \sigma_{HM} + 2\alpha w_L w_M \sigma_{SM} \quad (9)$$

where w_i is the weight of asset i and $w_L + w_H + w_M = 1$.

In such a personal portfolio, the person can adjust her mutual fund more easily than her human capital and real estate. As she adjusts her mutual fund, the variance of the return of mutual fund and the covariance between the return of mutual fund and that of human capital changes accordingly. Simultaneously, the covariance between the return of mutual fund and that of real estate also changes. We can see that this model possesses two characteristics: 1) In a personal portfolio, human capital and the real estate asset are not completely flexible in portfolio adjustment. 2) Because of inflexibility of the two assets, the objective of optimization of the personal portfolio is different from that implied by traditional portfolio theory. In this setting, the mutual fund becomes a tool for the person to hedge against the risk associated with her human capital and real estate.

Let us look at a person's typical life cycle. When the person graduates from college and gets her first job, she starts with only her personal human capital that has the following predetermined risk and return characteristics: $w_L = 1, w_H = w_M = 0$. As time goes by, her portfolio gradually shifts towards her mutual fund and real estate. Eventually, at retirement age, the weights of the three components become $w_L = 0$ and $w_H + w_M = 1$. At retirement, her human capital is zero. She would choose a mutual fund to maximize her utility given her total assets. In other words, her portfolio at retirement depends on her risk tolerance or risk aversion. Given this target portfolio on her retirement, she can choose different paths to reach this target portfolio when she retires. Even though all possible paths lead to the same portfolio, the paths may have important differences among each other. Next, let us examine some possible paths.

One possible path is that a person puts her savings directly into the target portfolio. When she retires, her human capital becomes zero and her portfolio is the target portfolio.

Another possible path is that she invests all her savings in risk-free assets and real estate. As her portfolio risk reduces to the risk level of her target portfolio, she redistributes her savings between risk-free and risky assets so that the risk level remains the same as that of her target portfolio. On retirement, her portfolio will be her target one.

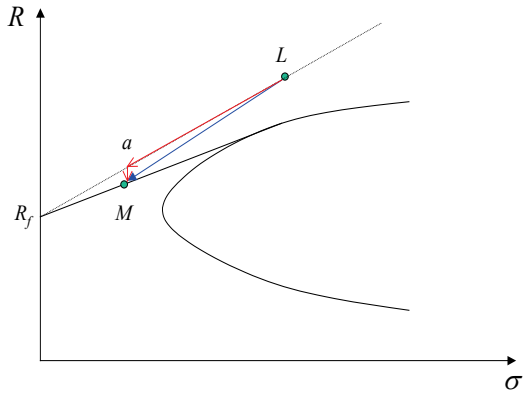
The difference between these two paths is the time at which the target risk level is reached. In the first path, she reaches the risk level exactly on her retirement date, while the second path allows her to reach the risk level before her retirement. We next use an example to show the difference between the two paths.

To simplify, we assume that a person rents an apartment and thus, her real estate asset is zero, $w_H = 0$. Her target portfolio, i.e. her mutual fund at retirement, is point *M* in Figure 2. Suppose that her target mutual fund is a combination of risk-free assets and a portfolio of risky assets. To reach her target portfolio, she may put her savings constantly into this mutual fund. As time goes by, the weight of her human capital decreases and the weight of her mutual fund increases. At retirement, 100 percent of her assets are in this mutual fund. Consequently, she reaches her target portfolio. Line *LM* in Figure 2 indicates this possible path.

Another possible path is that the person puts her savings into risk-free assets first, which counterbalances the risk associated with her human capital (layoff risk). Her path takes line *La* in Figure 2 to point *a*, at which the total risk of her portfolio reaches the risk level of her target portfolio. Then she changes her investment strategy by redistributing her savings in both risk-free and risky assets such that her portfolio eventually reaches her target portfolio at retirement, as indicated by line *aM* in Figure 2. The example suggests that the important difference between the two paths is the time taken to reach her target risk level. In the former path, the risk level of the target portfolio is reached exactly on the retirement date. In the latter path, the risk level can be reached before the retirement date.

The example above shows the important role human capital plays in portfolio choice. We find that if the risk associated with human capital is considered, the portfolio choice is quite different from the one suggested by financial advisors, which invests more risky assets at a young age and gradually reduces risk towards retirement. In reality, a person often starts with a single asset, human capital over the life cycle. Since human capital cannot be traded in the market, the young person is stuck with the risk associated with human capital. Her financial objective is generally how to adjust her relatively flexible assets to achieve her target portfolio. Our finding thus provides a plausible explanation on the puzzle that professional advice is not consistent with empirical evidence. The reason is that such professional advice may not allow for the risk associated with human capital in making a portfolio choice.

Figure 2: Possible Paths to Reach Target Portfolio



This figure shows two possible paths to reach a person's target portfolio (M) that consists of risk-free and risky assets. The path LM indicates that the person constantly puts her savings in a mutual fund. As time goes by, the weight of her human capital (L) decreases and the weight of her mutual fund increases. At retirement, 100 percent of her assets are in the mutual fund and the target portfolio is reached. The other path, La and aM, indicates that the person puts her savings into risk-free assets first, which counterbalances her human capital risk. At point a, the total risk of her portfolio reaches the risk level of her target portfolio (M). Then she redistributes her savings in both risk-free and risky assets such that her portfolio reaches her target portfolio at retirement, as indicated by aM.

EXTENSION AND IMPLICATIONS OF THE MODEL

In Section III, we assume that a person chooses to invest in risk-free assets to hedge her human capital risk at a young age. However, some young people may be less risk averse and invest more in stocks to hedge human capital risk. In this case, the path is represented by line *Lb* in Figure 3, which shows that an investor can reach the risk level of the target portfolio earlier by investing in portfolio *c* instead of the risk-free instrument. In addition, the return at point *b* is higher than that at point *a*. Therefore, in this case, investing in *c* is superior to investing in a risk-free instrument. Proposition 1 states the result.

Proposition 1: If there is a portfolio *c* that satisfies
$R_c > R_f$ and

$$\sigma_M^2 < -\frac{2\alpha\sigma_S \left[\sigma_p^2 - w_H^2\sigma_H^2 - w_H\sigma_{HL}(1-w_H) + A\right] + 2w_H\sigma_{HM}\left[\sigma_L^2(1-w_H) + w_H\sigma_{HL} + A\right] - w_H A}{\sigma_L^2(1-w_H)^2 - \sigma_p^2 + w_H 2\sigma_{HL}(1-w_H) + w_H\sigma_H^2}$$

where

$$A = \sqrt{\sigma_p^2\sigma_L^2 + w_H^2\left(\sigma_{HL}^2 - \sigma_H^2\sigma_L^2\right)},$$

then investing in portfolio *c* is superior to investing in risk-free assets. R_c and R_f denote the rate of return of portfolio *c* and risk-free assets respectively. Other variables are defined as before. Please see Appendix A for the detailed proof.

To illustrate Proposition I, we still use the example in Section 3.4. Since the person is assumed to rent an apartment and thus, her real estate assets are zero, $w_H = 0$. The results in Proposition 1 can be simplified as

$$\sigma_M^2 < -\frac{2\alpha\sigma_{SM}\left(\sigma_L\sigma_p + \sigma_p^2\right)}{\sigma_L^2 - \sigma_p^2}. \tag{10}$$

If layoff risk is lower than the risk of the target portfolio, $\sigma_L < \sigma_p$, the person can invest in risky assets to achieve higher returns. However, the typical case is that layoff risk is higher than the risk of the target portfolio, $\sigma_L > \sigma_p$. In deciding whether to invest in risk-free assets or a portfolio of risky assets, she has to search for a portfolio that satisfies the condition shown in equation (10):

1. Because $\sigma_L > \sigma_p$, for the right-hand-side of the inequality to be positive, σ_{SM} must be negative. This means the correlation between the firm's stock and portfolio *c* is negative.
2. The more negative the correlation, the higher the variance for portfolio *c*. Or, the more risky portfolio *c* is.

If the person can find a portfolio that satisfies the above condition, she should invest in a risky portfolio instead of risk-free assets. This path allows her to reach the risk level of the target portfolio earlier than the path by investing in the risk-free assets. Figure 3 illustrates this case.

Figure 3: The Path to Reach Target Portfolio Earlier

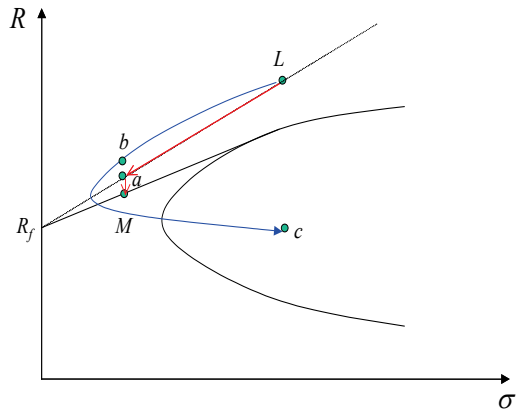


Figure 3 shows a path to reach a person's target portfolio (M) earlier. Path Lb indicates that the person invests more in stocks to hedge human capital (L) risk because she is less risk averse. At point b, the total risk of her portfolio reaches the risk level of her target portfolio (M). To reach her target portfolio earlier, it is better to invest in portfolio c, rather than in the risk-free assets.

The above example suggests that Proposition 1 provides several intuitive implications. First, the proposition implies that the risk of the mutual fund a person chooses should be negatively correlated with the risk of the stock of the firm hiring her. Since risk of human capital (layoff risk) is often positively correlated with risk of a firm's stock, risk of the mutual fund must be negatively correlated with the risk of human capital. In this way, the risk of human capital can be diversified away by choosing the mutual fund. Second, the proposition provides the same rationale behind the negative correlation between the mutual fund and real estate. Hence, the risk of real estate assets can be hedged by the mutual fund.

Our analysis shows that risk associated with human capital is the most important risk in the early stages of a person's career. Hedging this risk is a key factor in making personal portfolio choices over the life cycle. Our finding thus provides a plausible explanation on the puzzle of household investment behavior that contradicts common wisdom – the holding of stocks decreases with age. The Survey of Consumer Finances by Heaton and Lucas (2000, see Table 1) shows that young people, who are less than 35 years old, have a relatively higher percentage of their investments in cash than middle-aged people, who are between 35 to 64 years old. The stock holding exhibits a humped shape as people age. According to our model, young people hold a large amount of cash to hedge human capital risk. As human capital risk decreases as people age, middle-aged people tend to invest in more risky assets – stocks. However, as people approach retirement, they become more risk averse, thereby reducing the holding of stocks.

CONCLUSIONS

In this paper, we propose a model that incorporates human capital into personal investment portfolio decisions. Human capital is a major source of income for people who do not inherit a large amount of assets. Human capital differs from other assets traded on the market in that the sole owner of human capital is an individual, and human capital cannot be sold or transferred on the market. Thus, individuals have to take the risk associated with human capital by themselves.

Over a life cycle, an individual converts her human capital into income, which supports her consumption and savings. Therefore, part of human capital is gradually transformed into financial assets through personal savings. Most young people starting out on their careers have limited financial assets. Some young people even have negative financial assets, such as education loan liabilities. Their main "asset" is human capital. However, in the early stage of their careers their jobs are less stable than those of older people. As a result, young people hold risk-free assets to hedge against the risk associated with human capital (layoff risk). As time passes, people accumulate more savings, but the present value of the future incomes generated by human capital decreases. People then allocate more financial assets to risky assets to obtain higher returns. As people grow older and head towards retirement, their human capital diminishes and their financial assets are dominant factors in their investment decisions. As predicted by the classical portfolio theory, old people have higher risk aversion to hold more risk-free assets in their portfolios.

Our model thus predicts an investment pattern that is consistent with empirical observation. The model suggests that individuals should take job security into account in making portfolio choices and that financial advisors should tailor their investment advice to different individuals with different levels of job security. Although our model provides insightful implications, it has a few limitations. First, our model does not rigorously consider the variation on risk aversion among different people, which is an important factor in personal portfolio choices. Second, the expected human capital and its expected rate of return are not constant. They are likely affected by various factors, such as the state of the macro economy and policy changes in health insurance. Therefore, stochastic rates of returns (including the one on human capital) are more realistic. These extensions are interesting and worthwhile for future pursuit in this line of research.

APPENDIX

Appendix A: Proof of Proposition 1

The variance of a portfolio that is composed of human capital, real estate, and mutual fund is as follows:
$\sigma_p^2 = w_L^2\sigma_L^2 + w_H^2\sigma_H^2 + w_M^2\sigma_M^2 + 2w_L w_H \sigma_{LH} + 2w_H w_M \sigma_{HM} + 2\alpha w_L w_M \sigma_{SM}$.
If investing in portfolio *c* as the mutual fund, we solve for w_M to yield

$$w_{M,c} = \frac{\left(\sigma_L^2 - \alpha\sigma_{SM}\right)\left(1 - w_H\right) + w_H\left(\sigma_{HM} - \sigma_{HL}\right) \pm \sqrt{B}}{\sigma_L^2 + \sigma_M^2 - 2\alpha\sigma_{SM}}$$

where

$$B = \left[\sigma_L^2 - \alpha\sigma_{SM}\left(1 - w_H\right) - w_H\left(\sigma_{HM} + \sigma_L^2 - \sigma_{HL}\right)\right]^2$$
$$-\left(\sigma_L^2 + \sigma_M^2 - 2\alpha\sigma_{SM}\right)\left[\sigma_L^2\left(1 - w_H\right)^2 - \sigma_p^2 + w_H\left(2\sigma_{HL} + w_H\left(\sigma_H^2 - 2\sigma_{HL}\right)\right)\right].$$

The solution with plus sign before $\sqrt{B}$ is not the one we need since we rule out possible negative weight, i.e., shorting an asset. For risk-free asset as the mutual fund, we have
$\sigma_M^2 = \sigma_{HM} = \sigma_{SM} = 0$.
Solve for w_M to yield

$$w_{M,R_f} = \frac{\sigma_L^2\left(1 - w_H\right) - w_H\sigma_{HL} \pm \sqrt{D}}{\sigma_L^2}$$

where

$$D = \left[\sigma_L^2 - w_H\left(\sigma_L^2 - \sigma_{HL}\right)\right]^2 - \sigma_L^2\left[\sigma_L^2\left(1 - w_H\right)^2 - \sigma_p^2 + w_H\left(2\sigma_{HL} + w_H\left(\sigma_H^2 - 2\sigma_{HL}\right)\right)\right].$$

The solution with plus sign before $\sqrt{D}$ is not the one we need. Let
$w_{M,R_f} > w_M$
which means that the portfolio needs more investment in risk-free assets than in portfolio *c* to get the same level of total risk. In general, we can solve for σ_M to yield Proposition 1.
By the assumption
$R_c \geq R_f$
and by definition
$R_p = w_L R_L + w_H R_H + w_M R_M$
for the same weight in mutual fund immediately we have
$R_{p,c} \geq R_{p,R_f}$.

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AN IMPLIED INCOME INEQUALITY INDEX USING L_1 NORM ESTIMATION OF LORENZ CURVE

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ABSTRACT

Distribution of income is among the most important issues in welfare economics. Economic literature provides different ways to measure income inequality. Most common inequality indices provide information about the income distribution and analyze the inequality of income allocation without any reference to the amount of money needed to reduce the income inequality.In this paper, we design a model to estimate the Lorenz curve function parameters. By this approach, any census summary data can be used to measure the distribution of income. We also introduce a new fiscal-compensation-based index for reduction of the degree of inequality. Using this index, we show how much transfer payment is needed to achieve the desired distribution of income consistent with the perceived economic goals of the society.

JEL: C63

KEYWORDS: Income distribution, Inequality index, Lorenz curve.

INTRODUCTION

Estimation of the Lorenz curve is a challenge and is coupled with some difficulties. To estimate, first we need to define an appropriate functional form that can accept different curvatures. Moreover, to generate the necessary data set for estimation of the corresponding parameters, a large scale of computation of sample income data is inevitable. In section (A) of this paper, we introduce a shortcut and use the probability density function of population income to estimate the Lorenz function parameters. We develop the continuous L_1 norm smoothing method to estimate the regression parameters. We use two different probability density functions: (a) Pareto density distribution function that is integrable and (b) log-normal function that is more suitable for a wider range of income but is not integrable. Most inequality indices concentrate on the statistical aspect of the distribution of income. That is, they generally analyze the distribution without inferring the amount of funds needed to correct the income inequality. In section (B) of this paper, we introduce an implied inequality index. We identify an income inequality index to show how much of a transfer payment is needed to achieve the desired distribution of income consistent with the perceived economic equality goals of the policy-maker.

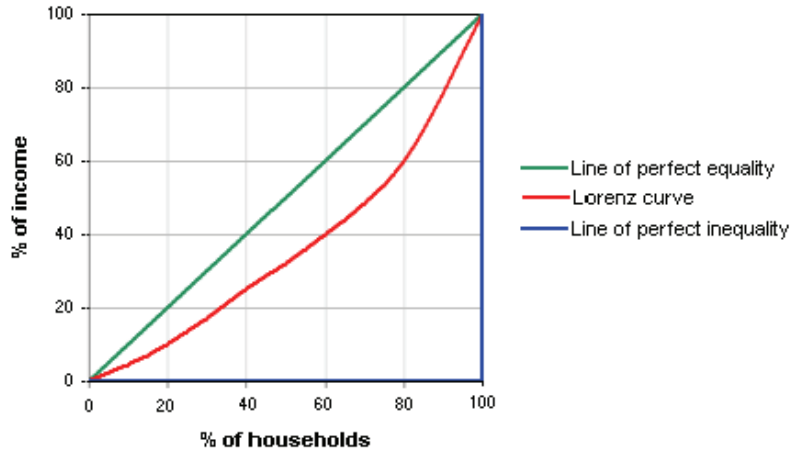
REVIEW OF LITERATURE

The degree of income inequality can be illustrated with a Lorenz curve. The Lorenz curve is a graphical representation of the cumulative income distribution function. It shows what portion of the total income **y** is received by the bottom percentages of households. The percentages of households are plotted on the horizontal axis, and the percentages of earned incomes are plotted on the vertical axis, as Figure 1 shows.
The income inequality shown by the Lorenz curve can be measured by the Gini ratio. This coefficient is a measure to express distribution inequality. It is defined as a ratio between 0 and 1. Its numerator is the area between the Lorenz curve and the diagonal line, which represents the uniform income distribution. The denominator is the area under the uniform distribution line. Since the skewness of income distribution is persistently exhibited for different populations, the Lorenz curve becomes a method to analyze the skew distributions. There is also a relation between the area under the Lorenz curve and the

corresponding probability distribution function. It is discussed that Pearsonian family distributions are rival functions to explain income distribution. See, Kendall and Stuart (1977).

When the probability distribution function is known, we may find the corresponding Lorenz curve as well as the Gini coefficient. Estimation of the Lorenz curve is associated with some difficulties. For this estimation, we should define an appropriate functional form that can accept different curvatures. In this regard, we need to have access to a large data set. Even though estimation of the corresponding parameters requires an extensive computational procedure, nevertheless, it leads to a low degree of significance for the estimated parameters. See, Bidabad and Bidabad (1989).

Figure 1: Lorenz Curve



In section (A), we use the probability density function of population income to estimate the Lorenz function parameters and concentrate on two rival probability density functions of Pareto and log-normal. The Pareto density function is integrable, and from this, we may uniquely derive the corresponding Lorenz function. However, the log-normal density function, which is more suitable for a wider income range than the Pareto distribution and is a better fit for higher income level -- see, Cramer (1973), Singh and Maddala (1976), Salem and Mount (1974) -- is not integrable. In this case, we need to define a general Lorenz curve functional form and apply the L_1 norm smoothing to estimate the relevant parameters. Using the approximation method for the discrete case, Bidabad (1989) has solved the L_1 norm estimation problems of linear one and two parameter models. He has also proposed certain directions for a continuous smoothing case. In our paper, this method is applied to estimate the Lorenz functional form introduced by Gupta (1984) and Bidabad and Bidabad (1989).

To have a solid understanding of guiding principles of income distribution, it is not enough to know the Lorenz curve and be familiar with the conventional inequality indices. The redistribution policies must enumerate specific budget guidelines to promote a more equal income distribution in the society. Economic literature provides different ways to measure income inequality (Atkinson, 1970; Cowell, 1977; Sen, 1973). Some of the most commonly used measures include: the Gini coefficient; the decile ratio; the proportions of total income earned by the bottom 50%, 60%, and 70% of households; the Robin Hood index; the Atkinson index; and Theil's entropy measure. The Gini is calculated as the ratio of the area between the Lorenz curve and the 45° line, to the whole area below the 45° line. Kakwani (1980) is a recalculation of the Gini coefficient and measures the length of the Lorenz curve. The Robin Hood index is equivalent to the maximum vertical distance between the Lorenz curve and the line of equal incomes. The Atkinson (1970) index is one of the few inequality measures that explicitly incorporate normative judgments about social welfare. It is derived by calculating the so-called equity-sensitive

average income, which is defined as that level of per capita income, which if enjoyed by everyone, would make total welfare equal to the total welfare generated by the actual income distribution. Theil's (1967) entropy measure is derived from the notion of entropy in information theory.

Obviously, there is no single "best" measure of the degree of income inequality. Some measures (e.g., the Atkinson index) are more bottom-sensitive than others, i.e., more strongly correlated with the extent of poverty. The measures perform differently under various types of income transfers. For instance, the Gini is much less sensitive to income transfers between households if they lie near the middle of the income distribution compared to the tails. The Robin Hood index is insensitive with respect to income transfers between households on the same side of the mean income. While there are alternative methods, there is no best way to calculate the inequality index, especially for fiscal purposes. That is, they generally analyze the distribution without inferring the amount of funds needed to correct income inequality.

In section (B), we introduce an implied inequality index, which satisfies the needs of the above mentioned policy implications. We identify an index that can be used to reduce the degree of inequality. We show how to use any income or census summary data (i.e., the average and the median income) to measure the distribution of income and calculate the amount of money needed to be levied on the upper income group and then transferred to the lower income group to promote a better income distribution within the society.

DEVELOPMENT OF CONTINUOUS L1 NORM FUNCTIONS

In this section, we develop the continuous L_1 norm smoothing method to estimate the regression parameters. First, we explain linear_*one* and *two* parameter models respectively. Next, we estimate the Lorenz curve parameters. To estimate; we use two different probability density functions: (a) Pareto density distribution function that is integrable and (b) log-normal function that is more suitable for a wider range of income but is not integrable. Finally, we have a hypothetical numerical example for calculation of the parameters of the Lorenz curve.

Generally, L_p norm of a function f(x) (see, Rice and White, 1964) is defined by,

$$\|f(x)\|_p == \int_{x\in I}\left(|f(x)|^P dx\right)^{\frac{1}{p}} \quad (1)$$

Where "I" is a closed bounded set. The L_1 norm of f(x) is simply written as,

$$||f(x)||_1 = \int_{x\varepsilon I} |f(x)|dx \quad (2)$$

Suppose the non-stochastic function f(x,**β**) and the stochastic disturbance term u form y(x) as follows:

$$y(x) = f(x, \boldsymbol{\beta}) + u \quad (3)$$

Where **β** is unknown parameters vector. Rewriting u as the residual of y(x)-f(x,**β**), for L_1 norm approximation of "**β**", we should find "**β**" vector such that the L_1 norm of "u" is minimum. That is,

$$\text{Min: } S = ||u||_1 = ||y(x)-f(x,\boldsymbol{\beta})||_1 = \int_{x\varepsilon I} |y(x)-f(x,\boldsymbol{\beta})|dx \quad (4)$$

B

Liniar One Parameter Continuous L1 Norm Smoothing

Redefine f(x,**β**) as βx and y(x) as the following linear function,

$$y(x) = \beta x + u \quad (5)$$

Where "**β**" is a single (non-vector) parameter. Expression (4) reduces to:

$$\text{Min: } S = \|u\|_1 = \|y(x) - \beta x\|_1 = \int_{x\varepsilon I} |y(x) - \beta x| dx \quad (6)$$
$$\beta$$

The discrete analogue of (6) is solved by Bidabad (1988, 1989). In those papers, he proposed applying discrete and regular derivatives to the discrete problem by using a slack variable "t" as a point to distinguish negative and positive residuals. A similar approach is used here to minimize (6). To do so in this case, certain Lipschitz conditions are imposed on the functions involved (see, Usow, 1967a). Rewrite (6) as follows:

$$\text{Min: } S = \int_{x\varepsilon I} |x| \ |y(x)/x - \beta| dx \quad (7)$$
$$\beta$$

Let us define "I" as a closed interval [0,1]. The procedure may be applied to other intervals with no major problem (see, Hobby and Rice, 1965, Kripke and Rivlin, 1965, Usow, 1967a). To minimize this function we should first remove the absolute value sign of the expression after the integral sign. Since "x" belongs to a closed interval "I", both functions, y(x) (which is a linear function of "x") and y(x)/x are smooth and continuous. And since y(x)/x is a uniformly increasing or decreasing function of "x", a value of tεI can be found to have the following properties:

$$\begin{array}{ll} y(x)/x < \beta & \text{if } x < t \\ y(x)/x = \beta & \text{if } x = t \\ y(x)/x > \beta & \text{if } x > t \end{array} \quad (8)$$

The value of the slack variable "t" actually is the border of negative and positive residuals. If the value of "t" were known, when x=t, we could calculate the optimal value of "β". Nevertheless, neither "t" nor "β" are known. To solve, according to (8), we can rewrite (7) as two separate definite integrals with different upper and lower bounds.

$$\underset{\beta}{Min}\ S = -\int_0^t |x| \ (y(x)/x - \beta)dx + \int_t^1 |x| \ (y(x)/x - \beta)dx \quad (9)$$

Decomposition of (7) into (8) has been done by use of the slack variable "t". Since both "β" and "t" are unknown, to solve (9), we partially differentiate it with respect to "t" and "β".

$$\frac{\partial S}{\partial \beta} = \int_0^t |x|dx - \int_t^1 |x|dx = 0 \quad (10)$$

And using the Liebniz rule to differentiate the integrals with respect to their variable bounds "t", yields,

$$\frac{\partial S}{\partial t} = -|t|\left[\frac{y(t)}{t} - \beta\right] - |t|\left[\frac{y(t)}{t} - \beta\right] = 0 \quad (11)$$

Since "x" belongs to [0,1], equation (10) can be written as,

$$\int_0^t x dx - \int_t^1 x dx = 0 \quad (12)$$

Or,

$$\tfrac{1}{2}\, t^2 - \tfrac{1}{2} + \tfrac{1}{2} t^2 = 0 \quad (13)$$

This yields,

$$t = \sqrt{2}/2 \quad (14)$$

Substituting for "t" in equation (11), yields,

$$\beta = \frac{y(\sqrt{2}/2)}{\sqrt{2}/2} \tag{15}$$

Liniar Two Parameters Continuous L1 Norm Smoothing

Given that y(t) is function y(x) evaluated at x=t. Value of "β" given by (15) is the optimal solution of (6). The above procedure is in fact a generalization of the Laplace weighted median for continuous case. Before applying this to the Lorenz curve, let us develop the procedure for the linear two parameters model.

To apply the above technique to the linear two parameters model, rewrite (4) as,

$$\text{Min: } S=\|u\|_1=\|y(x)-\alpha-\beta x\|_1=\int_{x\varepsilon I} |y(x)-\alpha-\beta x|dx \tag{16}$$
$$\alpha,\beta$$

Where, "α" and "β" are two single (non-vector) unknown parameters, and y(x) and "x" are as before. According to Rice (1964c), let f(α*,β*,x) interpolates y(x) at the set of canonical points $\{x_i;i=1,2\}$, if y(x) is such that: y(x)-f(α*,β*,x) changes sign at these x_i's and at no other points in [0,1], then f(α*,β*,x) is the best L_1 norm approximation to y(x) (see also, Usow, 1967a). With the help of this rule, if we denote these two points to t_1 and t_2, we can rewrite (16) for I=[0,1] as,

$$S = \int_0^{t_1} [y(x)-\alpha-\beta x]dx - \int_{t_1}^{t_2} [y(x)-\alpha-\beta x]\, dx + \int_{t_2}^{1} [y(x)-\alpha-\beta x]\, dx \tag{17}$$

Since t_1 and t_2 are also unknowns, we should minimize S with respect to α, β, t_1 and t_2. Taking a partial derivative of (17) using Liebniz' rule with respect to these variables and equating them to zero, we will have,

$$\frac{\partial S}{\partial \alpha} = -\int_0^{t_1} dx + \int_{t_1}^{t_2} dx - \int_{t_2}^{t_1} dx = 0 \tag{18}$$

$$\frac{\partial S}{\partial \beta} = -\int_0^{t_1} dx + \int_{t_1}^{t_2} dx - \int_{t_2}^{t_1} dx = 0 \tag{19}$$

$$\frac{\partial S}{\partial t_1} = 2\left[y(t_1) - \alpha - \beta t_1\right] = 0 \tag{20}$$

$$\frac{\partial S}{\partial t_2} = -2\left[y(t_2) - \alpha - \beta t_2\right] = 0 \tag{21}$$

Equations (18) through (21) may be solved simultaneously for α, β, t_1 and t_2. Thus, we have the following system of equations,

$$2t_2 - 2t_1 - 1 = 0 \tag{22}$$
$$t_2^2 - t_1^2 - \tfrac{1}{2} = 0 \tag{23}$$
$$y(t_1) - \alpha - \beta t_1 = 0 \tag{24}$$
$$y(t_2) - \alpha - \beta t_2 = 0 \tag{25}$$

The solutions are:

$$t_1=1/4 \tag{26}$$
$$t_2=3/4 \tag{27}$$
$$\alpha = y(3/4)-(3/4)\beta = y(1/4)-(1/4)\beta \tag{28}$$
$$\beta = 2[y(3/4)-y(1/4)] \tag{29}$$

This procedure may be expanded to include "m" unknown parameters. Some computational methods for solving the different cases of "m" parameters models are investigated by Ptak (1958), Rice and White (1964), Rice (1964a, 1964b, 1964c, 1969, 1985), Usow (1967a), Lazarski (1975a, 1975b, 1975c, 1977) (see also, Hobby and Rice, 1965, Kripke and Rivlin, 1965, Watson, 1981). Now, let us have a look at the Lorenz curve and its proposed functional forms.

Continuous L_1 Norm Smoothing Of Lorenz Curve

The Lorenz curve for a random variable with probability density function f(v) may be defined as an ordered pair.

$$(P(V|V \le v), \frac{E(V|V \le v)}{E(V)}) \qquad v \in R \tag{30}$$

For a continuous density function f(v), (30) can be written as,

$$(\int_{-\infty}^{v} f(w)dw, \frac{\int_{-\infty}^{v} wf(w)dw}{\int_{-\infty}^{+\infty} wf(w)dw}) \equiv (x(v), y(x(v))) \tag{31}$$

Taguchi (1972a, 1972b, 1972c, 1973, 1981, 1983, 1987, and 1988) multiplies the second element of (30) by $P(V|V\le v)$; his definition of (31) is equivalent to ours. We denote (31) by the ordered pair (x(v),y(x(v))) where x(v) and y(x(v)) are its elements. Next, "x" is a function which maps "v" to x(v) and "y" is a function which maps x(v) to y(x(v)). The function y(x(v)) is simply the Lorenz curve function. For the explicit function for the Lorenz curve, we use the form introduced by Gupta (1984) and a modified version, which benefits from certain properties. Gupta (1984) proposed the functional form,

$$y= xA^{x-1} \qquad A>1 \tag{32}$$

The modified version of Bidabad and Bidabad (1989) suggests the following functional form:

$$y= x^{B}A^{x-1} \qquad B\ge 1,\ A\ge 1 \tag{33}$$

To estimate "A" of (32) or "A" and "B" of (33), we need discrete data from the population to construct x and **y** vectors. On the other hand, if the probability distribution of income is known, we can estimate the Lorenz curve by using the continuous L_1 norm smoothing method for continuous functions. To estimate the Lorenz curve parameters when the probability density function of income is known and integrable, we can find the functional relationship between the two elements of (31) by simple mathematical derivation. However, when integrals of (31) are not obtainable, we will follow another procedure.

Suppose that the income of a society is distributed using the probability density function f(w). This density function may be a skewed function, such as Pareto or log-normal, as follows:

$$f(w) = \theta k^{\theta} w^{-\theta-1}, \qquad w,k>0,\ \theta>0 \tag{34}$$

$$f(w) = [1/w\sigma\sqrt{(2\pi)}]\exp\{-[\ln(w)-\mu]^2/2\sigma^2\}, \qquad w\varepsilon(0,\infty),\ \mu\varepsilon(-\infty,+\infty),\ \sigma>0 \tag{35}$$

These two distributions are known as good candidates for representing distribution of personal income. In the case of the Pareto density function of (34), we can simply derive the Lorenz curve function as follows:

Let F(w) denote the Pareto distribution function:

$$F(w) =1-(k/w)^{\theta} \tag{36}$$

With mean equal to,

$$E(w)= \theta^{k}/(\theta-1), \quad \theta>1 \tag{37}$$

If we find the function y as stated by (31) as a function of x, the Lorenz function will be derived. Rearrange the terms of (31) as,

$$x(v) = \int_{-\infty}^{v} f(w)dw \tag{38}$$

$$y(x(v)) = \left[1/E(W)\right]\int_{-\infty}^{v} wf(w)dw \tag{39}$$

Substituting Pareto distribution function,

$$x(v) = F(v) = 1-(k/v)^{\theta} \tag{40}$$

$$y(x(v)) = [(\theta-1)/\theta^{k}] \int_{k}^{v} w\theta k^{\theta} w^{-\theta-1} dw \tag{41}$$

$$\text{Or} \quad y(x(v)) = 1-(k/v)^{\theta-1} \tag{42}$$

By solving (40) for "v" and substituting in (42), the Lorenz curve for Pareto distribution is derived as,

$$y = 1-(1-x)^{(\theta-1)/\theta} \tag{43}$$

For log-normal distribution, we proceed as follows:
According to (30) and (31) independent and dependent variables of (32) and (33) may be written as,

$$x(v) = \int_{o}^{v} f(w)dw \tag{44}$$

$$y(x(v)) = \left[1/E(W)\right]\int_{0}^{v} wf(w)dw \tag{45}$$

Substitute (44) and (45) in (32) and include the random error term u, we will have,

$$\left[1/E(w)\right]\int_{0}^{v} wf(w)dw = \int_{0}^{v} f(w)dw.\, A^{\int_{0}^{v} f(w)dw-1}.e^{u} \tag{46}$$

Or,

$$y(x) = x\, A^{x-1} e^{u} \tag{47}$$

Similarly for the model (35),

$$\left[1/E(w)\right]\int_{0}^{v} wf(w)dw = \left\{\int_{0}^{v} f(w)dw\right\}^{B}.\, A^{\int_{0}^{v} f(w)dw-1}.e^{u} \tag{48}$$

Or,

$$y(x) = x^{B} A^{x-1} e^{u} \tag{49}$$

Taking the natural logarithm of (47) and (49), gives,

$$\ln y(x) = \ln x + (x-1)\ln A + u \tag{50}$$

$$\ln y(x) = B.\ln x + (x-1)\ln A + u \tag{51}$$

With respect to the properties of a Lorenz curve and the probability density function of f(w) and equations (46) to (49), it can be seen that x belongs to the interval [0,1]. Thus, the L_1 norm objective function for minimizing (50) or (51) is given by

$$\underset{A}{Min} : S = \int_{0}^{1} |u| dx \tag{52}$$

Or,

$$\underset{A}{Min} : S = \int_{0}^{1} |\ln y(x) - \ln x - (x-1)\ln A| dx \tag{53}$$

Or,

$$\underset{A}{Min} : S = \int_{0}^{1} |x-1| \; \left|\left[\ln y(x) - \ln\right]/(x-1) - \ln A\right| dx \tag{54}$$

By a technique similar to the one used by (9), we can rewrite (54) as,

$$\underset{A}{Min}: S = \int_0^t |x-1|\{[\ln y(x) - \ln x]/(x-1) - \ln A\}dx - \int_t^1 |x-1|\{[\ln y(x) - \ln]/(x-1) - \ln A\}dx \quad (55)$$

Since, 0≤x≤1 we have

$$\underset{A}{Min}: S = \int_0^t [\ln y(x) - \ln x - (x-1)\ln A]dx + \int_t^1 [\ln y(x) - \ln x - (x-1)\ln A]dx \quad (56)$$

Differentiate (56) partially with respect to "t" and "A"

$$\frac{\partial S}{\partial A} = +\int_0^t [(x-1)/A]dx - \int_t^1 [(x-1)/A]dx = 0 \quad (57)$$

$$\frac{\partial S}{\partial t} = -2[\ln y(t) - \ln t - (t-1)\ln A] = 0 \quad (58)$$

From equation (57) we have,

$$t = 1 \pm \sqrt{2}/2 \quad (59)$$

Since "t" should belong to the interval [0,1], we accept

$$t = 1 - \sqrt{2}/2 \quad (60)$$

Substitute (60) in (58), and solve for "A", gives the L_1 norm estimation for "A" equal to

$$A = \left[\frac{1-\sqrt{2}/2}{y(1-\sqrt{2}/2)}\right]^{\sqrt{2}} \quad (61)$$

Now, let us apply this procedure to another Lorenz curve functional form of (33), as redefined by (51). Rewrite the L1 norm objective function (52) for the model (51),

$$\underset{A,B}{Min}: S = \int_0^1 |\ln y(x) - B\ln x - (x-1)\ln A|dx \quad (62)$$

Or,

$$\underset{A,B}{Min}: S = \int_0^1 |x-1|\|[\ln y(x)]/(x-1) - (\ln x)/(x-1) - \ln A|dx \quad (63)$$

The objective function (63) is similar to (16). Thus, by a similar procedure to those of (17) through (29), we can write "S" as,

$$\begin{aligned}\underset{A,B}{Min}: S &= \int_0^{t_1} |x-1|\{[\ln y(x)]/(x-1) - (\ln x)/(x-1)\ln A\}dx \\ &- \int_{t_1}^{t_2} |x-1|\{[\ln y(x)]/(x-1) - (\ln x)/(x-1) - \ln A\}dx \\ &+ \int_{t_1}^1 |x-1|\{[ly(x)]/(x-1) - (\ln x)/(x-1) - \ln A\}dx\end{aligned} \quad (64)$$

Since 0≤x≤1, (64) reduces to

$$\begin{aligned}\underset{A,B}{Min}: S &= -\int_0^{t_1} [\ln y(x) - B\ln x - (x-1)\ln A]dx + \int_{t_1}^{t_2} [\ln y(x) - B\ln x - (x-1)\ln A]dx \\ &- \int_{t_2}^1 [\ln y(x) - B\ln - (x-1)\ln A]dx\end{aligned} \quad (65)$$

Differentiate "S" partially with respect to "A", "B", t_1 and t_2,

$$\frac{\partial S}{\partial A} = \frac{1}{A}\left[\int_0^{t_1}(x-1)dx - \int_{t_1}^{t_2}(x-1)dx + \int_{t_2}^1 (x-1)dx\right] = 0 \quad (66)$$

$$\frac{\partial S}{\partial B} = \int_0^{t_1} \ln(x)dx - \int_{t_1}^{t_2} \ln(x)dx + \int_{t_2}^{1} \ln(x)dx = 0 \quad (67)$$

$$\frac{\partial S}{\partial t_1} = -2\{\ln[y(t_1)] - B\ln(t_1) - (t_1 - 1)\ln(A)\} = 0 \quad (68)$$

$$\frac{\partial S}{t_2} = 2\{\ln[y(t_2)] - B\ln(t_2) - (t_2 - 1)\ln(A)\} = 0 \quad (69)$$

The above system of simultaneous equations can be solved for the unknowns: t_1, t_2, "A" and "B". Equation (66) is reduced to,

$$t_1^2 - t_2^2 - 2(t_1 - t_2) - 1/2 = 0 \quad (70)$$

Equation (67) can be written as,

$$t_1(\ln t_1 - 1) - t_2(\ln t_2 - 1) - 1/2 = 0 \quad (71)$$

Calculate t_1 from (70) as,

$$t_1 = 1 \pm \sqrt{(t_2^2 - 2t_2 + 3/2)} \quad (72)$$

Since $0 \le t_1 \le 1$ we accept,

$$t_1 = 1 - \sqrt{(t_2^2 - 2t_2 + 3/2} \quad (73)$$

Substitute t_1 from (73) into (71), and rearrange the terms, gives,

$$\ln \frac{\left[1 - \sqrt{(t_2^2 - 2t_2 + 3/2)}\right]^{\left[1 - \sqrt{(t_2^2 - 2t_2 + 3/2)}\right]}}{t_2^{t_2}} + t_2 - 3/2 + \sqrt{(t_2^2 - 2t_2 + 3/2)} = 0 \quad (74)$$

We can compute the root of equation (74) by a numerical algorithm. For five digits decimal point, we have:

$$t_2 = 0.40442 \quad (75)$$

Value of t_1 is derived by substituting t_2 into (73),

$$t_1 = 0.07549 \quad (76)$$

Values of "B" and "A" are computed from (68) and (69) using t_2 and t_1 given by (75) and (76). Thus,

$$B = \frac{(t_2 - 1)\ln y(t_1) - (t_1 - 1)\ln y(t_2)}{(t_2 - 1)\ln(t_1) - (t_1 - 1)\ln(t_2)} \quad (77)$$

Or,

$$B = -0.84857 \ln[y(0.07549)] + 1.31722 \ln[y(0.40442)] \quad (78)$$

And,

$$A = [y(0.07549)]^{1.28986}[y(0.40442)]^{-3.68126} \quad (79)$$

Now, let us describe how equation (61) for the model (32) and equations (78) and (79) for the model (33) can be used to estimate the parameters of the Lorenz curve when the probability distribution function is known. For the model (32) we should solve (44) for "v" such that,

$$x(v) = \int_0^v wf(w)dw = 1 - \sqrt{2}/2 = 0.29293 \qquad (80)$$

By substituting this value of "v" into (45), value of $y(1-\sqrt{2}/2)$ is computed. This value is used to compute the parameter "A" given by (61) for model (32).
Similarly, for the model (33) we will find two values for "v" by solving:

$$x(v) = \int_0^v wf(w)dw = 0.07549 \qquad (81)$$

&

$$x(v) = \int_0^v wf(w)dw = 0.40442 \qquad (82)$$

These values of "v" are substituted in (45) to find y(0.07549) and y(0.40442). These values of "y" are used to compute the parameters of the model (33) by substituting them into (78) and (79).The computation of related definite integrals of x(v) defined by (80), (81) and (82), can be done by using the appropriate numerical methods.

Numerical Example

Suppose the sample mean and median of income distribution of the society are given. For calculation of the parameters of the Lorenz curve, the following notations have been coded for MathCAD 11.
Assume that the sample mean of income distribution of the society is: $60,000.
Assume that the sample median of income distribution of the society is: $40,000.

The standard deviation can be calculated as: $\sigma := \sqrt{2 \cdot \ln\left(\frac{\text{Mean}}{\text{Med}}\right)}$

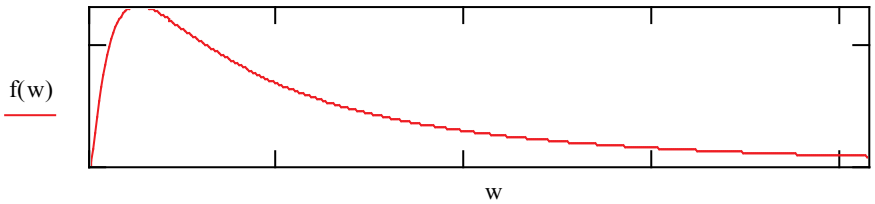
And, $\mu = \ln(\text{Med})$ such that, $\mu = 10.5966$, $\sigma = .9005$

Calculation of log-normal density function parameters based on sample mean and median is

log-normal Probability Density Function: $f(w) := \left(\frac{1}{w \cdot \sigma \cdot \sqrt{2 \cdot \pi}}\right) \cdot \exp\left[\frac{-(\ln(w) - \mu)^2}{2 \cdot \sigma^2}\right]$

For selective range for log-normal plot: $w := 10^{-5}, \frac{\text{Mean}}{200} .. 2 \cdot \text{Mean}$

Figure 2: log-normal plot



Precision Tolerance level TOL :=0.00001

TOL value can be changed for more accurate solutions (less TOL = higher precision).

For equation (45) we have: $y(v) := \left(\frac{1}{\text{Mean}}\right) \cdot \int_0^v w \cdot f(w)\, dw$

For equation (44) we have: $x(v) := \int_{0.00001}^{v} f(w)\,dw$

Calculation for Gupta Model:

Initial guess for v: $v := 20000$ It might be changed for faster convergence and less iterations.

For (60): $t_0 := 1 - \frac{\sqrt{2}}{2}$

Calculating v for (80): $v := \text{root}\left(x(v) - t_0, v\right)$, $v = 27136.6437$

y(t) $y(v) = 0.04208$ $z_0 := y(v)$

For (61): estimated A: $A := \left(\frac{t_0}{z_0}\right)^{\sqrt{2}}$ $A = 15.54768$

For (53): $S := \int_0^1 \left|\ln(z_0) - \ln(t_0) - (t_0 - 1)\cdot\ln(A)\right| dx$

Sum of absolute residuals: $S = 0$

Range of variable for plotting the Lorenz curves: $X := 0, 0.005 .. 1$

Gupta Lorenz curve: $Y(X) := X\cdot A^{X-1}$

Calculation of Gini coefficient: $Gini := 1 - 2\cdot\int_0^1 Y(X)\,dX$ $Gini = 0.51967$

Calculation for Bidabad Model:

For (76): $t_1 := 0.07549$

Initial guess for v: $v := 8000$ It might be changed for faster convergence and less iterations.

Calculating v for (81): $v := \text{root}\left(x(v) - t_1, v\right)$ $v = 9464.04318$

y(0.07549) $y(v) = 0.00442$ $z_1 := y(v)$

For (75): $t_2 := 0.40442$

Initial guess for v: $v := 27000$ It might be changed for faster convergence and less iterations.

Calculating v for (82): $v := \text{root}\left(x(v) - t_2, v\right)$ $v = 38826.25803$

y(0.40442): $y(v) = 0.07722$ $z_2 := y(v)$

For (79): $A := (z_1)^{1.28986}\cdot(z_2)^{-3.68126}$

For (78): $B := -0.84857\cdot\ln(z_1) + 1.31722\cdot\ln(z_2)$

Estimated A and B: $A = 11.41481$ $B = 1.22709$

For (62): $S := \int_0^1 \left|\ln(z_1) - B\cdot\ln(t_1) - (t_1 - 1)\cdot\ln(A)\right| dx$

Sum of absolute residuals: $S = 0.00002$

Range of variable for plotting the Lorenz curves: $X := 0, 0.005 .. 1$

Modified Lorenz curve: $Y(X) := X^{B} \cdot A^{X-1}$

Calculation of Gini coefficient: $Gini := 1 - 2 \cdot \int_0^1 Y(X)\, dX$ $\quad Gini = 0.51834$

INTRODUCTION OF IMPLIED-INEQUALITY-INDEX

In this section we introduce a new income inequality index. The redistribution policies must enumerate specific budget guidelines to promote a more equal income distribution in the society. Using our calculated implied-inequality-index, we show how much of a transfer payment is needed to achieve the desired distribution of income consistent with the perceived economic equality goals of the policy-maker. While there are alternative methods; there is no best way to calculate the inequality index .Most inequality indices concentrate on the statistical aspect of the distribution of income. That is, they generally analyze the distribution without inferring the amount of funds needed to correct the income inequality. First, we define our index. Second, we use a hypothetical numerical example to show how much money should be transferred from the upper income group to the lower income group to achieve the desired distribution of income.

Definition Of The Inequality Index

Suppose there is a personal income υ at which half of the total income of the population belongs to those who have an income less than υ, and the other half of the income belongs to those who have a higher income than υ. That is:

$$\int_{-\infty}^{v} wf(w)dw = \int_{v}^{+\infty} wf(w)dw \tag{83}$$

By definition, we have:

$$\mu = \int_{-\infty}^{+\infty} wf(w)dw = \int_{-\infty}^{v} wf(w)dw + \int_{v}^{+\infty} wf(w) \tag{84}$$

That is:

$$\int_{-\infty}^{v} wf(w)dw = \mu/2 \tag{85}$$

On the other hand:

$$\frac{\int_{-\infty}^{v} wf(w)dw}{\int_{-\infty}^{+\infty} wf(w)dw} = 1/2 \tag{86}$$

According to (31) this is a point on the Lorenz curve with the following ordered pair:

$$(\int_{-\infty}^{v} wf(w)dw, 1/2) \tag{87}$$

Thus, we define implied-inequality-index (iii) as $\int_{-\infty}^{v} f(w)dw$ when υ satisfies (83). That is,

$$iii = \int_{-\infty}^{v} f(w)dw \qquad \text{when v satisfies} \qquad \frac{\int_{-\infty}^{v} wf(w)dw}{\int_{-\infty}^{+\infty} wf(w)dw} = 1/2 \tag{88}$$

To find iii, (85) should be solved for υ and its value be replaced in (88). As iii approaches ½, distribution becomes more symmetric. If iii tends to 1, distribution tends to be fully right-skewed, indicating high (right) inequality and, as iii tends to 0, distribution tends to be left-skewed and distribution tends to high (left) inequality. The values of iii less than ½, however, have no economic implication for income distribution. Let us define the cost of equalization as:

$$C = [iii-½]\times N\times \mu \quad (89)$$

The above expression means that to equalize the distribution of income without changing the average income of the society, the amount of C should be transferred from higher income earner to lower income earner, where N and μ are the population size and average income of the society. We may normalize this index by dividing the equalization cost by total income of the society and find an inter-societies comparable index. That is:

$$\text{Relative cost of equalization} = [(iii-½)\times N\times \mu] / (N\times \mu) = (iii-½) \quad (90)$$

Numerical Example

To illustrate, the following table of income distribution for a hypothetical society is used. Consider a society of 400 households with total income of the society equal to $2,000, where 70% of the population (280 households) receives only half of the total income, and the remaining 30% (120 households) receive the other half. According to Table 1, we have:

$N = 400$	(Number of households)
$\upsilon = \mu = 2000/400 = 5$	(Average income)
$\mu_{lower} = 1000/280 = 3.57$	(Average income of lower category)
$\mu_{upper} = 1000/120 = 8.33$	(Average income of upper category)
$iii = 280/400 = 0.7$	(implied inequality index
$C = (0.7-0.5) \times 400\times 5 = \$400$	(Cost of equalization)

That is, if we collect a total tax of $400 from the top 30% of the population and transfer it to the lower 70% of income earners, the average income of both groups will be the same:

$(1000+400)/280 = (1000-400)/120 = 5$

Relative cost of equalization = 0.7-0.5 = 0.2

That is, the cost of such equalization is 20% of the total income of the society.

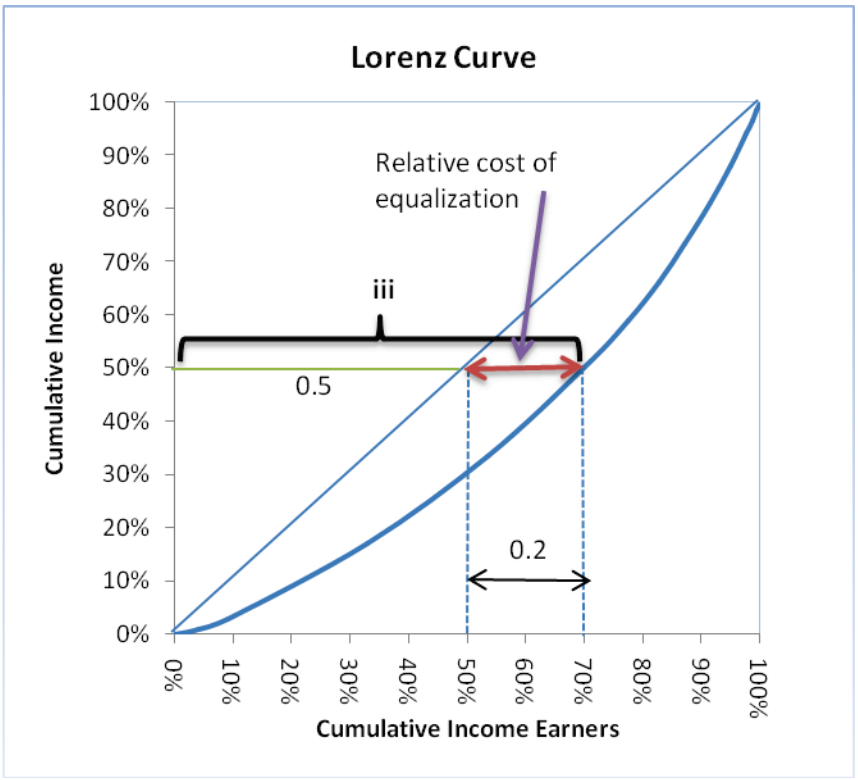
In Figure 3, we show the implied inequality index (iii) and the relative cost of equalization on the Lorenz curve. This is depicted by using columns (4) and (9) of Table 1.

Table 1: Income Distribution for a Hypothetical Society

Income w	Frequency f	Cumulative Frequency F	Relative Frequency	Relative Cumulative Frequency	Half Income Earner	w . f (1)*(2)	Cumulative Income	Relative Cumulative Income	Half Income
($)	(Numbers)	(Numbers)	(%)	(%)	(Numbers)	($)	($)	($)	($)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	17	17	4.3%	4.3%		17	17	0.9%	
2	20	37	5.0%	9.3%		40	57	2.9%	
3	95	132	23.8%	33.0%		285	342	17.1%	
4	82	214	20.5%	53.5%		328	670	33.5%	
5	66	280	16.5%	70.0%	280	330	1000	50.0%	1000
6	30	310	7.5%	77.5%		180	1180	59.0%	
7	21	331	5.3%	82.8%		147	1327	66.4%	
8	18	349	4.5%	87.3%		144	1471	73.6%	
9	17	366	4.3%	91.5%		153	1624	81.2%	
10	14	380	3.5%	95.0%		140	1764	88.2%	
11	11	391	2.8%	97.8%		121	1885	94.3%	
12	4	395	1.0%	98.8%	120	48	1933	96.7%	
13	3	398	0.8%	99.5%		39	1972	98.6%	
14	2	400	0.5%	100.0%		28	2000	100.0%	1000
	400		100%		400	2000			2000

In Table 1, column (1) depicts dollar values of income categories and column (2) shows the number or frequencies of households in each income category of column (1). Columns (3), (4) and (5) are for cumulative frequencies, relative frequencies and relative cumulative frequencies. Column (6) shows the number of lower and higher income earners. Column (7) shows the multiplication of the paired elements of the columns (1) and (2). Column (8) cumulates (7) and (9) shows the relative cumulative income. Column (10) shows half of the total income of the society.

Figure 3: Implied Inequality Index iii



This figure depicts the information of Table 1. The implied inequality index (iii) and relative cost of equalization are shown as corresponding parts of a Lorenz curv

CONCLUSION

Estimation of the Lorenz curve is fraught with difficulty. To circumvent this, we tried to estimate the functional form of the Lorenz curve by using continuous information. We employed the probability density function of population income to estimate the Lorenz function parameters by using the continuous L1 norm smoothing method. To have a better understanding of policy arrangements regarding the inequality of income distribution, it is not enough to know the conventional inequality indices. The redistribution policies need to deal with specific budget guidelines in order to lead society toward a position of greater equality. Obviously, there is no single "best" measure of income inequality. While there are alternative methods, there is no best way to calculate the inequality index, especially when concentrating on the fiscal view. That is, the existing methods generally analyze the distribution without inferring about the amount of funds needed to correct income inequality. In this paper, we introduced an implied inequality index, which satisfies these policy implications. We designed an implied inequality index as a fiscal guidepost to improve income distribution. In this paper, we only used the 50% point as the benchmark for our policy objective. This model can be extended to use quantiles or deciles points as equalization policy objectives. To do so, we need to derive the necessary formula for the model. These developments will improve the policy applications of the derived indices.

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MEASURING SERVICE QUALITY: PERCEPTIONS OF EMPLOYEES

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ABSTRACT

The purpose of this paper was to assess the service quality of a call centre as perceived by its employees using the SERVQUAL model. The paper focused on employees as internal customers and the critical role employees play in the delivery of quality service. The dimensions predicting front-line employee satisfaction and loyalty were explored. Data was collected by field study in a particular call centre in Mauritius using a modified SERVQUAL questionnaire. The study examined both perception and expectation levels of front-line employees. Regression models were used to test the influence of service quality dimensions on satisfaction and loyalty. The results indicated that loyalty was best predicted by overall satisfaction, tangibles and responsiveness. This study contributes to the understanding of service quality, satisfaction and employees' loyalty within a business process outsourcing organization.

JEL: M31

Keywords: Employee**,** Satisfaction, Loyalty, SERVQUAL, Call Centre, Mauritius

INTRODUCTION

The worldwide Business Process Outsourcing (BPO) market is growing rapidly and in Mauritius this sector is expected to grow into the fifth pillar of its economy. The country is aiming to become a cyber island so as to meet the demands of an ever changing economic environment. The Information Technology Enabling Services (ITES)-BPO industry in Mauritius is a relatively young and nascent sector, barely over five years old. The workforce in the ITES-BPO sector has recorded an increase of 26.2% over the period of 2006-2007 with the call centre industry still the highest generator of employment (Board of Investment, 2007). Since 2006, the government strategy is to attract higher value-added activities in the ITES-BPO field and generate $1 billion revenue from this sector. The government objective is also to expand and create as many as 20,000 jobs in the sector by 2008. To achieve the set goals, it is essential for this sector to effectively manage its resources.

In today's competitive markets, service organizations are continuously exploring different ways to gain sustainable competitive advantage. In the services marketing research, quality has received considerable attention has been to satisfaction and loyalty. Despite numerous studies linking service quality to customer satisfaction and customer loyalty, little empirical work has been done in assessing employee satisfaction and loyalty. Front-line employees (FLE) in call centre perform a crucial role in the delivery of frontline services, which is fundamental to the management of customer relationships (Frenkel *et al.*, 1998). Although the call centre industry is growing at a rapid rate, yet little is known about employee satisfaction with respect to service quality within this industry. Previous studies have observed that employee commitment and high levels of employees' turnover are issues of great concern in call centers (Deery, Iverson and Walsh, 2002; Malhotra and Mukherjee, 2004). Therefore it is essential to measure the perceptions of FLE in a service setting. Despite the large amount of research examining customer service, little attention has centered on the employees who are responsible for customer service processes in the service industries. Gabbott and Hogg (1998) suggested that the quality of the service encounter involves

two significant elements: service personnel and the service setting. Thus the purpose of this paper is to evaluate service quality and satisfaction among FLE in a particular call centre in Mauritius. More specifically, this study seeks: (1) to measure employees' expectations and perceptions of service quality based on the SERVQUAL model and (2) to examine service quality dimensions in predicting satisfaction and loyalty among FLE in call centre in Mauritius.

This paper provides a brief review on service quality, employee satisfaction and loyalty, followed by the research methodology and main results of the study. Finally conclusions and further research are outlined.

SERVICE QUALITY

Delivering quality service is considered to be an important strategy for success in today's competitive environment (Parasuraman *et al*., 1985; Reichheld and Sasser, 1990; Zeithaml *et al.*, 1990, 1996). According to Grönroos (1988), service quality is commonly defined as a discrepancy between the service quality that is delivered by the organization and the service performance that employees expect. Conceptually, service quality is defined as global judgment or attitude relating to the overall excellence or superiority of the service (Parasuraman *et al*., 1988). Parasuraman *et al*. (1985) developed the framework for measuring service quality, the gap theory. SERVQUAL is the most widely utilized tool for measuring service quality (Parasuraman *et al*., 1988; 1994; Sureshchandar *et al*., 2001; Chiu, 2002) and its application continues to increase in different service settings, such as banks (Jabnoun and Al-Tamimi, 2003), hospitality industry (Saleh and Ryan, 1992), health sector (Arasli *et al.*, 2008), education (Tan and Kek, 2004) and travel and tourism (Fick and Ritchie, 1991). The service quality model examines the discrepancy between the expectations and perceptions and is often referred to as a disconfirmation model (Oliver, 1980; Bitner, 1990). The initial 10 categories were (1) reliability; (2) responsiveness; (3) competence; (4) access; (5) courtesy; (6) communication; (7) credibility; (8) security; (9) understanding/ knowing; and (10) tangibles (Parasuraman *et al*., 1988). In 1988, they refined the SERVQUAL dimensions which collapsed to five dimension as follows: Tangibles (physical facilities, equipment, and appearance of personnel), Reliability (ability to perform the promised service dependably and accurately), Responsiveness (willingness to help customers and provide prompt service), Assurance (knowledge and courtesy of employees and their ability to inspire trust and confidence), and Empathy (caring, individualized attention the firm provides its customers). The SERVQUAL instrument for measuring service quality has been subjected to a number of criticisms. Researchers have criticized the SERVQUAL dimensions (Crompton and MacKay, 1989; Taylor *et al*., 1993 and Babakus and Boller, 1992) and they argued that the dimensions change with the type of service. Researches (Cronin and Taylor, 1992; Teas, 1993) have argued that there is no real evidence to support the concept of performance minus expectations gap as a basis for measuring service quality. Despite the criticisms, Parasuraman *et al.* (1991; 1994) contended that the SERVQUAL scale using the expectation/performance gaps method is a much richer approach to measuring service quality.

Relationship between Service Quality and Satisfaction

Studies in services marketing have shown that service quality and satisfaction are closely related constructs (Cronin and Taylor, 1992; Oliver, 1993; Babakus *et al.*, 2004). Employee satisfaction is an important factor in determining service quality (Zeithaml *et al.*, 1990). Satisfied employees are more committed to continuous improvement and quality (Matzler *et al.*, 2004), thus they are also more committed to delivering quality service. However, the interactive nature of service delivery places service employees in a very critical role in the delivery of quality services (Zeithaml and Bitner, 2000). Numerous studies also show that satisfied employees are highly motivated, have good morale at work, and work more effectively and efficiently (Eskildsen and Dahlgaard, 2000; Yoon and Suh, 2003). Research by Reichheld and Sasser (1990) suggest that the higher the degree of employee satisfaction, the greater the chance of customer satisfaction and customer retention. According to Schmit and Allscheid

(1995) satisfied employees will engage in better service delivery. Yoon, Beatty, and Suh (2001) found a significant linkage between front-line bank employees' satisfaction and customer-perceived service performance. Yee *et al.* (2008) empirically examined employee satisfaction through a survey of service shops in Hong Kong and found that employee satisfaction is significantly related to service quality and customer satisfaction, while the latter in turn influenced firms profitability. Employee satisfaction should not be ignored, yet very few businesses seriously consider employee satisfaction. According to Allred (2001) the most difficult step to service quality improvement usually involves developing consistent service performance from front-line employees. This study therefore is interested in investigating employee satisfaction as a function of service quality perceived by front-liners.

Relationship between Service Quality, Satisfaction and Loyalty

Service quality has been related to customer satisfaction and loyalty. Satisfaction often plays a mediating role between customer perceptions of service quality and the creation of behavioral intentions (Cronin and Taylor, 1992; Boulding *et al.*, 1993; Cronin, Brady and Hult, 2000). According to Zeithaml *et al.* (1996), behavioral intentions can be measured by repurchase intentions, word-of-mouth, loyalty, complaining behavior and price sensitivity. Customer loyalty can be defined and assessed by both attitudinal and behavioral measures. In practice, it is difficult to observe and measure action loyalty. Most researchers employ behavioral intentions, to measure the compromise of loyalty (Yang and Peterson, 2004). This study focused on intentions to stay and willingness to recommend as specific forms of loyalty.

Today service organizations are concerned in the delivery of quality service and the building of loyalty among employees and customers. If employees are not happy with the work, they are more readily to quit their jobs than satisfied employees. Researchers have found that satisfied employees are more likely to improve their job performance (Judge *et al.*, 2001), be creative and cooperate with others because satisfaction is the inner force that drives employee behavior. Previous studies have suggested that loyal employees are more willing and capable of delivering a higher level of service quality (Loveman, 1998; Silvestro and Cross, 2000). According to Schneider and Bowen (1985; 1993) the efforts to promote service quality must be based on managing employee behaviors and training them in interpersonal skills in order to exhibit a true customer focus. Bitner *et al.* (1990) observed that in service encounters, employee behavior will impact on the customer perceptions of service quality. Zeithaml *et al.* (1990) argue that employees who are not suited to their jobs will not be able to deliver quality service. Consequently having the right employees will enhance the likelihood of success for any enterprise. It is therefore crucial to understand employees' needs, demands and wishes and not only those of the customers (Edvardsson *et al.*, 1997). Conversely, employee satisfaction can improve productivity, reduce staff turnover and enhance creativity and commitment. Employees who are satisfied have higher intentions of staying with an organization and recommending the organisation to others. However, although a substantial amount of service quality research has focused on service customers' perceived service quality (Parasuraman *et al*., 1988; Carman, 1990; Parasuraman *et al.*, 1991; Babakus and Boller, 1992; Cronin and Taylor, 1992), relatively little attention has been paid to exploring what factors impact on service employees' behavior with regard to delivering service quality, and to articulating the predictors of employee behavior to service quality perception and satisfaction.

RESEARCH METHODOLOGY

Service quality from the employees' perspective in call centre has not been widely researched. This study seeks to fill that gap by adapting the SERVQUAL model to explore the factors predicting call centre employee satisfaction and loyalty. The items incorporated in the SERVQUAL model were modified to collect data from FLE (Appendix 1). The service firm examined for this study was a call centre located in the Business Park at Ebene in Mauritius. The research design was based on Parasuraman *et al*. (1988) five dimensions of service quality: responsiveness, reliability, assurance, empathy and tangible. Some

modifications were made to the items as 19 items were selected out of the SERVQUAL 22 items in order to suit the call centre service setting and to measure the expectations, perceptions and satisfaction of internal service levels of front-line employees. Each item was reworded to capture internal rather than external service quality. The questionnaire consisted of three sections. In the first section, demographic information about the respondents was captured. The second section was designed to measure the expectations (E) and perceptions (P) of the respondents according to the five service dimensions. Respondents were asked to rate their expectations and perceptions of each of the 19 items on a 5-point Likert scale ranging from "1 = strongly disagree" to "5 = strongly agree" as suggested by Babakus and Mangold (1992) and Johns *et al.* (2004). The final section was structured for the purpose of measuring employees' satisfaction with the call centre and subsequently their loyalty towards the organization. The study adopted the use of a single five-point item with endpoints "extremely dissatisfied" to "extremely satisfied" to measure FLE satisfaction and loyalty was assessed by two five-point items, namely intentions to stay and willingness to recommend the organization to others.

The developed questionnaire was pilot tested and no major problems were observed, but respondents suggested a few minor changes in the wordings of the instrument. The survey was administered to the FLE population of a particular call centre during a one-week period in March 2008. All employees in the call centre were invited to participate in the study. A total of 130 questionnaires and covering letters were distributed. In total, 90 were judged usable for data analysis for this study. The SPSS 14.0 for Windows was used to analyze the data. Descriptive statistics analysis was used to investigate the service quality gaps. A paired t-test was used to evaluate the internal service quality of the call centre. Gap measures were defined as the difference in scores between the rating of each perception measure statement and the rating of the corresponding expectation statement. Regression analyses were used to identify the SERVQUAL dimensions influencing overall satisfaction and FLE loyalty.

RESULTS

In this study, the ratio of male to female employees was 56 percent to 44 percent. More than 61% of the respondents were between the ages of 18-25 and it is observed that employees in the call centre are on average young. Approximately 83% have either School Certificate or Higher School Certificate as highest level of education and the majority (68%) has less than 1 year of service.

While the main objective of the study was to address the issue of FLE perceptions of service quality in a call centre, it also proved useful to test the use of the adapted SERVQUAL instrument for measuring service quality within this service setting. The reliability of the scale was tested using Cronbach's alpha. An alpha value of 0.904 was obtained indicating a good internal consistency for the 19 item scale. The mean scores and standard deviation for the 19 expectations and perceptions items are presented in Table 1 together with the mean service quality gaps.

Table 1 also presents the grand mean scores on the basis of the expectations, perceptions and gap for the five dimensions. The gap scores enable the service manager to understand current service quality and also to quantify gaps that exist. The t-statistics was calculated to test for the significance difference between expectations and perceptions. The gap scores for the five dimensions were all negative implying that FLE expectations were actually not being met. All the gap scores were statistically significantly different at $p < 0.05$. It is further observed that the gap scores for Reliability (-1.12) is significantly higher than the other dimensions, followed by the gap scores for Empathy (-0.80), Tangibles (-0.68), Assurance (-0.54) and Responsiveness (-0.51). The gap scores for Reliability could be used to prioritize systems and process improvements while the other four gap scores could be used to develop staff training programs and improve service environment. The overall gap score (-0.57) was statistically significantly different at $p < 0.05$, indicating that the overall service quality fell below the employees' expectations.

Table 1: Gap Mean Difference between Expectations and Perceptions

Description of Items	Mean Expectation Scores		Mean Perception Scores		Gap Scores (P-E)		t-value
	Mean	SD	Mean	SD	Mean	SD	
Reliability	**4.56**	**0.77**	**3.44**	**0.92**	**-1.12**	**0.81**	**-12.29**
When we promised to do something by a certain time, we do so	3.91	0.99	3.41	1.33	-0.50	1.36	- 3.32*
We show sincere interest on solving our customers' problems	3.46	0.97	3.25	1.02	-0.21	1.19	- 1.51
We perform services right the first time	3.90	0.69	3.20	1.24	-0.70	1.23	-5.02*
We provide services at the time required/ promised	3.67	1.14	3.42	1.16	-0.25	1.26	-1.79*
We provide correct /accurate information to our customers	4.09	0.77	3.92	1.03	-0.17	1.19	-1.23
Responsiveness	**3.89**	**0.66**	**3.39**	**1.06**	**-0.51**	**0.89**	**-5.06**
We provide prompt services to our customers	3.78	1.06	3.19	1.41	-0.59	1.17	-4.51*
We are always willing to help our customers	4.01	0.78	3.54	1.12	-0.47	1.16	-3.58*
We are never too busy to respond to our customers' request	3.89	0.91	3.43	1.16	-0.46	1.05	-3.87*
Assurance	**3.92**	**0.40**	**3.37**	**0.40**	**-0.54**	**0.78**	**-6.22**
Customers' behavior instill confidence in us	3.75	0.81	3.38	0.88	-0.37	1.16	-2.82*
We can be trusted by our customers	4.18	0.69	3.37	0.99	-0.81	1.35	-5.33*
We are consistently courteous to our customers	4.05	0.82	3.54	0.92	-0.51	1.44	-3.13*
We have the required knowledge to answer our customers' questions	3.70	0.82	3.20	0.99	-0.50	0.96	-4.58*
Empathy	**3.82**	**0.60**	**3.02**	**0.91**	**-0.80**	**1.02**	**-6.94**
We give individual attention to our customers	3.76	0.79	2.89	1.10	-0.87	1.10	-7.04*
We have our customers' best interest at heart	3.86	0.83	3.00	1.23	-0.86	1.53	-4.99*
We understand the specific needs of our customers	4.00	0.80	2.94	1.05	-1.06	1.26	-7.47*
We have convenient working hours	3.65	0.98	3.24	1.05	-0.41	1.45	-2.48*
Tangibles	**4.11**	**0.61**	**3.43**	**0.61**	**-0.68**	**0.95**	**-6.34**
We have up-to-date equipment	4.09	1.13	3.43	1.19	-0.66	1.56	-3.75*
The materials used in the workplace are visually appealing	4.43	0.78	3.48	1.22	-0.95	1.29	-6.54*
The work environment is comfortable and attractive	3.81	0.82	3.39	1.18	-0.42	1.28	-2.91*
Overall (Combined scores of 19 items)	**3.32**	**0.69**	**3.89**	**0.41**	**-0.57**	**0.66**	**-7.61***

Notes: Scores based on a five-point scale ranging from 1 = strongly disagree to 5 = strongly agree;
SD = Standard Deviation;
a Gap mean is defined as perception mean – expectation mean;
A negative gap indicates that customers perceived that internet banking service delivery did not meet their expectations;
*A positive gap indicates that customers perceived that internet banking service delivery exceeded their expectations; *Significant at p < 0.05*
Table 1 presents FLE perceptions, expectations and the gap scores for the five SERVQUAL dimensions. The scores show that FLE expectations were consistently higher than their perceptions for all the five dimensions, resulting in negative service quality gaps. This indicates that there is a need for service improvements in all service quality dimensions.

Relative importance of the SERVQUAL dimensions on overall satisfaction and loyalty

The focus of this study was the extent to which overall satisfaction and loyalty among FLE in call centre can be predicted; therefore regression models were used to determine these relationships. The regression models considered the SERVQUAL dimensions as independent variables and overall satisfaction and loyalty as dependent variables.

The adjusted R^2 of 0.304 indicates 30.4 percent of variances in FLE satisfaction can be predicted by the service quality dimensions (Table 2). Overall satisfaction is predicted by the four dimensions, with the exception of Tangibles. The results of the regression analysis showed that each coefficient carried negative signs. Reliability, Responsiveness, Assurance and Empathy appeared to be significant predictors of overall employee satisfaction. These negative coefficients mean decreasing level of satisfaction.

Table 2: Regression Analysis for FLE Satisfaction

Independent variable	Coefficient	Beta	t-vales
Constant	3.547		17.603[a]
Reliability	-0.170	-0.113	-0.608[a]
Responsiveness	-0.126	-0.092	-0.456[a]
Assurance	-0.400	-0.256	-1.577[a]
Empathy	-0.120	-0.268	-1.430[b]
Tangibles	-0.026	-0.020	-0.150

Note: R^2 = 0.304; [a] Significant at 0.01 level; [b] significant at 0.5 level

Table 2 shows the regression results of the five dimensions on FLE satisfaction. The table reveals that four of the five dimensions- 'Reliability', 'Responsiveness', 'Assurance' and 'Empathy' with the exception of 'Tangibles', were significant in predicting FLE satisfaction.

To further test employee loyalty measures against those of the SERVQUAL dimensions, additional regression analysis was conducted, using both employee satisfaction and SERVQUAL dimensions as predictors of intentions to stay and willingness to recommend the call centre to others. As it can be seen from Table 3, the regression is statistically significant. 36 per cent of the variation of loyalty could be explained by overall satisfaction and two of the five SERVQUAL dimensions, responsiveness and tangibles. The other SERVQUAL dimensions were not significant predictors of loyalty. It is surprising to note that tangibles of service did not contribute to overall satisfaction but contribute to willingness to recommend to others.

Table 3: Regression Analysis for Willingness to Recommend

Independent variable	Coefficient	Beta	t-vales
Constant	1.731		12.146[a]
Overall satisfaction	0.041	0.110	1.145[a]
Reliability	0.040	0.071	0.461
Responsiveness	0.239	0.464	2.793[a]
Assurance	-0.014	-0.024	-0.176
Empathy	0.116	0.261	2.366
Tangibles	-0.074	-0.154	-1.394[b]

Note: R^2 = 0.36; F = 6.759; [a] Significant at 0.01 level; [b] significant at 0.5 level

Table 3 shows that only 'Overall satisfaction', 'Responsiveness' and 'Tangibles' are significant in predicting loyalty among FLE. The other SERVQUAL dimensions were not significant predictors of loyalty.

DISCUSSION

The purpose of this study was to examine the relationships between the five SERVQUAL dimensions, overall satisfaction and their predictive power in terms of loyalty among FLE in a call centre setting. The SERVQUAL items used in the present study were modified so as to assess the internal service setting. The results showed that the FLE perceptions were consistently lower than their expectations. These negative gaps revealed that the internal service levels were below the FLE expectations of service quality and the call centre quality improvements require change in Mauritius. The SERVQUAL dimensions with the exception of tangibles have negative influence on overall employee satisfaction. This suggests that the service delivered by the FLE at the call centre do not necessarily result in higher levels of employee satisfaction. According to Berry and Parasuraman (1991) it is important to create job products that meet the needs of employees thus satisfying and motivating them.

The results of the regressions analyses showed that overall satisfaction, responsiveness and tangibles were significantly associated with employee willingness to recommend the call centre, and intentions to stay. Researchers suggest that employee attitudes such as satisfaction and intention to stay are developed through interaction with the work environment (Naumann, 1993). This study show that overall satisfaction is more important than the SERVQUAL dimensions when predicting employee willingness to recommend the call centre and their intentions to stay.

CONCLUSIONS AND LIMITATIONS OF STUDY

The study presented the findings of the expectations and perceptions of internal service quality for a call centre. According to Comm and Dennis (2000) employee satisfaction is vital because it will determine the success or failure of what the customer experiences. The SERVQUAL dimensions were found to have significant negative relationships with an employee's overall satisfaction. These findings should enable the manager to identify specific areas for performance improvement that should have a direct effect on employee satisfaction. Call centre employees also do not allow for tangible elements in assessing their level of satisfaction and managers must take this issue into account. They should direct their resources towards improving the human services rather than the tangibles element of their services. It is clear from this study that the SERVQUAL instrument can be modified to measure the quality of the internal customer. Assessing the service quality of FLE and understanding how the different dimensions influence overall service quality should enable service organizations to effectively and efficiently design the service delivery process, thus ultimately provide better service to the external customers.

There are some limitations in this study that need to be acknowledged. The results reported in the study are specific to a particular call centre, so the findings may be limited to this call centre only and might not represent the call centre service quality in the whole island. Further the study used a single-item employee satisfaction measure, multi-item perceptions may give different results. The five SERVQUAL dimensions of service quality were used in this study, further research may consider other dimensions of service quality that may have an indirect influence on employees' loyalty via overall satisfaction.

APPENDIX 1

Survey Questionnaire

Dear respondent
This questionnaire aims to collect data that will be used in academic research. The survey measures your expectations from an excellent BPO company and your actual performance as an employee of the BPO services. Please indicate the level of importance each statement has for you. Your comment is highly important to the analysis, and will be treated with anonymity and confidentiality. Thank you very much for your cooperation.

Part 2: Please tick the appropriate box below

1. Gender:
☐ Male ☐ Female

2. Marital Status:
☐ Single ☐ Married ☐ Divorced

3. Your age group:
☐ 18 – 25 ☐ 36 – 45 ☐ 55 +
☐ 26 – 35 ☐ 46 – 55

4. Highest level of education:
☐ School certificate Diploma ☐

☐ Higher School certificate ☐ Degree

☐ Others (specify :……)

5. How many years have you been working for this organisation?

☐ Less than 1 year ☐ 3 years < 5 years

☐ 1 year < 3 years ☐ > 5 years

6. What is your income range?

☐ Rs 5000 – Rs 9999

☐ Rs 10000 – Rs 14999

☐ Rs 15000 – Rs 19999

☐ Rs 20000 – Rs 24999

☐ More than Rs 25000

7. What is your position in this organisation?

☐ Call Agent ☐ Team Leader

☐ Data Entry Operator ☐ Supervisor

☐ Others (Please specify :…….....)

Part 2: Center column contains some attributes that as an employee, you would expect from an excellent BPO company. There are two scales on each side of this column, the one on the left measures your expectations and the one on the right measures your perceptions. Please read each attribute first and then circle the numbers in both scales that indicate your judgments. The corresponding values for the numbers are shown at the top of both scales.

When evaluating the service quality of an excellent BPO company as an employee, indicate the extent to which you agree or disagree with each statement using the scale 1 = Strongly disagree, 2 = disagree, 3 = Neither disagree nor agree, 4 = Agree and 5 = Strongly agree?					List of attributes	If you evaluated the services of the BPO company of which you are an employee, how would you rate the service for the attributes given in the center column using the scale 1 = Strongly disagree, 2 = disagree, 3 = Neither disagree nor agree, 4 = Agree and 5 = Strongly agree?				
Reliability										
1	2	3	4	5	When we promised to do something by a certain time, we do so	1	2	3	4	5
1	2	3	4	5	We show sincere interest on solving our customers' problems	1	2	3	4	5
1	2	3	4	5	We perform services right the first time	1	2	3	4	5
1	2	3	4	5	We provide services at the time required/ promised	1	2	3	4	5
1	2	3	4	5	We provide correct /accurate information to our customers	1	2	3	4	5
Responsiveness										
1	2	3	4	5	We provide prompt services to our customers	1	2	3	4	5
1	2	3	4	5	We are always willing to help our customers	1	2	3	4	5
1	2	3	4	5	We are never too busy to respond to our customers' request	1	2	3	4	5
Assurance										
1	2	3	4	5	Customers' behavior instill confidence in us	1	2	3	4	5
1	2	3	4	5	We can be trusted by our customers	1	2	3	4	5
1	2	3	4	5	We are consistently courteous to our customers	1	2	3	4	5
1	2	3	4	5	We have the required knowledge to answer our customers' questions	1	2	3	4	5

When evaluating the service quality of an excellent BPO company as an employee, indicate the extent to which you agree or disagree with each statement using the scale 1 = Strongly disagree, 2 = disagree, 3 = Neither disagree nor agree, 4 = Agree and 5 = Strongly agree?					List of attributes	If you evaluated the services of the BPO company of which you are an employee, how would you rate the service for the attributes given in the center column using the scale 1 = Strongly disagree, 2 = disagree, 3 = Neither disagree nor agree, 4 = Agree and 5 = Strongly agree?				
Empathy										
1	2	3	4	5	We give individual attention to our customers	1	2	3	4	5
1	2	3	4	5	We have our customers' best interest at heart	1	2	3	4	5
1	2	3	4	5	We understand the specific needs of our customers	1	2	3	4	5
1	2	3	4	5	We have convenient working hours	1	2	3	4	5
Tangibles										
1	2	3	4	5	We have up-to-date equipment	1	2	3	4	5
1	2	3	4	5	The materials used in the workplace are visually appealing	1	2	3	4	5
1	2	3	4	5	The work environment is comfortable and attractive	1	2	3	4	5
Satisfaction										
1	2	3	4	5	Overall I am satisfied with the services of the BPO company	1	2	3	4	5
Loyalty										
1	2	3	4	5	I intend to stay with this BPO company	1	2	3	4	5
1	2	3	4	5	I will recommend this BPO company to someone who seeks my advice	1	2	3	4	5

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DISPARITIES BETWEEN SERVICES DEMANDED AND SERVICES RECEIVED IN TAIWANESE RESTAURANTS

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ABSTRACT

The aim of this study is to evaluate the service quality performance of Taiwanese foreign restaurants. After a review of the literature on service quality and discussions with managers of Taiwanese foreign restaurants, we decided to use the DINERSERV questionnaire. The methodology, an Importance-Performance Analysis (IPA), is used to categorize whole service items into four dimensions: 1) "keep up the good work", 2) "possible overkill", 3) "low priority", and 4) "concentrate here", all in accordance with the service performance of each service item. The critical findings indicate that Taiwanese foreign restaurants should improve upon the following seven service items: the parking lot around the restaurant (I2), regular updates to the menu (I8), comfortable seating (I11), fast service (I18), waiters' problem-solving ability (I20), waiters' understanding of customers (I27), and always putting the customer first (I28). The results of the study are discussed, along with the implications for managers of Taiwanese foreign restaurants.

JEL: C10; M10; M31

KEYWORDS: Taiwan; SERVQUAL

INTRODUCTION

Service quality is the major driving force for business sustainability, and in today's competitive global marketplace, it is recognized that high quality service is essential for the success of the firm (Ismail et al., 2006). Furthermore, service quality measurement plays an important role in assessing service performance, diagnosing service problems, managing service delivery, and determining employee and corporate rewards (DeMoranville & Bienstock, 2003). Therefore, evaluating quality performance and searching for ways to improve is critical for service-oriented businesses, especially those operating in a foreign country.

In Taiwan, an increasing number of people have begun to emphasize health and privacy (Chen & Chen, 2008). Therefore, more and more service-oriented businesses have developed, both domestic and foreign alike. Recently, a number of foreign restaurants have appeared in Taiwan, especially in Taipei City. Thus, how to become more attractive and survive in such a competitive market has become a critical issue for them. In this regard, we chose the most famous night market in Taipei City, known as the Shida night market, to conduct our research; it is also the site of a large cluster of foreign restaurants.

The remainder of this paper is organized as follows. The literature review is discussed in Section 2. Data and methodology are discussed in Section 3. Results are detailed in Section 4. Concluding comments are discussed in the last section.

LITERATURE REVIEW

Service Quality and Its Measurement

Service quality is an interaction between customers and service providers, with service providers trying to influence customers' perceptions and the image of the carriers (Gursoy et al., 2005). Therefore, service quality can be defined as a consumer's overall impression of the efficiency of the organization and its services (Park et al., 2004) or as a chain of services in which the entire service delivery is divided into a series of processes (Chen & Chang, 2005) (although definitions vary from one study to another.)

The importance of service quality to the overall performance of an organization has been well established in various industries (Wilkins et al., 2007). A review of the literature indicates that high service quality leads to customer satisfaction (Cronin & Taylor, 1992; Teas, 1994; Parasuraman et al., 1994; Caruana, 2002), and that customer satisfaction leads to customer loyalty (McDougall & Levesque, 2000; Wilkins et al., 2007). In addition, research has increasingly focused attention on customer service and how to upgrade the quality of external service encounters between contact employees, such as waiters, and customers (Stanley & Wisner, 2002).

A huge body of literature is based on the concept of service quality as perceived and evaluated by customers (Berry et al., 1988; Parasuraman et al., 1988; Gronroos, 1990). Some studies point out that service quality is difficult to quantify due to the very nature of service itself (Stanley & Winsner, 2002). The most used customer-perceived service quality model is SERVQUAL, which was developed by Parasuraman et al. (1985). SERVQUAL has five dimensions: reliability, responsiveness, assurance, empathy, and tangibles. Detailed information regarding the five dimensions is presented in Table 1, which was summarized by Ismail et al. in 2006.

Table 1: Descriptions of the Dimensions of SERVQUAL

Dimensions	Description
Reliability	The ability to perform the promised service dependably and accurately.
Responsiveness	The willingness to help customers and to provide prompt service.
Assurance	Employees' knowledge and courtesy, and their ability to inspire trust and confidence.
Empathy	The caring individualized attention given to customers.
Tangibles	Appearance of physical facilities, equipment, personnel, and written materials.

This table shows the detailed definitions of five measurement dimensions of SERVQUAL.

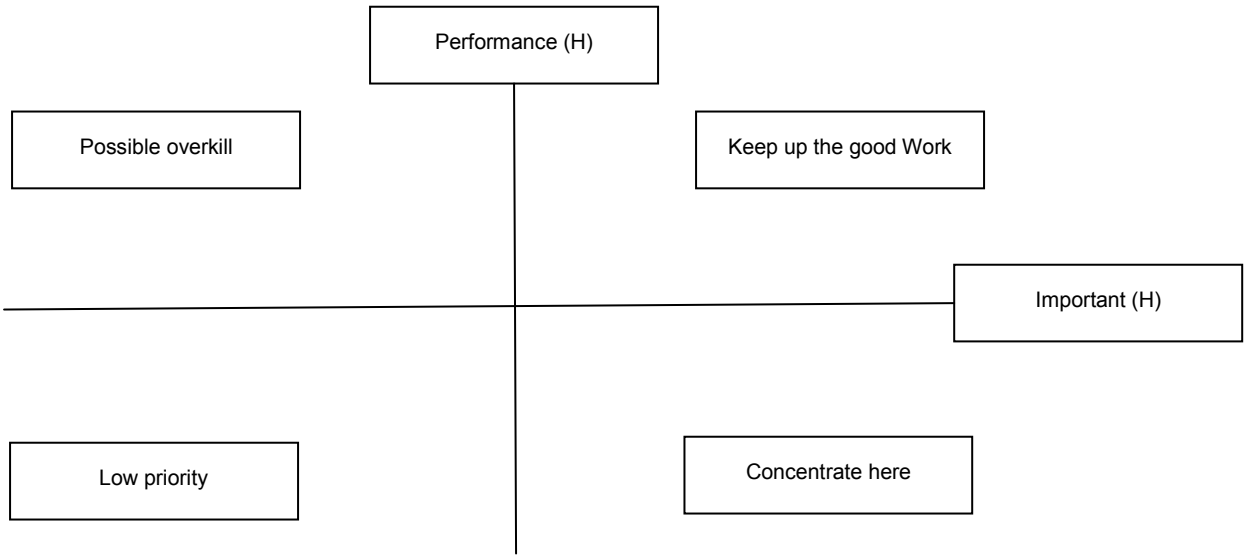
Nonetheless, there is a recent and growing body of literature that argues that the dimensions identified are not transferable from one industry to another; hence, there is a lack of support for the applicability of the SERVQUAL dimensions to a restaurant, especially a foreign one. A specific application for the restaurant, called DINERSERV, has been adopted to fit the characteristics of restaurants based on SERVQUAL, and uses similar dimensions (Steven et al., 1995). In order to present more accurate results, DINERSERV was used in this research.

Importance-Performance Analysis (IPA)

The methodology, IPA, is mainly used to evaluate the competitive advantages of an organization in the market, identify improvement opportunities, and guide the development of strategic projects for a firm (Deng, 2007). IPA was first proposed by Martilla and James in 1977 to identify which product or service items are more beneficial to a firm and which items should be improved to increase customer satisfaction (Matzler et al., 2004). Data from customer satisfaction surveys or service quality surveys are used to develop a two-dimensional matrix, where importance is depicted along the x-axis and performance (some have also used the term "satisfaction") is depicted along the y-axis. Importance is measured using some form of explicit statements of importance, such as rating scales or constant sum scales. It is also measured implicitly through multiple regression weights, structural equation modeling weights, or partial correlation weights (Deng, 2007). The mean values of performance and importance separate the matrix into four parts, as shown in Figure 1.

In accordance with each dimension, performance (customer satisfaction) can be seen as a major or minor strength or weakness. The dimensions where both performance and importance are high, called "keep up the good work", represents those opportunities for maintaining a competitive advantage and are therefore major strengths. The dimension where performance is high and importance is low, called "possible overkill", represents those areas where additional business resources committed to these service items would be overkill and should be deployed elsewhere and are therefore minor strengths.

Figure 1: Importance-Performance Analysis (IPA) Model



This figure shows the model of Importance-Performance Analysis (IPA) which proposed by Martilla and James in 1977 to identify which product or service items are more beneficial to a firm and which items should be improved to increase customer satisfaction.

The dimension where performance and importance are low, called "low priority", represents those areas that are minor weaknesses and do not require additional effort. Lastly, the dimension where performance is low and importance is high, called "concentrate here", represents those areas on which the organization needs to focus immediate attention for improvement and are therefore major weaknesses. A firm that cannot identify these dimensions may threaten its competitive advantages in the market and develop low customer satisfaction (Deng, 2007).

Due to the rising competition between foreign restaurants in Taiwan, how to fulfill Taiwanese customers' needs plays a critical role in determining the success or failure of restaurants that are also facing domestic restaurants. Thus, IPA was adopted to identify Taiwanese customers' perceptions of the importance of service items and to measure the level of satisfaction toward existing foreign restaurants.

DATA AND METHODOLOGY

The aim of this study was to measure the quality performance of foreign restaurants in Taiwan. After reviewing the literature and interviewing managers of foreign restaurants, we decided to use the most famous questionnaire that focuses on the service quality of restaurants, DINERSERV (shown in Table 2). We then constructed an appropriate sample, with a total of 1000 questionnaires sent to customers who enter foreign restaurants to have their meals. Of the 1000, 503 were returned and after discarding 192 questionnaires for statistical reasons, the overall response rate was 31%, or a total of 311 questionnaires used for analysis.

Seventy percent of the respondents are male and 30% were female; 33% of the respondents are between 31-40 and 28% are 41-50; more than half (56%) of the respondents have a Bachelor's degree and about 29% have a Master's degree or above; 31% of respondents are public servants and 26% serve in the business industry; about 33% of respondents received 60001-80000 NT dollars each month and 27% of respondents received 40001-60000 NT dollars each month. Detailed demographic information is given in Table 3.

Before proceeding with the factor analysis, we calculated the Kaiser-Meyer-Olkim (KMO) measure of sampling adequacy to be 0.821 for DINERSERV measurement items. The results of the Bartlett test of sphericity are shown in Table 4. Major factor analysis was also conducted with orthogonal rotation, and the results are provided in Table 4. Generally, the overall Cronbach's α should be above 0.7 and each dimension's Cronbach's α should be above 0.6; the study's inner and outer Cronbach's α for both dimensions are above this standard, which suggests that the sampling results are reliable (see Table 5). As to validity, we went through the interviews with managers of foreign restaurants to adjust items for use in DINERSERV; thus, the study fits the content validity requirement (Kaiser, 1974). Besides, because the significance of the correlations of most of measurement items with respect to the overall measurement are above 0.5, it reveals that the study has high construct validity (see Table 6).

In addition to this analysis, to assess the importance and satisfaction perceptions of customers, the study adopted a paired t-test analysis, the results of which are presented in Table 7. The *p*-values of all measurement items are significant ($p < 0.05$), which indicates a huge gap between the perception of importance and satisfaction in customers' mind. Thus, foreign restaurants still have room to improve their service quality. Lastly, from the results of Table 7, we used IPA to explore the results of the combinations of importance and satisfaction as perceived by customers. We then made the total means (4.025, 3.371) of both dimensions a midpoint; further, we separated the area into four areas based on the midpoint of importance (x-axis) and performance (i.e.; satisfaction, y-axis) as shown in Figure 2.

Table 2: Research Structure

Goal	Measurement Dimensions	Measurement Items
DINERSERV for Taiwanese Foreign Restaurant	Tangible	The appearance of restaurant is conspicuous (I1)
		Parking lot around restaurant (I2)
		The eating area attracts customers (I3)
		Waiters' dress is clean and neat (I4)
		The restaurant's décor fits the price (I5)
		The content of the menu is easy to understand (I6)
		The design of the menu is attractive (I7)
		The content of the menu updates regularly (I8)
		The eating area is clean and comfortable (I9)
		The restroom is clean (I10)
		The seating is comfortable (I11)
	Reliability	Mistakes are corrected soon as they occur (I12)
		Service is reliable (I13)
		The bill is accurate (I14)
		Balance the books quickly (I15)
		Waiters rarely provide the wrong meals to customers (I16)
	Responsiveness	Waiters support each other when busy (I17)
		Timely service (I18)
		Timely response to unique requests from customers (I19)
	Assurance	Waiters have problem-solving abilities (I20)
		Waiters are reliable (I21)
		Waiters can introduce the content of the menu in detail (I22)
		Waiters provide security to customers (I23)
		Waiters are well-trained and experienced (I24)
	Empathy	Waiters do not ignore customer questions due to company regulations (I25)
		Waiters consider the needs of customers in advance (I26)
		Waiters show understanding for customers at all times (I27)
		Always put the customer first (I28)

This table shows our research structure for later utilization.

Table 3: Demographic Information

Variable	Item	Distribution	Percentage
1. Sex	(1) Male	217	70%
	(2) Female	94	30%
2. Age	(1) Under 20	66	21%
	(2) 21- 30	40	13%
	(3) 31- 40	103	33%
	(4) 41- 50	87	28%
	(5) 51- 60	9	3%
	(6) Above 61	6	2%
3. Educational	(1) Junior High or Less	18	6%
Degree	(2) High School	30	10%
	(3) Bachelor's	174	56%
	(4) Master's and Above	89	29%
4. Occupation	(1) Student	58	19%
	(2) Public Servant	95	31%
	(3) Industry	24	8%
	(4) Business	81	26%
	(5) Agriculture	0	0%
	(6) Freelancer	16	5%
	(7) Housekeeper	13	4%
	(8) Others	24	8%
5. Income	(1) Under 20,000	35	11%
(Monthly)	(2) 20,001- 40,000	42	14%
(NT Dollars)	(3) 40,001- 60,000	84	27%
	(4) 60,001- 80,000	103	33%
	(5) 80,001- 100,000	29	9%
	(6) Above 100,001	18	6%

This table shows the detailed demographic information of this study.

RESULTS

The questionnaire used in this study is based on DINERSERV, which focuses on measuring the service quality of restaurants. The original dimensions are Tangibles, Reliability, Responsiveness, Assurance, and Empathy. After using factor analysis, all dimensions remained the same (see Table 4). For all service quality measurement items, the analysis of the distance between importance and satisfaction reveals that in customers' minds, there exists a huge gap between those items that are important and those items that are satisfactory (see Table 7). Hence, there is room for foreign restaurants to improve their service quality.

To customers, the top three items of importance are: 1) the eating area is clean and comfortable (I9); 2) the restroom is clean (I10); and 3) the customer is always put first (I28). On the other hand, the top three items for which customers are most satisfied are: 1) waiters' dress is clean and neat (I4); 2) the bill is accurate (I14); and 3) waiters rarely provide the wrong meals to customers (I16) (see Figure 2).

The IPA results reveal that foreign restaurants may need to improve upon the following seven items: 1) the parking lot around restaurant (I2); 2) regular updates to the content of the menu (I8); 3) the seating is comfortable (I11); 4) timely service (I18); 5) waiters have problem-solving abilities (I20); 6) waiters show an understanding for customers at all times (I27); and 7) the customer is always put first (I28). However, the following nine are their competitive advantages: 1) the waiters' dress is clean and neat (I4); 2) the restaurants' decor fits the price (I5); 3) the eating area is clean and comfortable (I9); 4) the restroom is clean (I10); 5) mistakes are corrected as soon as they occur (I12); 6) each service is reliable (I13); 7) the bill is accurate (I14); 8) waiters rarely provide wrong meals to customers (I16); and 9) timely responses to unique requests from customers (I19). Detailed information is provided as Figure 2.

Table 4: Result of Factor Analysis

New Dimensions	Items	Variance explained (%)	Total variance explained (%)	Kaiser-Meyer-Olkin	Chi-Squared
Tangible	1	42.248	42.248	0.821	2741.580***
	2				
	3				
	4				
	5				
	6				
	7				
	8				
	9				
	10				
	11				
Reliability	12	6.898	49.146		
	13				
	14				
	15				
	16				
Responsiveness	17	6.816	55.962		
	18				
	19				
Assurance	20	6.519	62.481		
	21				
	22				
	23				
	24				
Empathy	25	5.808	68.289		
	26				
	27				
	28				

This table shows the results of the Bartlett test of sphericity and factor analysis of this study. *** $p<0.001$

Table 5: Cronbach's α for Importance and Performance of Each Dimension

Dimensions	Cronbach's α of Importance	Cronbach's α of Performance
Tangible	0.8356	0.8690
Reliability	0.8175	0.8643
Responsiveness	0.8186	0.8429
Assurance	0.8075	0.8015
Empathy	0.8777	0.8895
Total	0.9337	0.9452

This table shows the result of the reliability analysis of this study. It reveals that the study has high construct validity.

CONCLUDING COMMENTS

Due to rising competition, how to go about attracting more customers by improving service quality has been one of crucial issues for service-oriented businesses. In addition, more and more foreign restaurants have recently developed in Taiwan, particularly in Taipei City. Hence, for such restaurants, knowing which service items are more critical in Taiwanese customers' minds and how customers feel about their service quality in recent years is much more important for them to be able to improve service quality. After a review of the literature on service quality and discussions with managers of Taiwanese foreign restaurants, we decided to use the DINERSERV questionnaire. The methodology, an Importance-Performance Analysis (IPA), is used to categorize whole service items into four dimensions:

1) "keep up the good work", 2) "possible overkill", 3) "low priority", and 4) "concentrate here", all in accordance with the service performance of each service item.

Based on the results, the study provides three suggestions for top managers of foreign restaurants: increase the professionalization of waiters, improve customer-oriented operations, and increase the size of the parking lot. The first suggestions are for top managers to train his/her employees to support each other even while busy, or make many groups to promote work specialization. In doing so, the professionalization and speed of waiters will improve. The results reveal that waiters are not servicing in a customer-oriented way. Because customer satisfaction will lead to customer loyalty, waiters need to service in a customer-oriented manner. The study suggests that top managers need to empower waiters so they will know how to solve customers' problems when they arise. Alternatively, top managers can develop a "most welcoming waiter of the week" to motivate employees to service in a customer-oriented manner. When a waiter wins the contest, he or she can acquire a bonus.

Table 6: The Correlation List of Importance and Performance for Each Dimension

Dimensions	**Items**	**Important**		**Satisfaction**	
		Corrected Item-Total Correlation	Alpha if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
Tangible	1	0.3244	0.7993	0.5061	0.8492
	2	0.1788	0.8287	0.2938	0.8662
	3	0.4235	0.8330	0.6343	0.8517
	4	0.6670	0.8045	0.5632	0.8592
	5	0.5810	0.8145	0.5598	0.8595
	6	0.5695	0.8159	0.6263	0.8526
	7	0.4516	0.8331	0.6040	0.8550
	8	0.3753	0.7966	0.4157	0.8553
	9	0.5489	0.8186	0.6544	0.8498
	10	0.7685	0.7899	0.6962	0.8444
	11	0.5557	0.8186	0.6395	0.8511
Reliability	12	0.6842	0.7612	0.6452	0.6495
	13	0.5777	0.7906	0.4353	0.7308
	14	0.7005	0.7005	0.3940	0.7427
	15	0.5442	0.5442	0.6135	0.6634
	16	0.5531	0.5531	0.4846	0.7142
Responsiveness	17	0.5179	0.1242	0.6722	0.8153
	18	0.5324	0.1091	0.7703	0.7194
	19	0.4139	0.2780	0.6855	0.8042
Assurance	20	0.6594	0.7167	0.5827	0.7643
	21	0.6599	0.7094	0.6637	0.7438
	22	0.3909	0.7957	0.5976	0.7618
	23	0.5863	0.7351	0.5515	0.7749
	24	0.5299	0.7545	0.5575	0.7730
Empathy	25	0.6359	0.8716	0.7044	0.8774
	26	0.7911	0.8109	0.7833	0.8481
	27	0.7271	0.8356	0.7951	0.8464
	28	0.7675	0.8194	0.7634	0.8579

This table shows the result of correlation analysis of importance and performance for each dimension.

The second suggestion reflects the result of the study that points to menu updates being too slow or even showing no change; in addition, some of customers feel that they are uncomfortable while eating. Thus, the study suggests that top managers send chefs out to learn new techniques or hire more chefs to be able to brainstorm and come up with new and innovative ideas. The third suggestion is that foreign restaurants can partner with surrounding parking lots and therefore increase the desirability of the restaurant for customers who drive their cars.

Although the study tries to make the content, structure, and method of this research detailed and objective, there are some limitations that we could not avoid. Outside of Taipei City, there are many cities in Taiwan that have foreign restaurants. Even within Taipei City, there are some outside of the Shida night market. Thus, the results of this study cannot represent the entirety of the foreign restaurant market in Taiwan. In addition, there are many kinds of foreign restaurants. The study is conducted based on several kinds that exist in the Shida night market; however, any one type may be represented by a small sample. Thus, we faced a dilemma when deciding the sample.

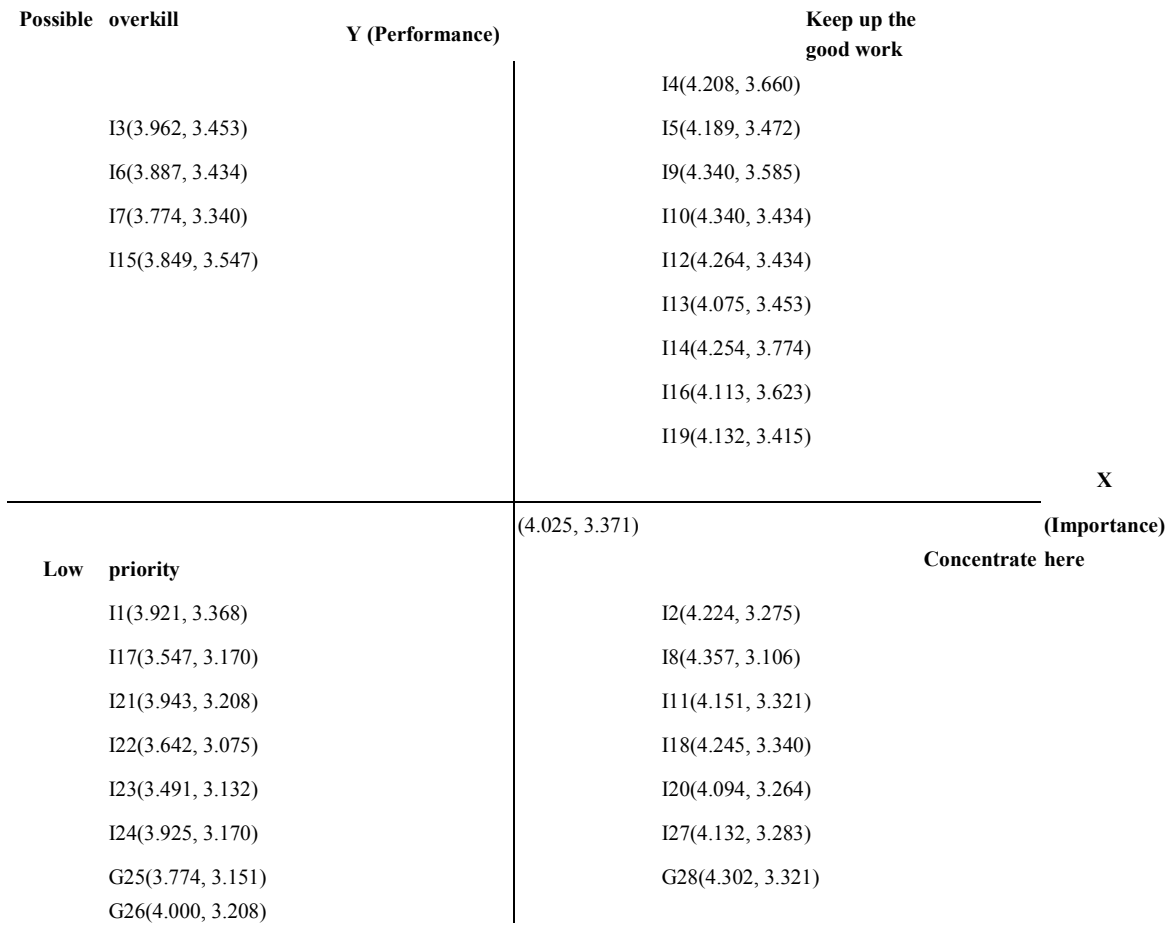
Given the limitations, the study suggests that future studies focus on certain types of foreign restaurants and extend the region within Taiwan to conduct their research. Future studies may result in more precise suggestions for foreign restaurants to improve service quality.

Table 7: The Result of Paired t-Test of Importance and Performance for Each Dimension

Dimensions	Items	Mean of Importance	Mean of Performance	t-Test	p-Value
Tangible	1	3.66	3.43	4.164	0.000***
	2	3.25	2.92	4.098	0.000***
	3	3.96	3.45	5.626	0.000***
	4	4.21	3.66	2.992	0.004**
	5	4.19	3.47	3.322	0.002**
	6	3.89	3.43	6.621	0.000***
	7	3.77	3.34	6.439	0.000***
	8	3.21	3.09	5.749	0.000***
	9	4.34	3.58	6.463	0.000***
	10	4.34	3.43	5.017	0.000***
	11	4.15	3.32	3.767	0.000***
Reliability	12	4.26	3.43	2.173	0.034**
	13	4.08	3.45	4.338	0.000***
	14	4.25	3.77	2.507	0.015*
	15	3.85	3.55	7.291	0.000***
	16	4.11	3.62	5.896	0.000***
Responsiveness	17	3.55	3.17	7.769	0.000***
	18	4.25	3.34	7.018	0.000***
	19	4.13	3.42	4.334	0.000***
Assurance	20	4.09	3.26	3.045	0.004**
	21	3.94	3.21	5.123	0.000***
	22	3.64	3.08	4.513	0.000***
	23	3.49	3.13	5.624	0.000***
	24	3.92	3.17	6.979	0.000***
Empathy	25	3.77	3.15	6.823	0.000***
	26	4.00	3.21	4.164	0.000***
	27	4.13	3.28	4.098	0.000***
	28	4.30	3.32	5.626	0.004**

This table shows the result of paired t-Test of importance and performance for each dimension of this study. The result reveals that there is a huge gap between the perception of importance and satisfaction in customers' mind. *: P<0.05; **: P<0.01; ***: P<0.001

Figure 2: The IPA Result of This Study



This figure shows the overall result of this study which presented based on Importance-Performance Analysis (IPA) model.

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EVIDENCE ON EFFORTS TO ALIGN ORGANIZATIONAL STRUCTURES AND BUSINESS STRATEGIES

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ABSTRACT

This paper is based upon a research study to determine the significance of managerial leadership practices in a corporation's transformation during the period from 2004 to 2008. The study attempted to discover how managerial leadership practices effectively advance horizontal integration of an inclusive and collaborative organization. The study was grounded on propositions involving organizational development roles, IT governance, and collaborative organizations. Triangulated inquiry from peer-reviewed documents and a survey of 24 participants who included 2 women and 22 men comprising a chief information officer, 7 functional managers, 8 project managers, and 8 engineers of a corporation in the Northeastern United States confirmed the propositions. The findings indicated that horizontal integration has begun in transition from being separate toward becoming collaborative. This paper will reveal how disparate images that are subculture bound could be enhanced by the Full Spectrum Leadership model involving collaborative and integrative leadership practices.

JEL: M15

KEYWORDS: IT Management, business strategy

INTRODUCTION

Organizations today utilize different strategies to promote growth and stability within its internal and external operations. Within these strategies are two types of integration that occur in businesses: horizontal and vertical. Vertical integration refers to the organization's control of business activities; this can be an increase or decrease of product or service distribution (Vidal, 2008). Horizontal integration, on the other hand, can mean internal or external expansion within the organization. This can be the result of a merger or expansion of other organizations to help improve the existing organization's product offering (QuickMBA.com, 2007). For the purpose of this article, the horizontal integration of an organizational structure and business strategies will be discussed.

Palepu, Healy, and Bernard (2000) suggested that business strategies that lend themselves to the ultimate decision to merge with, or acquire any organization include: (1) taking advantage of economies of size (2) improving target management (3) combining complementary resources (4) capturing tax benefits (5) providing low cost financing to a financially constrained target (6) increasing product market. Horizontal integration should enable a firm to expand its products and existence geographically throughout the United States and international to enhance the economies of scale. In addition, the firm's resources can be shared and reused internally and externally to improve economies of scope. Furthermore, the firm's market power can be increased through partnerships. The firm can relocate factories in foreign countries to lower labor and operating cost; thus increasing its profitability and reach to the consumers.

However, horizontal integration can pose challenges due to cultural differences within companies acquired (QuickMBA.com, 2007; Schein, 2004). Companies may have different financial and technical applications and business practices which are impractical to maintain due to cost effectiveness, yet difficult to consolidate due to cultural and organizational differences. Thus, horizontal integration does

not always provide effective economies of scope because of redundant structures and differences of applications and practices.

The organization that will be used as an example in this article is named SYNERGY. This is a real organization located in New Jersey. To maintain confidentiality and privacy of this organization, a pseudonym was used as an example. SYNERGY is a pseudonym for an engineering company located in the Northeastern United States. SYNERGY is the "mother" organization that controls the activities of five companies. Each company has independent information technologies, lines of business, and working cultures. Each product has its own applications and processes. The companies have different cultures (Schein, 2004), organizational structure, and geographical locations throughout the United States. To satisfy customers and stakeholder relationships and to enhance its competitive advantage, SYNERGY has integrated its organizational units into a single enterprise to achieve common systems, applications, and processes. SYNERGY has named this organizational transition horizontal integration. The horizontal integration is the consolidation of product lines, financial systems, and engineering applications and processes. The goal is to reduce discrepancies, eliminate redundancies, and improve organizational performance.

An example of a known company that practices horizontal integration is GAP. Similar to SYNERGY, GAP controls three clothing companies: Banana Republic, the Old Navy, and the GAP company. Each company has its own target population and market focus; yet, as a whole, it takes control of the big retail clothing industry (Spies, n.d.)

LITERATURE REVIEW

The literature review explicates the study's theoretical framework and presents propositions involving organizational development, IT governance, and collaborative organization. The goal is to understand how organizations promote horizontal integration.

Organizational Development Roles

Chen and Latendresse (2003) indicated that knowledge growth, information exchange, and competition in business happen at a rapid pace and that IT projects must not fail to accommodate these requirements. When an IT project fails, an entire business may fail. Top management should be a proponent of an IT project and understand the importance of the project in order to allocate adequate resources to see the project to conclusion. N. Evans and Hoole (2005) noted an IT executive can establish organizational development roles to promote business-IT fusion.

IT Governance

The objective of IT governance research is to achieve strategic alignment between business and IT to ensure that IT investment delivers value to business. Haes and Grembergen (2005, 2006) provided a summary of previous research on IT governance. For example, Gardner mentioned IT governance improvement for the first time in 2003. Grembergen (2002) emphasized that IT governance can promote the fusion of business and IT if the board, executive management, and management formulate and implement IT strategies. Nagel and Rietveld (2004) introduced 11 reasons firms need to implement IT governance. The reasons include reduced IT costs, business continuity, centralization of IT services, synergy, security success rate for IT projects, the possibility for outsourcing, added value of IT, market dynamics, legislation and compliance, and external pressure. Table 1 presents the rationale and percentage ranking for IT governance.

Table 1: Rationale and Percentage Ranking for IT Governance

Rationale	*Ranking*
Reduction in information technology costs	74
Business continuity	68
Centralization of information technology services	62
Synergy	52
Security	50
Success rate of information technology projects	48
Outsourcing	45
Added value of information technology	41
Market dynamics	39
Legislation and compliance	26
External pressure	15

Adapted from Nagel and Rietveld (2004).

Information technology governance should include a mixture of processes, structures, and relational mechanisms (Haes & Grembergen, 2005). If these elements are not designed and coordinated well, fusion will not be promoted. If firms have IT governance in place but do not have the necessary processes, structures, and relational mechanisms in place, IT governance will not be optimized or implemented properly.

Collaborative Organization

Firms implement relationship management to build and improve customer relationships for the sake of competitive advantage (Eriksson & Mattsson, 2002). Relationship management is expanded to partners and subcontractors domestically and internationally (Griffith, 2002). Hunt and Morgan (1994) explained that firms must meet changing requirements to compete and grow. This requires firms to cooperate with their partners and work effectively with their network of organizations. The synergy of networking and partnering can only be created and maintained through relational exchanges, trust, and commitment in relationship marketing (Hunt & Morgan). In addition, service quality has become an important attribute for competitive advantage (Hitt, Katsuhito, & Kochhar, 2000). Service quality reflects customer satisfaction, especially when service quality aims to strengthen relationship management for competitive advantage.

Dibb and Meadows (2001) posited that relationship management can provide good financial products to customers. Coughlan, Lycett, and Marcredie (2004) believed that relationship management could promote fusion between business and IT. Coughlan et al. asserted that collaboration is the key element for aligning business and IT activities and improving business performance. However, collaboration is hard to achieve in a large organization. Therefore, relationship management becomes a useful mechanism to manage and maintain business and IT collaboration and activities.

DATA AND METHODOLOGY

The research techniques included surveying 24 professionals who include 2 women and 22 men, a CIO, 7 functional managers, 8 project managers, and 8 team members involving 8 stakeholders. Two SYNERGY nonparticipants were asked to review and comment on the survey questions prior to their administration to ensure the questions are relevant to the study's purpose and objectives. In addition to surveying, a sample of the company's relevant artifacts such as charters, statements, annual reports, business plans, IT projects, and management structures and processes was examined, analyzed, and interpreted in accordance with themes developed in the propositions. The artifacts illustrate organizational activities and reflect the context of reorganizing, integrating, consolidating, and transforming the business-IT structures and processes relative to business-IT fusion. The charters, statements, annual reports, and messages were obtained from SYNERGY's archive.

The managerial leadership effectiveness demonstrated during the horizontal integration was measured in terms of how well organizational development roles, IT governance, and relationship management were established. To measure these constructs, the survey questions were designed in the form of a Likert-type scale (Likert, 1932) to measure frequencies of organizational development roles, IT governance, and relationship management attributes provided by the stakeholders. Likert-type scales were used to quantify results and obtain shades of perceptions. Choices or categories of responses ranged from strongly disagree to strongly agree. As the categories moved from one to the next, for example from strongly disagree to agree, the value increased by one unit.

The levels of leadership effectiveness were measured in terms of how well organizational structures and business processes were successfully consolidated and integrated. To measure these constructs, a sample of the company's relevant artifacts such as charters, statements, annual reports, business plans, IT projects, and management structures and processes were examined, analyzed, and interpreted in accordance with themes developed in the propositions. The goal was to gather the elements of a good story and generate useful findings about processes and outcomes for those who must make decisions about horizontal integration (Patton, 2003).

Instrumentation

This qualitative evaluation using a case study design was a "triangulated inquiry" (Patton, 2002, p. 66). A triangulated inquiry refers to a combination of several data sources converging on a single construct of managerial leadership practices about horizontal integration (Hilton, 2002). The data sources included survey data and strategic and operational plans, charters, annual reports, statements, IT projects, and management structures. The multiple data sources provided different perspectives about how managerial leadership practices contribute to a decrease in the business-IT gap. A triangulated data source can minimize "deficiencies intrinsic to a single-investigator, single-site, single-theory, single method, or single-unit of analysis" (Hilton, p. 2).

The triangulated inquiry focuses on understanding the perspectives of participants and audiences (Patton, 2002). The Likert-type scales and open-ended questions are presented in Appendix A. The sequence of questions formulated in the survey addressed the research problems and objectives. The survey questions provide traceability and "pattern matching" (Campbell, as cited in Yin, 2003, p. 26) that establish the logic that links the survey data to specific propositions. Pattern matching follows a systematic approach and method that indicates connections between theories and case study propositions.

Pattern matching allows for comparisons between the findings of the study and the findings of previous studies to identify new insights and knowledge. A systematic approach for process tracing was used to eliminate irrelevant patterns. Relevant patterns are expected to reflect qualitative findings from the survey and other artifacts. Process tracing involves statistical analysis including frequency distributions, percentages, means, standard deviations, and statistical manipulations in order to arrive at more conclusive findings and conclusions.

The survey questions were designed in the form of a Likert-type scale to measure frequency distribution, percentages, means, and standard deviations of the organizational development roles, IT governance, and relationship management attributes. The results are presented in tabular formats so that correlations and relevant models are established. The survey comments and open-ended questions provided a platform for the stakeholders to speak their voice (Patton, 2003). A sample of charters, statements, annual reports, business plans, IT projects, and management structures and processes illustrated organizational activities that reflect organizational cultures and management practices during the horizontal integration. The purpose was to establish logical links from the organizational models to the propositions. Table 2 shows the relationship between the data sources, purposes, and instruments.

Table 2: The Relationship of Data Sources, Purposes, and Instruments

Data source	Purpose	Instrument
SYNERGY stakeholders	Focus on specific propositions to answer the first research question "how managerial leadership practices effectively advance business-IT fusion of an inclusive and collaborative organization" and determine the business-IT interrelations	Likert-type scales and comments
SYNERGY stakeholders	Focus on stakeholders' voice to answer the second research question "how business-IT fusion affect risks and profitability" and provide recommendations to improve business-IT fusion	Open-ended questions
Annual reports, PowerPoint slides for program and technical operations, key messages, process and tools newsletters, and IT architecture framework	Focus on additional insights about managerial leadership practices to answer both research questions	Documents

Data Collection

Data collection included the following: (a) key stakeholders as participants, (b) a survey with participants to evaluate managerial leadership practices and to recommend strategies for business-IT fusion, and (c) reviews of company documents for evidence of managerial leadership practices and new insights. Stakeholders were identified based on key programs and business-IT units.

E-mail, telephone, or face-to-face meetings were used for the survey. The participants received an explanation about the survey, purpose, schedule, benefit, risk, confidentiality, and who and what were involved. After the participants agreed to participate in the survey, they received the survey questions as an e-mail attachment or as a hard copy with an agreement of a specific schedule for the survey to be completed and returned. The survey questions were used to collect data and included a Likert-type scale and open-ended questions. All hard-copy responses from the participants were kept in a safe box and all electronic responses were stored on a secure computer. Appendix A shows the survey instrument. A sample of SYNERGY's charters, statements, messages, annual reports, business plans, IT projects, and management structures and processes were obtained from SYNERGY's archive. All data were stored in a database.

Data Analysis

The survey included Likert-type scales and open-ended questions that were documented and analyzed as an aid to understanding the participants' perspectives. A sample of SYNERGY's charters, annual plans, reports, statements, organizational structures, and program processes were obtained and analyzed to examine how management implemented the horizontal integration. Data reduction techniques such as transcription procedures using an Excel spreadsheet and Statistical Package for Social Science (SPSS) software tools were used for statistical manipulation. Data from the Likert-type scale survey and the open-ended questions and a sample of SYNERGY's artifacts were analyzed and coded for interpretation (Creswell, 2002).

Likert-Type Scale Data

The Likert-type scale survey was designed to answer the first research question, namely, how managerial leadership practices effectively advance business-IT fusion of an inclusive and collaborative organization. The Likert-type scale data were entered into Excel spreadsheets for loading into SPSS. The data were

tabulated by the number of responses per scale and transferred to SPSS to generate tabulated reports of distributions and trends.

The Likert-type scale survey measured frequency distribution, percentages, means, and standard deviations of the organizational development roles, IT governance, and relationship management attributes. The mean indicates the average answer direction and standard deviation indicates the average distance from the mean. A low standard deviation indicates that observations cluster around the mean. A high standard deviation indicates that variations in the answers exist. A zero standard deviation suggests that responses to a question are the same.

The Likert-type scale survey was coded to the nominal accept and reject levels by combining all agree and disagree answers. The Likert-type scale ranged from 1 to 5 and the scale is presented as follows: 1, *strongly disagree*; 2, *disagree*; 3, *neutral*; 4, *agree*; and 5, *strongly agree*. The score for each response was computed by multiplying each frequency count to the scale (1 to 5) and adding them together. The highest percentage score and the lowest score are computed and presented as the following:

The highest percentage score $X = 24 \times 5 = 120$ (where 24 = number of participants and 5 = strongly agree)

The lowest percentage score $X = 24 \times 1 = 24$ (where 24 = number of participants and 1 = strongly disagree)

Thus, the X score of each response could be computed by applying the following formulas:
$X = Y\,(120/100)$ or $X = 1.2Y$,

where X is a score and Y is a percentage score between the lowest score and the highest score. When all participants strongly agree with a question, it has the highest score. Conversely, when all participants strongly disagree with a question, it has the lowest score.

Comments, Open-Ended Questions, and Document Data

The comments and open-ended questions provided a platform for the stakeholders to speak their voice (Patton, 2003) and provide new insights. The goal was for the stakeholders to answer the second research question, namely, how business-IT fusion affect risks and profitability. Moreover, the open-ended questions were designed to solicit participants' recommendations about how to solve the business-IT gap and how to improve organizational performance.

A sample of charters, statements, annual reports, business plans, IT projects, and management structures and processes illustrated SYNERGY's activities during the horizontal integration and reflected organizational cultures and managerial leadership practices. The purpose was to evaluate what management did and how management consolidated five companies. Moreover, the purpose was to establish logical links from the organizational models to the propositions. According to Creswell (2002), qualitative data should be organized and developed into themes for interpretation. Creswell presented the following coding process for qualitative data:

1. Preparing, organizing, and exploring the data
2. Explaining and establishing themes from the data
3. Depicting and communicating the findings
4. Interpreting the findings
5. Corroborating the relevancy of the findings

The comments from the open-ended questions and data from the documents were organized and developed into themes reflecting the propositions. Component parts, their relations, and meanings in making up the propositions were established. Key words, synonyms, and frequency counts were developed using NVivo software to identify patterns to answer the research questions and reveal new knowledge. Figure 1 presents the process that guided the analysis of the survey and the development of a code for interpretation. In addition, Table 3 presents the questions that guided the development of themes from the data.

RESULTS

Key business, programs, process, and IT stakeholder interpretations of the activities involving horizontal integration were collected using survey that reflected the findings of previous studies from A. Evans (2003), N. Evans (2004a, 2004b), N. Evans and Hoole (2005), Haes and Grembergen (2005, 2006), and Coughlan et al. (2004). The data pertaining to organization development roles, IT governance, and collaborative organization were analyzed for purposes of determining managerial leadership practices enabling the horizontal integration. The survey data, comments, and open-ended questions list participatory characterizations, and the documentary data list activities pertaining to horizontal integration. As the documents presented the horizontal integration structures, process, and activities, they reflected managerial leadership practices during the horizontal transformation. The documents indicated the horizontal integration activities for propositional corroboration or disputation and inference (Yin, 2003).

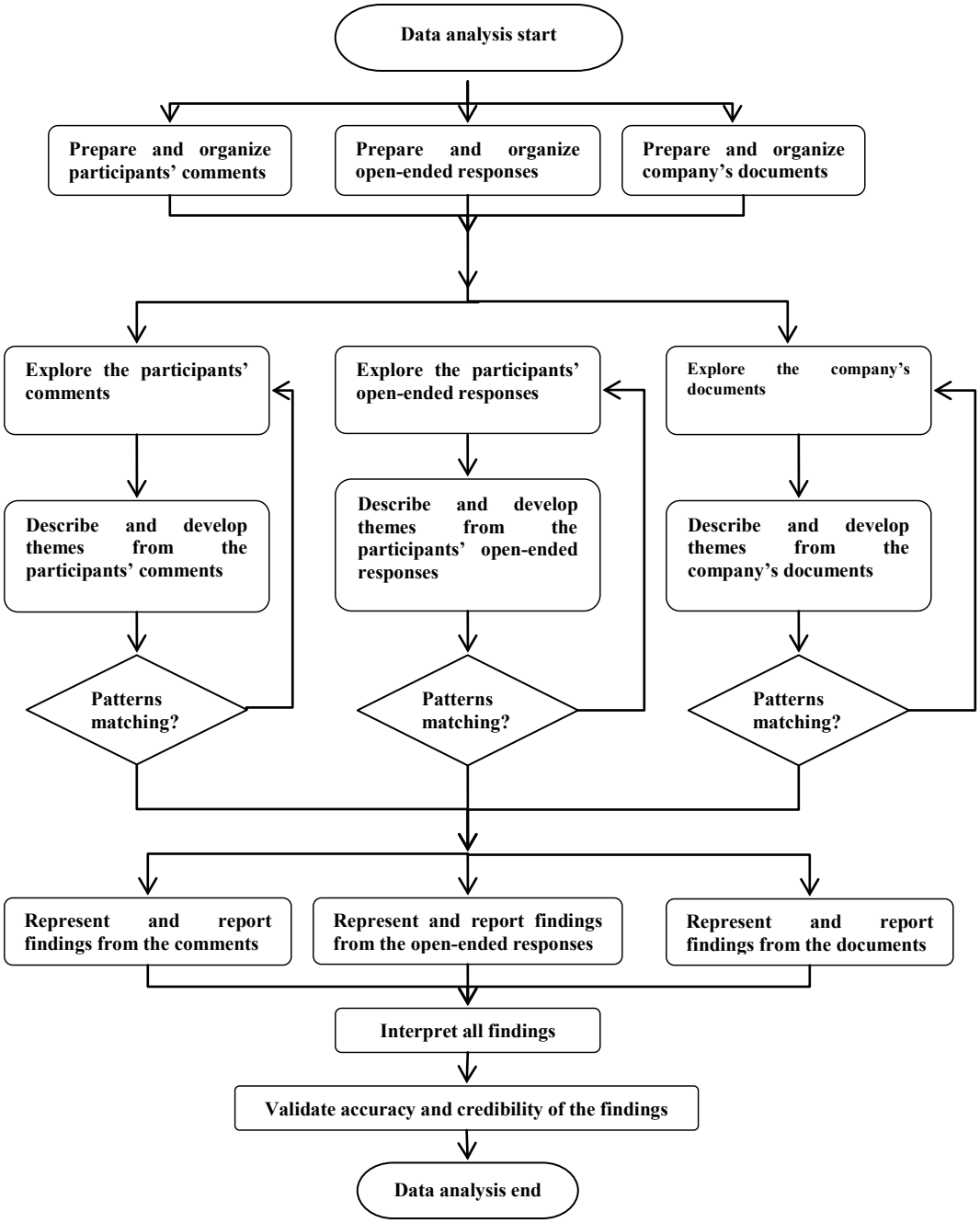
The horizontal integration involved more than designing better applications and processes and intended to improve organizational performance and involved better management. However, organizational development roles were not properly addressed during the horizontal integration of system development processes. Knowledge between organizational units and programs was not effectively transferred. Trust, collaboration, and relationship management were not emphasized. Information technology was unable to create environments that allow the business units to make rational decisions for the horizontal integration. Meaningful governance mechanisms were not defined and the success of projects was due largely to the efforts of the individual contributors. Effective leadership principles were needed at all levels of responsibility, enabling IT participation in a program's proposal phase.

Table 3: Guide: Analysis of Qualitative Data

Questions	Purposes
What is the whole? What are component parts of the whole? What are their relations? What are the substances?	Organizing and exploring the data for analysis
What are the key words?	Identifying the themes from the data
What are the synonyms?	Developing the themes from the data
What are the frequency counts?	Linking and developing the sub-themes
What are the patterns?	Matching the findings to previous studies
Do the patterns match the propositions?	Confirming the findings
Do the patterns answer the research questions?	Validating the credibility of the findings
What are the new patterns?	Identifying the new patterns and knowledge
What is the new model for future research?	Constructing a new model

Adapted from Creswell (2002) and Yin (2003).

Figure 1: Analysis of the survey and development of a code for interpretation (adapted from Creswell, 2002 and Yin, 2003).



With some apparent orientation toward establishing horizontal integration teams and chartering and bolstering some integration activity across different sites, some common tools and processes have become standards. Stakeholders apparently held positive views of the horizontal integration activity. The documentary coding data indicated integration activity crossed aspects of synergy. The documents indicate some horizontal integration teams were formulated to lead integration activities across different sites to take advantage of resources and skill sets to provide the best solutions to complex challenges. Trade studies were conducted to define common tools and standard processes.

The findings of this qualitative evaluation using a case study method have revealed the significance of managerial leadership practices of SYNERGY's horizontal transformation between 2004 and 2008 and shown how horizontal integration could enhance organizational performance. Using a qualitative evaluation case study approach, the research comprised an examination of SYNERGY's horizontal integration grounding on studies by Evans and Hoole (2005), Haes and Grembergen (2005, 2006), and Coughlan et al. (2004) to determine the effectiveness of the horizontal integration. In terms of the horizontal integration, effective implementation of horizontal integration requires managerial leadership that pays attention to ethical considerations (Donaldson, 2000; Evans & Jewels, 2005) promoting an inclusive organization.

The horizontal integration of disparate systems, applications, and processes that corroborated the studies of N. Evans and Hoole (2005), Haes and Grembergen (2005, 2006), and Coughlan et al. (2004) should show the following: (a) IT executives can design organizational development roles to improve organizational effectiveness, (b) the board and executives can design IT governance to guide and support processes and structures to meet organizational development roles, (c) organizational leaders can promote collaborative organization to support relationship management, (d) good working relationships between business and IT reduce business-IT gaps, and (e) shared ownership and responsibilities between business and IT contribute to risk mitigation, ROI, and organizational performance.

Within the study, answers to the question regarding how well N. Evans and Hoole (2005), Haes and Grembergen (2005, 2006), and Coughlan et al. (2004) described qualities of business-IT fusion in the horizontal integration setting were found. Although the horizontal integration was apparently not wholly transformed from a disparate organization, there is evidence that inclusivity and diversity in regards to leadership and managerial practices contributed to horizontal integration effectiveness.

Multiple horizontal integration teams were established to define common processes and common framework to consolidate different applications and processes. However, subculture conflicts and disparate applications and processes posed challenges. Because the horizontal integration was to involve better management and to improve organizational performance, consolidating or designing better applications and processes was one of several facets to enhance such performance. Other organizational issues such as cultural and human aspects should be properly addressed during the horizontal integration of system development processes to allow knowledge to be transferred between organizational units and programs. Although the horizontal integration was apparently not wholly transformed from a disparate organization, there seems to have been positive and improving risk mitigation and ROI.

From 2004 to 2008, SYNERGY has continued to transform from five individual operating companies into one integrated organization. SYNERGY has implemented cross-site relationships by developing Horizontal Integration Teams and common processes that support the strategic plan. SYNERGY has leveraged its people, technology, and processes to support the growth strategy. SYNERGY established up a cross-enterprise engineering organization to transition from a site and line of business-based functional organization to an engineering discipline-based organization with cross site centers. This change was focused on improving engineering consistency and discipline, assigning clear accountability and authority, and fostering cross-enterprise product leverage and development, as well as providing individual career growth opportunities. SYNERGY aligned the majority of its engineering work force along common functional disciplines, regardless of geographic location.

SYNERGY introduced a "Full Spectrum Leadership" model with the objective of making it "the language of leadership." The model consists of five key imperatives which all employees were asked to focus on and strengthen, both in themselves and in their management-level employees. These qualities include the ability to shape the future, build effective relationships, energize the team, deliver results, and model personal excellence in terms of integrity and accountability. The Full Spectrum Leadership was viewed as

a development for the management team and employees. It became the language of leadership at SYNERGY in helping to build on the company strengths to meet the demands of the future growth.

The focus of the 2008 year was to help the management team understand Full Spectrum Leadership and develop in areas where the team had opportunities for improvement. In addition, Full Spectrum Leadership was incorporated into business processes for talent selection, management, development, and performance accountability. Thus, the Full Spectrum Leadership Imperatives provide a comprehensive framework for leadership excellence and become the integrator of SYNERGY efforts to achieve full Horizontal Integration for growth and performance and deliver greater value to its customers. As the horizontal integration has begun its transition from being separate toward becoming collaborative, the transformation of an inclusive and collaborative organization by A. Evans (2003), N. Evans (2004a, 2004b), N. Evans and Hoole (2005), Haes and Grembergen (2005, 2006), and Coughlan et al. (2004) was confirmed.

CONCLUDING COMMENTS

The study was limited to SYNERGY's horizontal integration from 2004 to 2008 that reflects the business-IT fusion and managerial leadership practices implemented during the horizontal integration. Thus, study findings may not be repeatable from other organizational contexts. The situations or responses detailed in the study are unique to SYNERGY, which limits the generalizability of the study. However, the "effectiveness" and "impact" (Simon, 2006, p. 27) of business-IT fusion, lessons learned, and best practices may be generalized and constructed into some strategies. The findings disclosed that implementing Full Spectrum Leadership model and integrating organizational development roles, IT governance, and relationship management were the preferred modality when promoted horizontal integration to enhance collaborative and integrative aspects of the organization. The findings substantiated the need for further research specific to the following research questions: how organizations demonstrate horizontal integration's contribution to the success of the enterprise and how horizontal integration facilitates organizational transformations. Finally, the research indicates a collaborative and integrative model is needed to gain further insights into and subsequently improve managerial leadership practices. Strategies to implement the collaborative and integrative model to large organizations can present significant challenges because of subcultures-bound; however, these challenges could yield greater organizational performance by enhancing the capabilities of leaders and employees within the organization.

APPENDIX A: COPY OF SURVEY INSTRUMENT

Section 1: Strategies for Promoting Business-IT Fusion

The survey asks questions about managerial leadership practices for organizational development roles, IT governance, relationship management, horizontal integration, and business-IT synergy. The survey allows you to express your opinions and provide information about your experiences anonymously; your name is not attached in any way to the responses you give. By answering the questions, you will help your organization learn about its strengths and weaknesses and improve its strategies for promoting business-IT fusion. The survey has columns for your responses (Table A1). Please mark x in the column that corresponds to the significance of each of the following factors for contributing to managerial leadership practices.

Table A1: Surveyed Columns for Responses

SA	A	N	DA	SDA
Strongly agree	Agree	Neutral (neither agree nor disagree)	Disagree	Strongly disagree

Please avoid the neutral column as much as possible. Additional comments can be added at the end of each category. In addition, Tables A2, A3, A4, A5, and A6 contain Likert-type scale survey questions and Table A7 contains the open-ended questions as follows.

Table A2: Likert-type Scale Survey for Organizational Development Roles

Statement for evaluation	SA	A	N	DA	SDA
1. IT is an integral part of most forms of business initiatives at SYNERGY.					
2. IT is properly used at SYNERGY.					
3. IT projects are capable of delivering what clients expect at SYNERGY.					
4. SYNERGY's IT executives are aware of the organizational factors that contribute to project failure.					
5. Organizational issues are properly addressed during system development processes at SYNERGY.					
6. The SYNERGY's organizational development roles improve organizational performance.					
7. The SYNERGY's organizational development roles support the structures and processes of the entire system.					
Comments:					

Table A3: Likert-type Scale Survey for IT Governance

Statement for evaluation	SA	A	N	DA	SDA
1. IT governance is exercised by IT management in order to create business-IT synergy.					
2. The management ensures that money spent on IT delivers value for the business.					
3. The SYNERGY's Business-IT units make business-IT decisions together.					
4. IT department creates an environment that allows programs to make rational decisions.					
5. The IT department understands goals and requirements of the programs to establish clear engagements.					
Comments:					

Table A4: Likert-type Scale Survey for Relationship Management

Statement for evaluation	SA	A	N	DA	SDA
1. IT has resources to find the right people for the job.					
2. The right people take lead roles according to their degree of specialization.					
3. IT people do not wait to be told what to do.					
4. Colocation with programs being supported is important for IT technical personnel.					
5. IT people seem to have a one-team attitude because they are part of the program.					
6. Program units see IT as some sort of adjunct.					
7. Program units know who to talk to in IT.					
8. IT knows who to talk to in the program units.					
9. The IT department and the program units have the necessary knowledge of each other's requirements.					
10. IT people understand that they are responsible to work towards delivering a product to a customer.					
11. IT people and the programs communicate with one another.					
Comments:					

Table A5: Likert-type Scale Survey for Horizontal Integration from 2004 to 2008

Statement for evaluation	SA	A	N	DA	SDA
1. Horizontal integration development improves organizational performance.					
2. Horizontal integration development focuses on processes between different sites.					
3. Organizational issues were properly addressed during the Horizontal integration of system development processes.					
4. Horizontal integration involves more than designing better tools; it involves better management.					
5. The IT departments create environments that allow the business units to make rational decisions for horizontal integration.					
6. The IT departments establish clear agreements to support business units in achieving of horizontal integration.					
7. Trust, collaboration, and relationship management were emphasized.					
8. Effective leadership principles are applied at all levels of responsibility.					
9. Effective knowledge transfer between IT and programs is promoted during horizontal integration.					
Comments:					

Table A6: Likert-type Scale Survey for Business-IT Synergy

Statements for evaluation	SA	A	N	DA	SDA
1. IT continually tunes itself to business with contingency plans in place.					
2. Tools architecture supports horizontal integration.					
3. Tools are integrated with input from end users for continuous improvement.					
4. Results of business must be known for all IT investments (solution benefit).					
5. Programs own products; IT delivers financial value.					
6. IT is fully embedded in business strategy (technology strategy).					
7. Programs and IT equally share ownership.					
Comments:					

Section 2: Open-Ended Questions

Table A7: Open-ended Questions

1. Should IT focus on standardization and harmonization of differences?
2. Is IT a commodity or a competitive advantage?
3. Should IT people situate themselves as change agents?
4. How managerial leadership practices existed from 2004 to 2006 that demonstrated fusion in work relationships for horizontal integration?
5. How does management contribute to the decrease of the business-IT gap?
6. How does this company promote business-IT fusion in work relationships for the horizontal integration?
7. How does business-IT fusion affect project risks and return on investment?
8. What strategies do you suggest in order to promote business-IT fusion?

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BIOGRAPHY

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THE STUDY OF THE GUANXI TRANSFERRING PROCESS FROM INDIVIDUAL TO THE ORGANIZATION BY GENETIC ALGORITHM

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ABSTRACT

Guanxi covers not only the relationships, but also the core social customs of individuals from China. This study is similar to previous studies, in focusing on the link between an individual's guanxi and the organization. It differs from previous studies, however, in the way that subjects' process of transferring guanxi is analyzed. This paper proposes modeling the economies of individual guanxi so that its impact on the organization in dyadic business exchanges can be measured. First, this paper introduces the concept of individual guanxi in the business environment. Secondly, some of the variables that are related to this issue are presented. Thirdly, a process for transferring guanxi is proposed to better understand the effect on the organization. With the transferring process, the organization could recognize the importance of guanxi, and gather up the threads of improve performance. Finally, we propose a numeric simulation to perform this guanxi transferring process using a genetic algorithm. In this process, it is found that the chromosome (the individual guanxi), crossover probability (the interaction between the individual guanxi), and mutation probability (the uncertainty of guanxi) all play important roles.

JEL: A1, O53

KEYWORDS: Guanxi, Genetic Algorithm, Mutation Probability

INTRODUCTION

Guanxi is considered to be important in the context of impersonal business dealings within a weak regulatory environment (Xin and Pearce, 1996). Bian (2005) regards guanxi as a Chinese phenomenon, and defines it as a dyadic, sentimental tie with frequent interaction, high intimacy, enduring emotional attachments, and repeated resource exchanges. Comparing to Western, social customs are different in many dimensions, such as business customs, transaction rule, interpersonal contact, and relationships with family, friends, and strangers.

Guanxi is not only an important factor in doing business in China, but also in wilder Chinese society. Guanxi is costly and time consuming to develop (Park and Luo, 2001; Yu, 2002; Fan, 2002b; Reid and Jallat, 2006), and while it may produce beneficial effects for the focal parties, it may reduce overall efficiency and effectiveness. (Warren et al., 2004). Davies et al. (1995) suggest that guanxi is believed to offer help in obtaining information on government policies, market trends and business opportunities and thus is an indispensable bridge between business and officials. A common conception by many Westerners is that guanxi is unethical(Chan et al., 2002), and it is often taken to be synonymous with bureaucratic corruption and bribery (Lovett et al., 1999; Su and Littlefield, 2001; Su, Sirgy, and Littlefield, 2004), or regarded as a source of nepotism and cronyism (Braendle et al., 2005; Chan et al., 2002; Tan and Snell, 2002), resulting in favoritism or under the table deals (Millington, Eberhardt, and Wilkinson, 2005). However, guanxi is for more complex than this, and is an important way that Chinese social network are able to function efficiently.

Zhang and Zhang (2006) suggest that when an individual joins an organization, their resources, including

guanxi, are introduced into their new employer. Guanxi can thus be beneficial to an organization, while the guanxi's value to the individual is not reduced. However, individual-level guanxi needs to be transformed into an appropriate form to best serve the organization, and we propose a conceptual framework to describe this. The transferring process can be divided into four stages: germinating, nurturing, transplanting (and converting), and expanding (or weakening). Not all of an individual's guanxi will pass through these four stages, and when an individual leaves an organization, some of their guanxi may be lost, meaning that it did not transplant or convert to the organization. However, if an organization can offer better employment terms to an individual, they may stay and develop their guanxi to improve firm performance. Further, through out genetic algorithm, we can regard the individual's guanxi as chromosomes and will be allocated reproductive opportunities to be selected. Under the given standard of fitness, we choose the better chromosomes to reproduce, crossover, and mutation to find the better target optimal solution. We can observe many variables in the guanxi transferring process. It will be an useful consideration of planning strategy for the organization in the future. The paper closes with some concluding comments.

The paper aims to provide readers with a sound understanding of the process of transferring guanxi and to act as solid base for further study and research. The work is organized as follows. In the next section, we review the literature and explains the purpose of study. In thhe following section, we discuss the framework of the guanxi transferring process and the related four stages. Finally, we propose a numeric simulation to illustrate the framework with a genetic algorithm.

LITERATURE

Many studies have acknowledged the importance of individual's guanxi for the organizations that they work for. However, there has been little investigation into the process by which this guanxi is transferred, and that is thus the aim of this study. With regard to the inter-organizational level, Park and Luo (2001) suggest that organizations connect with others to acquire new technologies and to expand their product or market reach. Studies have shown that organizational and technological competency is often at the nexus of these networks. In addition, because resources are often scarce and organizations tend to compete for them, the resource dependence model focuses on inter-organizational efforts to gain power and control over essential resources, while minimizing threats to organizational autonomy (Cummings, 1984). In a competition for resources, organizations may maintain good guanxi with other firms in order to build an inter-organization social network. To date, the majority of guanxi research in the organizational context has focused on operations in the public domain or between personnel representing inter-organizational guanxi (Kao, 1993; Luo, 1997; Park and Luo, 2001; Tung and Worm, 2001; Yeung and Tung, 1996; Fock and Woo, 1998).

At the intra-organization level, the individual employee is the essential unit. Studies have indicated that a primary concern of Chinese managers and organizations is to engage in extensive networking activities through guanxi and various informal agreements to build trust and exchange favors (Tsui and Farh, 1997). Pearce and Robinson (2000) suggest that people do business only with those they know and trust. Negotiations are undertaken more obliquely than in the West, often focusing on long-term goals rather than specific current objectives. Negotiators thus take longer to gather information about the other party and evaluate the trustworthiness of a potential partner, and the focus is rarely on closing a business deal as soon as possible.

At the firm level, Park and Luo (2001) showed that managers' guanxi ties enhance firm performance through access to diverse information, resources, and opportunities. In a similar study, Peng and Luo (2000) illustrated that the impact of managerial ties on firm performance varied by ownership, firm size, and industry. Grainger (2004) investigates this question by examining and comparing survey results collected from trade executives based in Hong Kong (Fock & Woo, 1998) with data collected from

employees from a large State Owned Enterprise (SOE) in south-west China. The results confirm that in both the intra-organizational and inter-organizational environments, mutual cooperation and trust are important characteristics of guanxi. However, individual guanxi is the foundation of success for the organization. Consequently, the important point to examine is how individual's guanxi transfers into the organization.

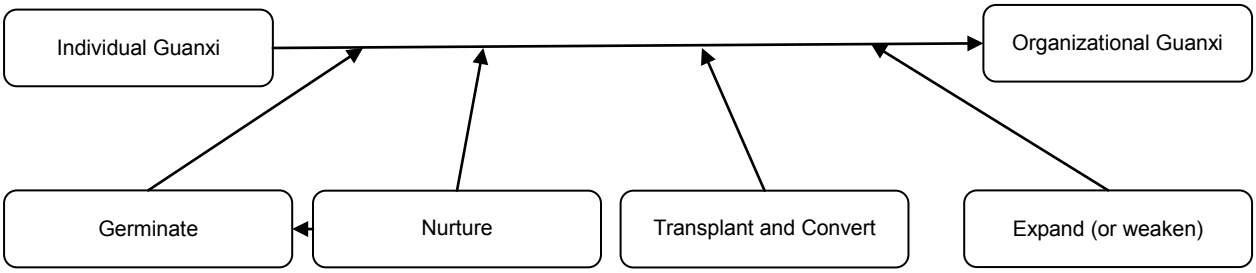
Peter and Humphreys (2007) suggest that guanxi is in general considered as an important element of the national culture of China, and as such it can also become an asset in corporate culture, as personal relationships are dedicated to and used by the firm. Possessing guanxi may allow a manager to increase business sales, avoid fines or taxes, receive business permits or information on proprietary technology (Pearce and Robinson, 2000; Xin and Pearce, 1996). Some studies have drawn on resource-based theory by taking guanxi as a kind of organizational resource and capability that not only affects the firm's performance, but creates competitive advantages (Tsang, 1998). Many scholars have explored the process of building, maintaining and managing guanxi (Chen and Chen, 2004; Leung, Wong, and Wong, 1996; Vanhonacker, 2004). In an organizational context, a guanxi-based network is part of an organization's core competency and provides competitive advantage (Luo, 1997). In the rapidly changing economic and social environment of China, guanxi has become even more entrenched with strong and direct implications for business practices (Park and Luo, 2001). Understanding and applying the notion of guanxi is thus necessary if Western firms wish to be successful when engaging in business in China. Still other investigators maintain that- guanxi has no effect or even a negative one on firm performance (Braendle et al., 2005; Li and Athuahene-Gima, 2001), and that its role in Chinese business is diminishing (Fan, 2002a).

Park and Luo (2001) also maintain that guanxi can become an asset at the organizational level when personal relationships strong connections among key managers. Although their opinion is correct, and Zhang and Zhang (2006) illustrate the process, neither study tries to understand how individual guanxi is transferred into the organizational guanxi by numerical analysis. The study is an attempt to supplement the findings of individual guanxi studies.

CONCEPTUAL FRAMEWORK

When an individual joins an organization, they will bring their personality and other resource into it, eventually changing how the enterprise operates. This process is presented in figure 1, which illustrates the four stages of the transferring process: germinating, nurturing, transplanting (and converting) and expanding (or weakening). There are many factors that influence the different stages. In stage 1, family and personal background perform a critical role. In stage 2, organizational resource and efficiency are important factors. In stage 3, the interaction between individuals has the main influence. Finally, in stage 4, environmental uncertainty is a critical factor.

Figure 1: The Process of Individual Guanxi Transferring to Organizational Guanxi



This figure shows the key stages in the guanxi transferring process. We suggest that individual guanxi will change with distinct features in the different stages.

Stage One: Germinate

In Chinese society, family members, close clan members and in-laws are the foundational base. Yang (1994) proposed that the Chinese often categorize others into three types of guanxi: (1) family people, (2) familiar people, (3)strangers, and some researchers even define guanxi as a web of extended family relationships (Kipnis, 1997). An individual with a higher rank has an obligation to provide favors to help their family members with a lower rank without an anticipation of reciprocity (Farsh et al., 1998; Su and Littlefield, 2001). Loyalty and mutual trust are thus two core factors in the relationship between family members. Zhang and Zhang (2006) noted that the strength of family relationships is generally not affected by whether or not beneficiaries actually return favors, and that this is the longest lasting and strongest kind of guanxi. When the individual joins the organization the initial stage, the family members will possess different endowments and do not endeavor to develop. The endowment with powerful guanxi will improve organization and business development. Otherwise is not. It deserves to be mentioned that nature endowments of guanxi may be consumed away or damaged organization. We could conclude that family guanxi may help an individual to get better job or position. Moreover, the relationship between family members will have effects over a long period of time.

Chen (1995) suggested that guanxi is best defined as friendship, with implications of a continual exchange of favors. Yang (1994) defined building guanxi as a transformation process, whereby two discrete individuals construct a basis of familiarity to enable the subsequent development of their relationship. Guanxi can be defined as a special type of relationship which contains trust, favor, dependence and adaptation (Wong, 1998). We suggest that guanxi can evolve from family to friends and to strangers, and can disperse from individuals to organizations and further to government officials. It is noteworthy that if this dispersion process develops well, it could improve the performance of organization. Otherwise, it may harm. The wider relationship is the reciprocal type that includes neighbors, classmates, and colleagues who have a common background. They may provide assurance and trust and create a barrier to competitors (Vanhonacker, 2004), while within, they exchange favors which are roughly equivalent in value and repeat exchanges (Su and Littlefield, 2001), although once they can not reciprocate, the guanxi may not be as close as before.

Stage Two: Nurture Stage

The individual uses resources provided by the organization to maintain the original guanxi and broadens guanxi with others. They may use their guanxi (in their private capacity) to benefit to their employer, but this guanxi remains personal property and will not become an organizational asset (Tsang, 1998). Meanwhile, if the individual abuses resources, the organization will be damaged. In particular, if an individual leaves the organization they can take the guanxi they have developed with them. Some organizations protect their capital from abuse by adopting strict policies. Consequently, such organizations fall into a vicious circle, and eventually lose business. In contrast, if organizations can establish appropriate internal regulations, they could increase individual loyalty and improve performance.

The guanxi network improves efficiency by reducing transaction costs (Davies et al., 1995; Lovett et al, 1999). Guanxi may bring personal gains to individuals, and vital resources and cost savings to the organizations that employ them. For foreign investors, guanxi relationships provide informal ways to reduce environmental uncertainty and opportunistic behavior (Standifird and Marshall, 2000). Foreign entrants in Chinese markets should thus mount sustained efforts to build up guanxi to gain a competitive edge. Guanxi can be a negative asset, however, if not well managed within and between foreign and local firms (Vanhonacker, 2004), and while it is vital to adopt the guanxi approach in their relationships with Chinese partners, foreign investors should be aware that guanxi alone cannot eliminate threats and competition (Fock and Woo, 1998).

Stage Three: Transplant and Convert Stage

Based on the individual's abilities and the organization's resources, the individual can make efforts to improve performance. In addition, the organization can establish itself as reputable by having a multitude of organizational participants engaged in guanxi-based business practices. However, firm performance will be further raised by team work, which is important for achieving organizational objectives. Barnard (1938) stressed that motivating participants to continue to make contributions is one of the most important activities of management, and purposed a cooperative system theory to illustrate the interaction between members. The theory emphasizes the combination of organizational objectives, members' willingness, and communication ability. The cooperating behavior within an organization may be affected or limited by environment conditions and social factors. Highly connected individuals are attractive exchange partners due in large part to their network of connections, and the organization becomes an attractive exchange partner to the extent that individuals within it are well connected. Because guanxi is transferable from person to person, the development of individual links ultimately leads to a network of relationships. Once within a network, one maintains face, or mianzi, by reciprocating favor for favor, and such individuals will cooperate to do business well.

Yang (1994) provided excellent descriptions of how guanxi is established, maintained, and mobilized in China, and Farh et al. (1998) found that guanxi relationships promote interpersonal trust among individuals. Standifird (2006) suggested that the existence of highly connected individuals within a particular organization can have a multiplying effect to the extent that they are connected to one another. The connection of organizational employees to one another expands the quality of the guanxi networks for individuals working within an organization, which in turn makes a firm's dyadic relationship with it's employees more valuable. However, just because two individuals work within the same organization does not mean that they will have good guanxi with one another. Guanxi must be cultivated both within and across organizations, and thus, it is important that the organization explicitly support the development of guanxi among its employees.

Stage Four: Expand (or Weaken) Stage

After the transplant and convert stage, the organization may expand the business scope of guanxi. If the organization can provide enough resources and opportunities, the individual will still contribute to the same organization. The main factor that affects whether an individual will stay or leave is the mutation probability of the environment. We can classify a firm's environment into internal and external types. The mutation probability of the internal environment is determined by a firm's resources, system, staff and efficiency, while the mutation probability of the external environment is determined by macroeconomic factors. If the internal mutation probability is positive and beneficial to the organization, the individual will choose to stay, and the organization will achieve synergy. Otherwise, the performance of the organization will decline. If the external mutation probability is positive and beneficial to the organization, some individuals will choose to stay and get more welfare and higher positions within the firm, as it has sufficient resources. Others may leave the organization and take their guanxi and related derivatives away. As result, a firm's guanxi weakens.

The connection of employees to one another has the added benefit of creating obligations between organizational members. Guanxi is first and foremost a product of the individual. When an individual leaves the organization, so do the guanxi connections associated with them. Moreover, the embedded obligation of employees to one another reduces the probability that one will leave the organization for fear of losing face with members of their guanxi network. Thus, by encouraging the connection of employees to one another, the organization not only enhances the quality of the guanxi network for individual employees, but also reduces the probability that the individual will leave the organization.

NUMERIC SIMAULATION

We adopt a genetic algorithm (GA) to description the individual guanxi procell of transferring. GA is based on Darwin's basic conception of natural selection and "survival of the fittest", now has many fields of application in business administration. The most common genetic operators are reproduction, crossover and mutation (Foy et al, 1992). Reproduction chooses potential solutions from the population, based on their fitness evaluations, that will be used to create new generations. The high fitness characteristics are to be passed on, whereas the low fitness ones are to be discarded. The second operator, crossover, randomly selects two solutions from the population and crosses them at a random position to form two new offspring. In practice, we set a relevant fitness function, coding and initial population in order to decide the relevant chromosome. As the purpose of our study, we pick up the size of organization are 25, 50, 75 and 100 to illustrate the performance by computers. Hence, we need to set parameters that include population size, chromosome length, crossover probability and mutation probability.

Table 1: Description of Parameters

The Parameters	The Description of the Parameters
The population size	The more population, the more time we need. We consider different sizes of organization, simulating the sizes of 25, 50, 75 and 100.
The chromosome length	An individual is a chromosome for an organization. Everyone has the different family influence and personal ability. The different size of organization will perform the diverse achievement, and the chromosome length represents the guanxi of the individual. In general, we can get a more accurate solution with a longer chromosome, although this needs more time for coding and decoding According to accuracy and time concerns, we set the chromosome length at eight codes.
The fitness function	$rn_i = round\left(\frac{Nr \cdot (\gamma_i + \delta_r)}{\gamma_i + \delta_r + (1 - f_i)}\right)$ Where rn_i represents the reproduction of volume for chromosome i; Nr is the maximum reproduction of chromosome; $\gamma \in [0,1]$, δ_r is the factor of reproduction. The formula of the fitness function is as follows: $f_i = \frac{fit(chro^i)}{\max_k\left(fit(chro^k)\right)}$ Where $fit(chro^k)$ is the fitness value of the chromosome, and k=1,2,…,p.
The crossover probability	We use crossover probability to represent the interaction between individuals. A higher crossover probability makes the superior one replaced and a lower crossover probability terminate the search. Therefore, we set crossover probability equal 0.5. The crossover process is as in the following equations: $chro^{n1} = \gamma \cdot chro^{s1} + (1-\gamma) \cdot chro^{s2}$ $chro^{n2} = (1-\gamma) \cdot chro^{s1} + \gamma \cdot chro^{s2}$ Where $chro^{s1}$ and $chro^{s2}$ represent the selected chromosomes for crossover. $chro^{n1}$ and $chro^{n2}$ represent the new chromosomes after the crossover process. γ is random variable. In addition to the crossover, we evaluate the new chromosomes by the following function: $S_i = fit(chro^i) \cdot \gamma_i$ Where S_i is the fitness value for the judge of retained. We can then pick up a higher fitness value and put it into the evolution process.
Mutation probability	The interaction of the individual guanxi may help or hinder the organization. We need to consider the uncertainty of guanxi, and we use the mutation probability to describe its evolution. With GA, higher mutation probability will lose the similar between generations, and a lower mutation probability will converge at a local optimum. In general, an acceptance value is 0.05.

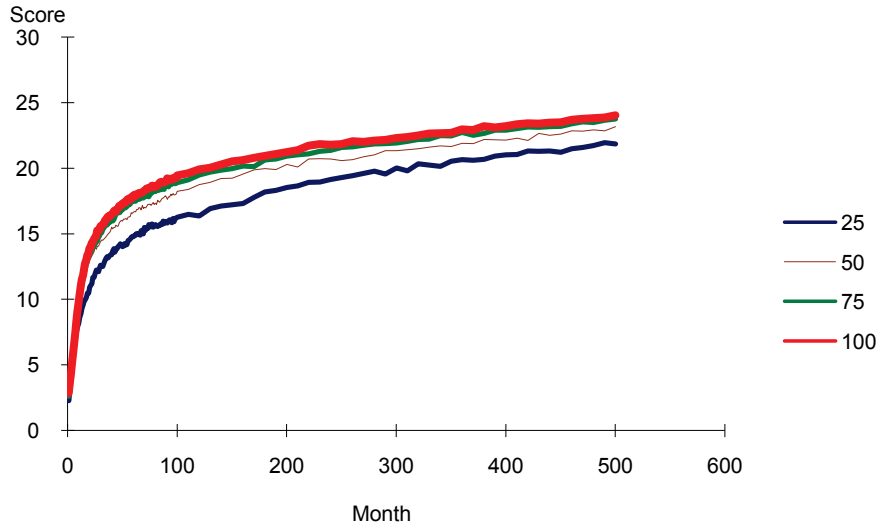
This table outlines the parameters used in the study

RESULT

According to the parameter settings above, we can simulate the performance of different size organizations as shown in Figures 3 and 4. Figure 3 illustrates that the bigger organizations will perform well in the long term, but the size of the performance difference decreases over a long period as shown in

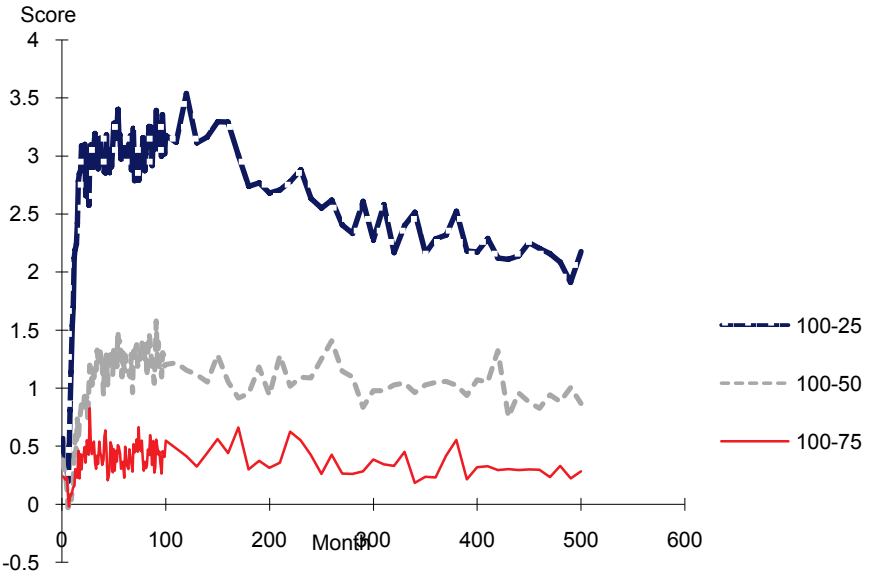
Figure 4. In addition, bigger organizations need more capital input and easily get into distress in the initial period. On the other hand, large organizations also have more resources to develop their business.

Figure 3: Performance of Different Sized Organization



This figure shows the performance of different sizes of organization. We simulate the sizes of 25, 50, 75 and 100 for 500 months. The larger companies performed well, especially in the initial periods.

Figure 4: Difference in Performance for Different Sized Organization



This figure shows the difference in performance between the different sizes of organization. We found the great the difference in company size, and the greater the difference in performance. However, this difference decreases in the long term.

CONCLUSION

The study purpose a framework to illustrate the process of transferring individual guanxi. Individual enter organizations to nurture, convert and expand their individual guanxi. The individual guanxi will display the different develop level and performance with organization. However, the individual guanxi is the basic element that will determine the development of organization. In the transplant and convert stage, the interaction between individuals will expand the network of organizational guanxi. After the guanxi generating deeply, due to the mutation probability of environment, the organization will show the multi-development. In the simulation, the bigger organization will perform well in the long term, but the difference between different size firms will decrease in the long run.

This study shows that foreigners who want to invest in China must be familiar with the process transferring of guanxi. There are some limitations of the research. First, although the results of the descriptive analysis have shown the overall pattern of the guanxi transferring process with simulated. Second, genetic algorithm generally could not provide a full picture of the guanxi of complicated and the failure case. Therefore, we suggest that future research can extend our research and test the different situation of performance by actual numbers. Next, future research can investigate the influence of individual guanxi on job performance by using questionnaires, and thus better understand the internal guanxi situation of a company. Finally, future research also might use other statistics or measurements to develop simulations and perhaps obtain better results. In view of the fact that China will be the most potential market and the factory, guanxi will play an extremely important role in the Chinese society. It would be beneficial to the development in the foreign capital entering the Chinese market if we manage the relations within the organization well.

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MEASURING MANAGERIAL EFFICIENCY: A BALANCED APPROACH

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ABSTRACT

In the paper a balanced approach to management efficiency measurement is proposed. The concept of measuring management function efficiency is presented. Most of the presented measuring instruments are non-financial in nature and are incorporated into a balanced scorecard methodology. The paper proposes weighting for each of five recommended managerial function measures in determining overall managerial performance. The implications of the technique are tested using a sample of Russian firms. The authors argue that the proposed measurement be applied not only in individual firms, but across supply chains.

JEL: L1, M1

KEYWORDS: management efficiency, management functions, balance, firms

INTRODUCTION

A guiding idea for management over the past century has been "If you can measure it you can manage it". Based on that principle a number of measurement systems for various enterprise activities have been devised. Managerial efficiency is usually defined in terms of enterprise efficiency which is not necessarily a good practice. A number of organizations have regularly paid dividends to satisfied owners only to suddenly end up in bankruptcy (Hartley, 2007, in Russian; Rampersad 2006, in Russian). These events demonstrate that shareholder value and annual profits are not sufficient measures of corporate efficiency and point to the need for better measures.

The motivation for this research came from an analysis of large and small Russian enterprise's. This analysis uncovered a number of interesting facts. For instance, some enterprises from the travel, insurance, educational and manufacturing industries presented impressive financial results but it was obvious that the results were biased by personnel acting to improve their own prospects. Some of those companies had competent staff while top-management in a few cases did not have the slightest idea of what was happening in the company.

On the other hand there were quite a few companies whose management was acting totally according to the latest management theories and doing exactly the "right things" (Drucker, 1998, in Russian) that ended up bankrupt or producing negative goodwill. There were also situations which could be described as abnormal market functioning companies. The energy supply industry which is a monopoly in the Russian Federation provides an example. These companies were dealing with unqualified personnel while paying little attention to customer care. They ignored planning and were still profitable even though 1/4 of their customers were not paying for the provided services at all. This situation resulted from government interference in the energy supply industry and the support it gave to certain firms. These, and other, observations led the author to address the issue of appropriately measuring managerial efficiency.

The paper is organized as follows. First a literature review is provided. Next the data and methodology is used in the study is discussed The results section follows. The paper closes with some concluding comments.

LITERATURE REVIEW

Management theoreticians agree that efficiency is a ratio of effect achieved to costs. But authors differ in their views upon appropriate managerial effects. The historical perspective suggests that within scientific management, managerial effect is a raise in employee productivity (Taylor, 1911) while administrative management place emphasis on subordination within a company (Fayol, 1930; Barnard, 1938). The idea of formalization of management occurs within the quantitative management perspective so the managerial effect is measured in monetary units. This proved to be impossible in some cases due to the fact that some quantitative models require unrealistic or unfounded assumptions (Griffin, 1999). In spite of that some researchers suggest measuring managerial efficiency as the ratio of additional profit company from a decision to the cost of the decision (Gorshkova, 2003, in Russian; Egorshin, 2008, in Russian; Vasilyev, Parachina, Ushvitsky, 2006, in Russian). This approach has limited usefulness as the connection between the decision and financial results is not always direct.

The other problem with managerial efficiency estimation is that some modern management theories measure efficiency by only one measuring scale. This point was emphasized by Brogan (Brogan, 2003) who estimates old-time and modern myopia in reference to management performance. The example of such theory is value-based management which emphasizes that the main measuring instrument is shareholder value. Though it is stated that value-based management is to be used in cooperation with balanced scorecard (Asheworth, James, 2006) the empirical data shows that application of the approach resulted in achieving high shareholder value despite the postponed costs it may produce. One must wonder the measurement systems that led Enron to its demise. This and other current crises emphasize the idea of measuring managerial efficiency by more than one scale.

A number of researchers explore the relation between managerial efficiency and different factors that influencing it. For example, Klein (Klein, 2002) finds that more independent board members have higher quality accruals. Huang et al. (2006) examine the relationship between earnings and CEO reputation while Bertrand and Schoar (2003) estimates the influence of management style on managerial efficiency. Demerjian, Lev and McVay (2006) examine the relation between managerial ability and earnings quality and provide mathematical instruments for measuring this relation. There also are works on the relation between managerial efficiency and human capital, (Dawson and Dobson, 2002) and give an instrument for estimating it.

The problem of finding a balance within enterprise's management was first introduced by Norton and Kaplan (2005, in Russian) and was afterwards used as part of consulting projects. The concept was extended by other researches such as Rampersad (Rampersad, 2005, in Russian) and Niven (Niven, 2005, in Russian). The main idea is that both financial and non-financial measures are to be mixed in measuring the efficiency of a firm. Olve, Roy and Wetter (2006, in Russian) provide a mechanism for applying strategic cards to different industries and emphasize the relation between balance and company results. Some issues associated with using balanced scorecard technology for enterprise's efficiency management are introduced by Gershun and Gorsky (2006, in Russsian). Especially the ratio between financial and non-financial indicators within a scorecard and the balanced model used within cultural transformation tools. (Barrett, 1997) estimates the influence of value balance and company success.

DATA AND METHODOLOGY

It is important to measure both enterprise's activity efficiency and management efficiency. If a company is efficient it is not necessary the result of proper company management. As such it is important to separate managerial efficiency from firm efficiency. We argue that the balance approach should be used for management efficiency measuring. To do so we suggest focusing on six issues, five of which are functions of management and the sixth is the results achieved by the company.

The five functions are: planning, organization, motivation, control and coordination. The fifth one was added to represent the importance of executing the previous for in concert. The indicators measuring the fulfillment of each function the percentage of money spent on it relative to the company revenue should be also listed. That amount is to be estimated and should not be exceeded. In order to prevent mistakes the efficiency of each function within the balanced managerial measurement should be estimated by no less than 3 different indicators.

To have a balanced estimation of management efficiency we pay attention to the result of company's activity also measured by more than one indicator. We suggest those indicators be chosen according to the specific features of the company's core industry. For example these could measure the following aspects: profitability, financial stability, market share, liquidity and shareholder value. Also the cost of management should be esteemed as a reference figure.

In Table 1 short-term and long-term planning accuracy are to be estimated by experts who should take into account the macroeconomic environment. For instance under regular circumstances short-term planning accuracy will be considered low if results differ from plan by more than 35%. Motivation quality is considered high when most of employees are satisfied with the job and low is the opposite. The other motivation measuring instrument measures the number of employees whose dominating motivation is as required for quality job performance. The quality control function is considered excellent when a high level of internal clarity is achieved. The dynamics in a quantitative sense of controlled positions is also to be taken into consideration. Finally, the coordination function is deemed excellent if a company produces positive synergetic effects and if the organization reaction to change is adequate.

Table 1: Suggested Managerial Efficiency Indicators

Figure	Group 1	Group 2	Group 3	Group 4	Group 5
Short-term planning accuracy	High	Average	Reasonable	Low	Intolerable low
Long-term planning accuracy	High	Average	Reasonable	Low	Intolerable low
Controllability standard	14 and higher	8-13	5-7	3-4	Less than 3
Management cell fulfillment	95-100%	85-94,9%	75-84,9%	60-74,9%	Менее 60%
Quality of motivation	High	Average	Reasonable	Low	Intolerable low
Motivation function performance (by position correspondence)	High	Average	Reasonable	Low	Intolerable low
Quality of control (by usage of formatted indicators)	Excellent	Good	Average	Satisfactory	Unsatisfactory
Quality of control (by shares of deviations found on different stages)	Excellent	Good	Average	Satisfactory	Unsatisfactory
Quality of control (by internal clarity)	Excellent	Good	Average	Satisfactory	Unsatisfactory
Quality of coordination (by synergetic effect)	Excellent	Good	Average	Satisfactory	Unsatisfactory
Quality of coordination (by reaction to changes)	Excellent	Good	Average	Satisfactory	Unsatisfactory
Share of management maintenance cost relative to total cost	10% and less	10-15%	15-20%	20-30%	More than 30%
Profitability	8% and more	6-8%	4-6%	2-4%	Less than 2%
Working capital to short-term debt	1.01-1.5	1.5-2.0	0.9-1.0	0.8-0.9	More than 2 or less than 0.8
EBIDTA/debt	4:1 – 2:1	2:1 – 1.3:1	1.3:1 – 1:1	1:2 – 1:4	More than 1:4

[1]*that indicator means that every manager has all subordinates he can possibly have according to controllability standard*
[2]*profitability and the other indicators below were chosen for travel agencies market*

In order to provide efficient estimation of managerial functional performance some indicators are suggested. Their values were divided into 5 groups representing the following: Group 1: business with a proper management system, Group 2: business with a somewhat unbalanced management system, Group

3: working managerial system that needs to be balanced, Group 4: misbalanced and sometimes non-working management system, Group 5: non-working management system.

To be rated as group 1 in each category a company gets 5 point, as group 2 – 4 points and so on to getting 1 point for group 5. If a company earns from 67 to 75 points it is group 1 company, from 54 to 66 – group 2 company, 43-53 – group 3, 33-43 – group 4 and less than 33 – group 5. Interestingly based on these measures, the company-leader in the market examined could not achieve the maximum score for group 1 indicating that even the best company is having difficulty with management balance.

The data for the research was collected by distributing questionnaires to almost 150 managers in one of the Russian Federation regions. The research involved 30 enterprises (travel agencies) of different size (from 4 people up to 50). The questions were asked of the firms were divided into three groups. The first questions concerned the presence of formal planning, organizational, motivation, control and coordination systems. Second included questions which asked how many resources a manager spent on each of the above functions. The third section contained questions which were aimed to determine if a manager needed more resources for performance of a certain function. In each of the companies, managers from different levels of hierarchy were interviewed. Financial data was collected from official financial statements provided by the companies.

RESULTS

The research shows that the most poorly performed functions were motivation and coordination but at the same time managers when asked directly if motivation or coordination should be improved answered mostly "no". Indirect questions proved that true answer is "yes". In most cases that was due to the fact that companies had formal motivation and coordination systems and viewed them as working properly, but indirect questions showed the opposite result. Most of the time the firms CEO did not agree with that point assuming they just need more control. That point demonstrates the importance of control was over-emphasized. Planning functions, especially short term planning, were performed more or less properly in most of the companies. With regard to organizational function, there were two company categories. In first type it was performed properly while in the second it was performed improperly.

Balance does not mean that managers should spend the same amount of time and money performing each function. Table 2 shows how the efficiency of companies corresponds to distribution of time and money spent by management. Spending more time and money on performing motivational functions is more successful in the market than an equal distribution of resources.

Table 2: A View of Balanced Management Efficiency Estimation of Travel Agencies*

Indicator	Company-leader	Average company
Time spent by CEO on performing management functions, %	100	100
- planning	20	15
- organization	12	25
- motivation	42	30
- control	10	25
- coordination	16	10
Money spent on performing management functions	100	100
- planning	15	15
- organization	15	25
- motivation	45	25
- control	15	25
- coordination	10	10
Profitability, %	6.4	4.2
Market share, %	14	1,1
Financial stability (EBIDTA/debt)	1:1	1:4

** The research was carried out by the author on Kazan travel agency's market. Over 100 agencies were involved in the research.*

Throughout the research the company-leader was defined as the one that has the largest number of customers, had the highest profitability and acceptable level of EBIDTA to debt of all the searched companies. For the industry, acceptable level of EBIDTA to debt is considered to be 1:2.

Both listed companies chosen as the result of survey are spending too much time and money on performing control functions according to the CEOs. It is also interesting that usually the share of time and money spent on motivation decreases when the share control increases. With high motivation, less coordination is normally needed.

Next we applying the instrument to the business (see table 3). The detailed research was carried for a company that appeared in the bottom sector of the researched companies. The points in the table below were appointed by the experts according to the guidelines set out in the data and methodology section.

Table 3: An example of management system efficiency estimation (mismanaged company)

Figure	Figure's value	Point
Short-term planning accuracy	Reasonable	3
Long-term planning accuracy	Low	2
Controllability standard	5	3
Management cell fulfillment	61%	2
Quality of motivation	Low	2
Motivation function performance (by position correspondence)	Unsatisfactory	1
Quality of control (by usage of formatted indicators)	Excellent	5
Quality of control (by shares of deviations found on different stages)	Satisfactory	2
Quality of control (by internal clarity)	Unsatisfactory	1
Quality of coordination (by synergetic effect)	Unsatisfactory	1
Quality of coordination (by reaction to changes)	Satisfactory	2
Share of management maintenance cost relative to total cost	27%	2
Profitability	3.7%	2
Working capital to short-term debt	0.56	1
EBIDTA/debt	1:10	1
Total	--	30

According to the grade, the company belongs to group 5. The company above was excluded from the survey listed in table 2 though its profitability and market share can be assumed average. This company demonstrates a case where profitability is due to the fact that staff is not following the CEOs decisions and are taking risks. Otherwise the bureaucratic structure of the researched company (which is seen from the value of management fulfillment, the company is overloaded with managers performing control function) would have already paralyzed its market activity. This is an example of a mismanaged company. It is also interesting that 41% of management time and money in this company is spent on performing control functions, 11% - on motivation, 13% – on planning, 25% on organization and 10% on coordination. That emphasizes the above observation that companies in the this sector lack motivation while over performing the control function.

The results for the average company and company-leader in terms of suggested management efficiency estimation are presented in Table 4. The average company is the group 3 number one. The company-leader is a group 2 company. This indicates that even the best company in this market lacks management balance, over performing control. From the tables above we make a few conclusions on the poorly performed functions: 1) strategic planning is at best performed on an average level though the researched market, 2) motivation is poor in all cases. All the companies use only financial motivation and only three deal with staff development. In some cases development was present but it was performed after working hours which did not create motivation due to work balancing issues, 3) the coordinating function is not good due to CEO's believes that employees should deal with coordination by themselves. During the survey many employees mentioned a need to deal with problems on their own while the results are shared with the management; and 4) all of the above lead to financial problems.

Table 4: An example of management system efficiency estimation (company-leader and Average Company)

Figure	Company-leader's value	Average company's value
Short-term planning accuracy	4	3
Long-term planning accuracy	3	2
Controllability standard	4	3
Management cell fulfillment	4	4
Quality of motivation	3	3
Motivation function performance (by position correspondence)	3	2
Quality of control (by usage of formatted indicators)	5	5
Quality of control (by shares of deviations found on different stages)	4	3
Quality of control (by internal clarity)	4	2
Quality of coordination (by synergetic effect)	4	3
Quality of coordination (by reaction to changes)	3	3
Share of management maintenance cost relative to total cost	5	3
Profitability	4	2
Working capital to short-term debt	3	3
EBIDTA/debt	3	3
Total	56	44

It is also interesting that in the mismanaged company, while 41% of time and money was spent on control it led to the poorest financial situation. At the same time the control function was performed poorly due to unsatisfactory internal clarity. If we look at the average company and company-leader we notice that the raise in internal clarity leads to better motivation function performance and to a rise of profitability. At the same time internal clarity is uncommon among Russian management and its high score as a company-leader is the result of the company type, a sort of family business. In all the other companies there are problems with internal clarity.

Finally, all the studied management systems are misbalanced both in terms of functional performance and time and money spent on performing different functions. But measurement system introduced in this paper allow us to figure out what changes are to be performed in order to achieve balanced and efficient management. The advantage of the introduced systems is that one is able to range the needed changes according to the current shape of management performance.

CONCLUDING COMMENTS

To improve managerial efficiency, the balanced approach should be used. This approach is based on the idea that a single manager can not measure all the activities a manager should undertake. We are talking about estimating system efficiency and the system can consist of a single person or large organization. Managerial balance should be achieved in all cases. While creating a balanced measuring system managers should pay attention not only to the way management functions are performed but also to the specific features of the industry a company performs in. These features can be used to indentify what company's activity indicators are to be included in the measuring system.

The research carried have shown that there is a relation between the balance of management and financial results of the company, there also are relations in resources put into performing different functions. First of all, enterprise's which management can be described as balanced or somewhat misbalanced (groups 1 and 2 in the introduced methodology) tend to perform better financial results and cover a larger market share than misbalanced ones. Balanced companies also tend to hold an acceptable level of EBITDA to dept which proved to be an important issue during current crisis.

Other conclusions concern the relation between management functions. The best companies viewed themselves as putting too much effort into control. That is usually due to the fact that there is inter-

management misbalance, for instance, top-managers pay no attention to motivation while managers of lowest level spent a lot of time on that issue. That inner misbalance forces top-management towards losing trust and thus over performing control. In general when emphasis on motivation increases, the first function to decrease is control. The relation between motivation and organization can also be seen from the research. The more resources that are put into motivation the more self-organized a company becomes so the need to perform the organizational function decreases. The same is true for motivation and coordination and organization and coordination.

Within the research carried out, the stated functions (planning, organization, motivation, control and coordination) were studied from the point of view of boundless organization. Thus those functions are to be performed not only towards the inner environment of the company but also for suppliers and customer relations with which need balanced managerial performance as well. So all the measurement system can be utilized on the entire supply chain.

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BIOGRAPHY

Svirina Anna was born and lives in the city of Kazan, Russian Federation where she had graduated from Kazan State Technical University in 2001 to work there afterwards. In 2004 she defended her Ph.D. thesis and started a career of independent consultant along with lecturing at Chistopol branch office of Kazan State Technical University.

MALMQUIST INDICES OF R&D PRODUCTIVITY GROWTH IN TAIWANESE IC-DESIGN INDUSTRY

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ABSTRACT

This article employs the Malmquist index, a data envelopment analysis-type nonparametric technique, to decompose productivity growth into technical efficiency and technological change for Taiwanese IC-design firms. The results indicate that the increase in R&D productivity is mainly attributed to the increase in technical change, and the efficiency gain found is largely the result of improvements in scale efficiency. R&D productivity growth from the panel Tobit regression empirically shows that productivity growth did occur due to an increase in the debt ratio, to the firm being small, as well as due to the firm's superior credit rating.

JEL : C61, L63, O30

KEYWORDS: Malmquist index, Productivity growth, Technological Efficiency

INTRODUCTION

The IC-design industry in Taiwan recorded sales of 323 billion NT dollars in 2006, which accounted for 32.2% of the whole of the IC industry's production value. IC-design firms represent one of the most important component producers in the high-tech manufacturing industry worldwide. An effective R&D operation is a major source of competitive advantage in Taiwan's IC-design industry. In the interests of accountability, it is essential to measure the R&D productivity of the firms. Griliches (1994) presents a 'knowledge production function', which views R&D activity as a production process under different parameter methods. The quantitative method begins to analyze R&D efficiency and productivity. However, R&D activity involves multiple inputs and multiple outputs, which makes it problematic to analyze using standard parametric methods. Nonparametric linear programming suits the characteristics of R&D activities much better, but few studies have used Malmquist indices to evaluate R&D productivity growth.

The purpose of this paper is to measure the R&D productivity of Taiwanese IC-design firms and to examine how R&D productivity at the firm level has changed over time. Fundamentally, the evidence presented using either the partial productivity or total factor productivity indices do not tell us anything about the dynamics of the microstructure and the spread of the productivity growth rate within the industry. The Malmquist productivity index we employ can provide additional insights since it can be decomposed into two additional components, one of which measures the change in technical efficiency (i.e., whether firms are getting closer to the production frontier over time), and one which measures changes in technology (i.e., whether the production frontier is moving outwards over time).

By comparing annual changes in the productivity, efficiency and technological change of individual IC design firms, it is possible to both identify general trends in the productivity of the IC-design sector as a whole, and to identify those firms exhibiting patterns of change in productivity. An important task that arises after the calculation of the Malmquist productivity indices is to attribute variation in productivity to the specific characteristics of the firms and the environment in which they operate. A careful analysis of the results should add to our knowledge regarding the factors determining the pattern of IC design firm productivity in Taiwan and provide at least some idea of the effectiveness of microeconomic reform.

This paper gives rise to the following results. First, there is a mean increase in total factor productivity of 21.2% for the period from 2002 to 2006. An examination of the components of the Malmquist TFP index for IC-design firms shows that productivity increase is mainly attributed to the increase in technical change. Technological change plays an important role in TFP growth. Second, in decomposing the components of efficiency change into pure technical efficiency and scale efficiency, we find that scale efficiency is more important in terms of the increase in efficiency. Third, the study shows which determinants are important in order for firms to increase their TFP. As the results of the panel Tobit regression indicate, firm size and TFP are found to be negatively correlated. The firm's credit rating also has a significant negative impact on TFP, whereas a lower debt ratio tends to lead to a higher TFP.

The remainder of the paper is organized as follows. The literature regarding the productivity of R&D activity is reviewed in Section 2. Section 3 provides a brief outline of the Malmquist productivity index. The data used in the present study are described in Section 4. Section 5 presents the empirical results, and Section 5 provides a discussion and conclusions.

LITERATURE REVIEW

The data envelopment analysis (DEA) and Malmquist index methodology usually investigates efficiency change at both firm and country levels. The nonparametric Malmquist index decomposes productivity change into technical change and technical efficiency change. This approach has been applied by many studiies. In the manufacturing industry, related studies include Färe et al. (1992), Hjalmarsson and Veiderpass (1992), Price and Weyman-Jones (1996), Tan (2006), Hashimoto and Haneda (2008), and Liu and Wang (2008). Relevant literature in the banking and financial services sector includes Berg et al. (1992), Gilbert and Wilson (1998), Rebelo and Mendes (2000), Alam (2001), Barros et al. (2005), Rezitis (2006), Lin et al., (2007), and Lee et al. (2008). In the higher education sector, studies include Fernando and Cabanda, (2007), Worthington and Lee (2005) and Flegg et al. (2004). Few papers, however, examine the changes in R&D productivity taking place in the IC design industry.

Griliches (1994) has termed the relationship between R&D inputs and outputs as a 'knowledge production function'. However, R&D inputs and outputs are not easy to quantify, and few studies have analyzed R&D efficiency and productivity. Geisler (1995) and Brown and Svenson (1998) list patents as the output, and compare these with R&D expenditure as the input. Kondo (1999) regards R&D expenditure and patent applications as the R&D input and output, respectively, and analyzes the dynamic mechanism of an R&D-patent function within Japanese industry. Hashimoto and Haneda (2008) present a DEA and Malmquist index methodology to measure the R&D efficiency of Japanese pharmaceutical firms and show that the R&D efficiency of the pharmaceutical industry has deteriorated throughout the sample period. Tollman et al. (2004) also find R&D efficiency has been declining in the pharmaceutical industry. Nasierowski and Arcelus (2003) investigate R&D efficiency (in relation to the use of its input/output ratio) and R&D productivity (by considering the contribution of R&D effort to the national economy), and show that most countries are inefficient by measuring the efficiency of 45 national innovation systems (NIS). Honjo and Haneda (1998) apply data envelopment analysis to the data for 14 companies to evaluate R&D efficiency over the 1977-1991 periods. Their study demonstrates the usefulness of DEA in the comparative evaluation of the R&D activities of companies, and their results show that the DEA and Malmquist index method is suitable for studying the R&D productivity issue. Therefore, in our analysis we focus on R&D productivity and assign variations in productivity change to the specific characteristics of IC-design firms.

ECONOMETRIC METHOD

In order to assess the growth in productivity over time, the study employs the nonparametric input-oriented Malmquist productivity index that decomposes productivity change into technical change

and technical efficiency change. This approach has been applied by many studies to analyze productivity.

The description below draws primarily upon the work of Färe et al. (1994), Färe et al. (1998) and Coelli et al. (1998). Let us assume that time period t is the base/current period and that period $t+1$ is the future period. The Malmquist index measures total factor productivity (TFP) change between two data points by calculating the ratio of the distances of each data point in relation to a common technology. Following the framework of Coelli et al. (1998), a production frontier representing the efficient level of output (y) that can be produced from a given level of input (x) is constructed, while making the assumption that this frontier can shift over time. The frontier (F) is obtained in the current (t) and future ($t+1$) time periods. If inefficiency is assumed to exist, the relative movement of any given firm over time will depend on both its position relative to the corresponding frontier (technical efficiency) as well as the position of the frontier itself (technical change). When inefficiency is ignored, then productivity growth over time will be unable to distinguish between improvements that arise when a firm catches up to the frontier or those that result from the frontier itself shifting over time. It is possible to employ the input-oriented Malmquist productivity index to decompose the productivity change between the two periods into technical change and technical efficiency change. The input-oriented Malmquist productivity change index is shown as:

$$M_{t+1}^{t}(y_{t+1},x_{t+1},y_t,x_t)=\left[\frac{d_t(y_{t+1},x_{t+1})}{d_t(y_t,x_t)}\cdot\frac{d_{t+1}(y_{t+1},x_{t+1})}{d_{t+1}(y_t,x_t)}\right]^{\frac{1}{2}} \tag{1}$$

where M is the productivity of the most recent production point (x_{t+1},y_{t+1}) (using period $t+1$ technology) relative to the previous production point (x_t,y_t) (using period t technology), and d is the input distance function. A value of M that is greater than unity indicates that there is positive total factor productivity growth between the two periods. Equation (1) also can be written as:

$$M_{t+1}^{t}(y_{t+1},x_{t+1},y_t,x_t)=\frac{d_{t+1}(y_{t+1},x_{t+1})}{d_t(y_t,x_t)}\cdot\left[\frac{d_t(y_{t+1},x_{t+1})}{d_{t+1}(y_{t+1},x_{t+1})}\cdot\frac{d_t(y_t,x_t)}{d_{t+1}(y_t,x_t)}\right]^{\frac{1}{2}} \tag{2}$$

or

$$M=E\times P \tag{3}$$

where

$$E=\frac{d_{t+1}(y_{t+1},x_{t+1})}{d_t(y_t,x_t)} \tag{4}$$

$$P=\left[\frac{d_t(y_{t+1},x_{t+1})}{d_t(y_{t+1},x_{t+1})}\cdot\frac{d_t(y_t,x_t)}{d_{t+1}(y_t,x_t)}\right]^{\frac{1}{2}} \tag{5}$$

Furthermore, M is the product of a change in efficiency E as measured in period $(t+1)$ and period t and a measure of technical progress P as measured by shifts in the frontier over the same period.

Färe et al. (1994) suggest that technical efficiency change can be decomposed into scale efficiency and pure technical efficiency components. If the majority of inefficiency is due to the small size of operations, i.e., increasing returns to scale, then the DMU will need to plan for expansion. On the other hand, pure technical inefficiency can usually be addressed in the short term without changing the scale of operations (Avkiran, 2001). Using this approach, it is thus possible to provide four efficiency and productivity indices for each firm and a measure of technical progress over time. These are: (1) technical efficiency change (E) (i.e., relative to a constant returns-to-scale technology); (2) technical

change (P); (3) pure technical efficiency change (PT) (i.e., relative to a variable returns-to-scale technology); (4) scale efficiency change (S); and finally total factor productivity change (M).

Once M is calculated, recalling that M indicates the degree of productivity change, if $M > 1$ then a productivity gain will occur, whilst if $M < 1$ a productivity loss will occur. An interpretation of changes in efficiency (E) is that technical efficiency increases (decreases) if and only if E is greater (less) than one. Technical progress (regress) will have occurred if P is greater (less) than one. An assessment can also be made of the major sources of productivity gains/losses by comparing the values of E and P. If $E > P$, then productivity gains are largely the result of improvements in efficiency, whereas if $E < P$ productivity gains are primarily the result of technological progress. In addition, an indication of the major source of efficiency change can be obtained by recalling that technical efficiency (E) is the product of pure technical efficiency (PT) and scale efficiency (S), such that $E = PT \times S$. Thus, if $PT > S$, then the major source of efficiency change is the improvement in pure technical efficiency, whereas if $PT < S$, the major source of efficiency is an improvement in scale efficiency.

After calculating the Malmquist productivity indices, an important task is to attribute variations in productivity growth to specific characteristics of IC-design firms and the environment in which they operate. We use a panel Tobit model to explain the variation. The general form is:

$$M_{it} = X_{it}^{'}\beta + \varepsilon_{it} \quad i = 1,...,28 \qquad t = 2003,...,2006 \tag{6}$$

where M_{it} is the Malmquist productivity index, $X_{it}^{'}$ is a $(1 \times K)$ vector of explanatory variables used to interpret productivity in those IC-design firms, β is a vector of parameters to be estimated, and $\varepsilon_{it} \sim N(0, \sigma^2)$.

DATA AND INPUT/OUTPUT SPECIFICATION

The data used in this study consist of annual observations of 28 Taiwan IC-design firms. The time period selected extends from 2002 to 2006. The inputs to innovation production activities are mainly R&D manpower, R&D expenditure, and physical assets. Physical assets are often a proxy for physical resources that support R&D activities and firm size. R&D manpower and R&D expenditures are usually used as standard inputs in the traditional production function context, and are the most crucial elements in promoting technological progress. R&D manpower data is compiled from officially-released data for each firm. R&D expenditures and physical assets are derived from the Taiwan Economic Journal (TEJ) database over the period from 2002 to 2006, and comprise a total of 5 years of data of publicly-traded companies. To increase the comparability and completeness of the sample, firms for which data were missing or unclear are removed from the dataset. Griliches (1990) indicates that the number of patents is probably the most important indicator of research output, related studies include Brown and Svenson (1998) and Hashimoto and Haneda (2008). The number of patents granted comes from WEBPAT. WEBPAT contains much patent information in Taiwan and widely accessible for research on the following website: http: //www.twpat.com/ WEBPAT/ Default. aspx.

The explanatory variables to be included in the panel Tobit regression are also presented in Table 1. These variables are intended to account for the effect of specific characteristics of IC design firms on productivity. All other things being equal, a big firm in terms of the number of its employees will have more resources to engage in R&D activity. In general, this would imply a positive impact on productivity for IC design firms, so that the coefficient of firm size (EMP) might be positive. However, small firms might be more efficient than big ones. The sign of the coefficient between firm size and

productivity is unclear. A high debt ratio (DB) means relatively high operational pressure. This would imply a positive coefficient for the results of the panel Tobit regression. A relatively high credit rating should be more disadvantageous when it comes to sourcing external funds from the capital market, for it may give rise to relatively less R&D productivity and less opportunity to adopt new technological innovations. By contrast, a high employee's bonus ($BOUNS$) may serve as a stimulus for R&D manpower to engage in innovation. While Bond et al. (1997) found that investment is sensitive to cash flow or profit, Audretsch and Thurik (1999) extended the model of Bond et al. (1997) and found that the relationship between R&D investment and cash flow is positive in the sample comprising the U.S. and France. For this reason, liquidity or profit seems to increase R&D investment and productivity. In the paper, we include earnings per share (EPS) as a proxy for liquidity and the profit effect in the panel Tobit model. We expect the coefficient between earnings per share and R&D productivity to be positive.

Table 1: Descriptive Statistics

Variable	Mean	Standard Deviation
R&D manpower (*RM*)	606.8	1043.9
R&D expenditure (*RE*)	2003440.1	2824862.1
Physical asset (*ASSET*)	24482802.7	48816320.2
Firm size (*EMP*)	3343.0	4919.8
Debt ratio (*DB*)	30.9	15.7
Credit rating (*TCRI*)	4.5	1.8
Employee bonus (*BOUNS*)	1506.1	4534.7
Earnings per share (*EPS*)	2.4	5.0

Note: BOUNS stands for employee bonus in 1000 NT dollars.

EMPIRICAL RESULTS

The descriptive statistics for all of the variables that we used are presented in Table 1. In the previous section, we defined the Malmquist indices of productivity growth relative to a reference technology. Using this method, three primary issues are addressed in our computation of the Malmquist indices of productivity growth over the sample period. The first is the measurement of productivity change over the period. The second involves the decomposition of changes in productivity into what are generally referred to as an efficiency change (a 'catching-up' effect) and a technological change (a 'frontier shift' effect). Then, the efficiency change is further decomposed to identify the main source of improvement, through either enhancements in technical efficiency or increases in scale efficiency.

At first, we begin by looking at the changes in productivity, efficiency, and technology for IC design firms over the period from 2002 to 2006. In Table 2 descriptive statistics of the average indices of total factor productivity growth (M), efficiency change (E) and technological change (P) over the sample period are presented. As indicated, there was a mean increase in total factor productivity of 21.2% over the period from 2002 to 2006. Given that the Malmquist index of productivity change (M) is a multiplicative composite of efficiency (E) and technological change (P), the major cause of productivity improvements can be ascertained by comparing the values of the efficiency change and technological change indexes. An examination of the components of the Malmquist TFP index for IC-design firms shows that the productivity increase is mainly attributed to the increase in technical change. The technical change component of those firms increases more than the efficiency change component throughout the analysis period.

The numbers of firms for each kind of productivity characteristic are detailed in Table 3, which provides a set of productivity indices that included total factor productivity, the main source of productivity change, efficiency change, the main source of efficiency change, and technological change. As we can see, 16.5 firms on average experienced technological progress. However, only 11.5 IC-design firms encountered

technological regress over the sample period. Furthermore, 16.5 firms experienced an overall gain in total factor productivity. On average 13.25 firms experienced an increase in efficiency. Once again, the main source of productivity change originated from technological change on average (18.5 firms), whereas the main source of efficiency change was derived from scale efficiency. In sum, technological change plays an important role in TFP growth and scale efficiency is more important for increases in efficiency.

Table 2: Average R&D Productivity over the Sample Periods

DMU No.	*Firm Name*	*E= PTxS*	*P*	*PT*	*S*	*M=ExP*
1	United Microelectronics Corporation, UMC	0.602	1.366	0.536	1.122	0.822
2	Advanced Semiconductor Engineering, Inc.	1	1.342	1	1	1.342
3	Siliconware Precision Industries Co., Ltd.	0.84	1.191	0.854	0.984	1.001
4	Orient Semiconductor Electronics, Ltd.	0.791	1.24	1.121	0.706	0.982
5	Taiwan Semiconductor Manufacturing Co., Ltd.	0.819	1.388	1	0.819	1.136
6	Macronix International Co., Ltd.	0.864	1.345	0.832	1.038	1.162
7	Mosel Vitelic, Inc.	1	1.285	1	1	1.285
8	Winbond Electronics Corp.	0.651	1.409	0.649	1.003	0.917
9	Silicon Integrated Systems Corp.	0.757	1.376	0.839	0.902	1.042
10	Lingsen Precision Industries, Ltd.	0.629	1.325	1	0.629	0.833
11	Realtek Semiconductor Corp	1.141	1.49	1.127	1.012	1.7
12	Via Technologies, Inc.	1	1.47	1	1	1.47
13	Sunplus Technology Co., Ltd.	0.97	1.464	0.976	0.994	1.421
14	Nanya Technology Corporation	0.835	1.279	0.841	0.993	1.068
15	Weltrend Semiconductor,Inc.	1.218	1.441	1.015	1.2	1.755
16	MediaTek Inc.	1.014	1.412	1.013	1.001	1.431
17	Elan Microelectronics Corp	0.781	1.44	0.831	0.94	1.125
18	ITE Tech. Inc	0.697	1.497	1.032	0.675	1.043
19	Novatek Microelectronics Corp.	1.162	1.498	1.077	1.079	1.74
20	Farady Technology Corp.	0.842	1.476	0.869	0.968	1.242
21	Ali Corporation	1.177	1.474	1.256	0.937	1.734
22	Powership Semiconductor Corp.	1.543	1.318	1.252	1.232	2.034
23	Vanguard International Semiconductor Corp. (VIS)	0.413	1.088	0.749	0.551	0.45
24	Etron Technology Inc.	0.926	1.403	0.995	0.931	1.3
25	ProMos Technology	0.766	1.316	0.81	0.945	1.007
26	Princeton Technology Corp.	1.168	1.448	0.842	1.387	1.691
27	Anpec Electronics Corp.	0.642	1.335	0.969	0.663	0.857
28	Holtek Semiconductor Inc.	1.357	1.504	1.227	1.106	2.042
	Mean	0.881	1.376	0.938	0.939	1.212

P is the geometric mean of the technological change index over the 2002-2006 period. E is the geometric mean of the technical efficiency index over the 2002-2006 period. PT and S are the geometric mean of pure technical efficiency and scale efficiency over the 2002-2006 period, respectively. M represents the geometric mean total factor productivity index over the 2002-2006 period.

Table 3: Productivity Characteristics over the Sample Period

Year	**Productivity**		**Main source of productivity change**		**Efficiency change**		**Main source of efficiency change**		**Technological change**	
	Gain	Loss	Efficiency	Technology	Increase	Decrease	Technical	Scale	Progress	Regress
2002/2003	16	12	6	22	11	17	13	12	16	12
2003/2004	18	10	8	20	13	15	15	10	18	10
2004/2005	19	9	8	20	14	14	11	15	16	12
2005/2006	13	15	16	12	15	13	9	16	16	12
Average	16.5	11.5	9.5	18.5	13.25	14.75	12	13.25	16.5	11.5

The first three columns of Table 4 present the estimated coefficients and standard errors for the regression of the TFP indices on the vector of explanatory variables. A test of the null hypothesis that all the slope coefficients are jointly zero is rejected at the 0.05 level using a Wald chi-square statistic. As the panel Tobit regression indicated, there is a significant negative relationship between firm size (EMP) and TFP. Some of the literature on firm growth shows that small firms grow more rapidly than big firms (Hall, 1987; Evans, 1987). Then, small firms may catch up with big firms. It is not surprising to find that small firms have higher TFP. The debt ratio (DB) exhibits a significant positive relationship with TFP. One implication derived from the results is that firms with higher debt ratios may have more operating pressure, for the larger the debt ratio, the more effort they will have to make. In addition, the firm's credit rating has a negative impact on TFP (Jenson, 1986). The result is that a firm with a higher credit rating (a worse credit situation) will tend not to borrow funds from the capital market. In addition, big firms will tend to borrow funds in an imperfect capital market. A firm's credit rating will tend to be mainly attributed to a regression in TFP.

Table 4 Determinants of Productivity Variation

Variable	Coefficient	Std. Error	t-value
Constant	2.6465***	0.6149	4.30
EMP	-0.0001***	0.0000	-2.73
DB	0.0341***	0.0136	2.51
TCRI	-0.3396***	0.1379	-2.46
BOUNS	0.0000	0.0000	0.81
EPS	-0.0417	0.0390	-1.07

The dependent variable in the panel Tobit regression is M_{it} *(TFP). Asterisks *** indicate significance at the 0.01 level.*

CONCLUDING REMARKS

The importance of R&D is widely recognized. Many firms engage in R&D to gain competitiveness in the market through the acquisition of patents. Many studies show that R&D investment affects the firm's value. However, it is certain that there have been few studies that have sought to evaluate firms' R&D efficiency or to investigate R&D productivity itself. In this paper, we introduce Malmquist index analysis to examine the time series change in R&D productivity at the firm level. The Malmquist index can decompose the productivity movement into two parts: movements of the frontier due to changes in the technological capabilities of the firm (technical change) and movements of the firm towards (or further away from) the frontier as it becomes more (less) successful at reducing internal inefficiency. We find that there was productivity growth during the sample period. The productivity growth appears to be largely due to an increase in technological change (a frontier shift effect). On the other hand, decomposing technical efficiency scores into pure technical efficiency and scale efficiency provides guidance as to what can be achieved. The scale efficiency scores are close to those for pure technological efficiency. The majority of inefficient IC design firms are inefficient due to their poor performance in terms of their pure technological efficiency. The results indicate that the low utilization of the inputs appears to be the key problem.

The results of the panel Tobit regression also indicate that a number of variables can help explain the variation in productivity change in the period. The most important factors determining the level of productivity appear to be the firm size, the debt ratio and the firm's credit rating (a proxy for the cost of capital), whereas the employee's bonus appears positive but insignificant in determining productivity growth. The methodology presented in this study, which is able to measure the R&D productivity change over the 2002 to 2006 period, is able to provide useful information on the firm's R&D activity management.

To conclude, our study provides new insights into the R&D efficiency. It will be interesting and useful to extend this research to other R&D intensive industry. What is more, we suggest future research might concentrate on the more complex methodologies for analyzing the topic on different countries. The limitations to our model is sample size, additional research needs to collect more firm-level data. Therefore, this study's results are regard as the first step of policymaking. Further results should need samples that are more detailed, calculations, and judgments.

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AN EMPIRICAL STUDY OF SMALL AND MEDIUM-SIZED ENTERPRISE INFORMATION COMMUNICATION TECHNOLOGIES (ICTS)

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ABSTRACT

The purpose of this study is to gather information about the use of ICTs among SMEs by firm size and industry sector and to determine the factors, which are related to the development created by the effective and efficient use of ICTs. In order to study the wide range of ICTs, they are separated in five main categories (Information systems, Enterprise systems, Electronic Business & Commerce, Telecommunications networks and Identification, Data Capture & Telemetric Technologies). The empirical analysis is based on a joint methodology of fully structured questionnaires and personal interviews in 54 Greek SMEs at four different industrial Sectors (Other Services, Manufacturing, Trade and Hotels).

JEL: M1; O3

KEYWORDS: ICT, SMEs, effective-efficient use, strategic management, process planning

INTRODUCTION

It is commonly accepted that our era is characterized by the intense globalization of markets and the constantly increasing competition. Within this global competitive environment, the small and medium sized enterprises (SMEs) are required to wage their own fight, a fight for modernization, for survival and for distinction. The SMEs are a component element of the structure of all economies and societies of our planet. Quite a few studies, research institutions and, of course, researchers have come to the conclusion that small and medium sized enterprises significantly contribute to economic development, production, competitiveness, employment, as well as decentralization and social coherence. They also function as the seedbed of new enterprises, innovative products and applications, flexible business forms, servicing of local needs and a zoning plan for the distribution of employment and income (Storey, D.J. 1994, Singh, R. & Garg, S. 2008, Thomson, A. & Gray, C. 1999).

Most small and medium sized enterprises use information and communication technologies. Relevant research has shown that the use, mainly of computers, serves administrative and functional uses, such as the rendering of accounts, payroll, the drawing up of a budget, inventory, and other similar functions (Bridge & Peel, 1999). The basic condition that arises for the use of computers, but also of all technologies, old or new, electronic or not, is not only their acquisition by the SMEs, but also their correct and functional use (El Louadi, 1998).

In this particular study, what is examined on the first level is the use of Information and Communication Technologies (ICT) among SMEs regarding firm size and industry sector and on a second level, the factors on which the development created by the effective-efficient use of ICT is dependent. For the categorization of the SMEs, what was used was the definition provided by the European Commission

(2003). According to this new definition, in article 2 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 categorizes SMEs in the following three categories:

1. The category of micro, small and medium-sized enterprises (SMEs) are made up of enterprises, which employ fewer than 250 persons and, which have an annual turnover not exceeding 50 million EUR, and/or an annual balance sheet total not exceeding EUR 43 million.
2. Within the SME category, a small enterprise is defined as an enterprise which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million.
3. Within the SME category, a micro-enterprise is defined as an enterprise which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million.

The remainder of the paper is organized as follows. Section 2 briefly 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.

LITERATURE REVIEW

In today's competitive environment, there are three basic reasons, which prove why the efficient use of information systems constitutes a primary condition in the competitiveness of SMEs. First of all, the competitive tension within each market entails that enterprises operate under pressure and therefore, seek out cleverer and more innovative methods in relation to those of their competitors. Secondly, the basic flow of all enterprises is turning inflow into profitable outflow. This means that the producers are directly dependent on the collaboration with their suppliers, their customers and their distribution network. Thirdly, information technology is the one that shows the way towards the internationalization of an enterprise. Researchers such as Quelch and Klein (1996) predicted the significant benefits that stem from the adoption of ICTs in the internationalization effort of SMEs, and they actually came to the conclusion that the creation of the Internet overthrew the traditional methods and practices of global marketing even within the developing economies. Furthermore, they were led to the conclusion that, as distribution channels tend to be less developed, direct and/or efficient in the emerging markets than in the American market, the Internet offers a unique opportunity to overthrow the present situation (Hamill, J.1997, Hamill, J. & Gregory, K. 1997, Poon, S. & Jevons, C. 1997, Bennett, R. 1997, Samiee, S. 1998).

The efficient-effective use of ICTs can contribute also in other ways to the development of the SMEs. The best known ways are microeconomic theory, the theory of transaction cost and the theory of representation. According to the microeconomic theory, the new technologies are considered to be the production factors which substitute capital and labour. The result is the requirement of less capital and labour for the production of the same result. According to the theory of transaction cost, enterprises exist because they can perform transactions internally in a cheaper way than with domestic enterprises in the market. The enterprise is profitable when it enters a market that it has not itself created. Information systems contribute to the reduction of the cost of participating in a market – that is the transaction cost- by making its active engagement within it more attractive. Traditionally, enterprises expand in size to reduce the transaction cost. Information systems reduce by definition the cost for a given size, providing at the same time the opportunity for the increase of income without a further increase in size, or even, in many cases, the opportunity for its reduction (Cordella. A. 2006, Cheung, Steven N. S. 1987, Niehans, J. 1987). Finally, as far as the theory of representation is concerned, the enterprise is a network of contracts among the interested individuals, and not a unified entity that seeks maximization of profit. The owner of the enterprise employs interested individuals by relinquishing authority and delegating responsibility. These

individuals need to be managed, supervised and controlled, which entails a certain cost, the cost of representatives or interested individuals. As organizations grow, the cost of representatives or interested individuals grows. Information systems "put pressure" on the cost curve downwards, thus averting the expansion of organizations at the expense of the cost of representatives or interested individuals (Wickramasinghe, N. 2006).

One of the obstacles hindering the effective use of ICTs in the SMEs is the lack of official planning, programming and methodology. Most of the planning time is wasted on survival techniques that the SME will develop, and as a result, the time allocated to information technology projects is minimal or non-existent (Pollard & Hayne, 1998). This was also shown by the study conducted for the Technology and the Internet in the SMEs by Dandridge and Levenburg (2000), in which many small and medium-sized enterprises are shown as having websites just because they have to. A second serious obstacle is lack of experience in ICTs, as well as in the possibilities offered in the intra-business procedures. Moreover, apart from the technical knowledge and possibilities, the bibliography focuses its attention on the importance of the use of these technologies (Chapman et al., 2000, Yap et al., 1992). The use includes, in essence, the strategic understanding of the opportunities in the market, provided by the new ICTs, their application in the enterprise and, of course, their ability to successfully lead to the creation of competitive advantages (Tetteh & Burns, 2001). A substantial obstacle to the successful use of ICTs for the SMEs is also the lacking understanding of the benefits offered.

On the other hand, neither do the investments on information technology alone suffice to render the enterprises and their executives more efficient, if they are not accompanied by supportive values, structures and attitudes within the organization, and by other complementary assets (K. Laudon & J. Laudon, 2006). Research has shown that the enterprises which invest in complementary assets, such as new business processes, executive behavior, and the organizational culture – training, achieve better performances (Brynjolfsson, 2003, Brynjolfsson & Hitt, 2000, Davern & Kauffman, 2000).

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, among a spectrum of SMEs from 4 out to 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 was 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 were positive responded. The main reason that 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 one deals with the adoption and use of ICTS and part two 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 three covered the financial information and the last part was based on general information about each firm.

Personal interviews were conducted with the person deemed to be most knowledgeable on the ICTs developments 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. Completed questionnaires were coded and analyzed using the SPSS 17.0 (Statistical Package for Social Sciences).

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 the attendance index of SMEs in each industry sector, contribution index of each industry sector in Gross Value Added and E-Business Index. The data for two first indices were found by National Statistical Service of Greece and ICAP databases while the last Index was adopted by *European E-Business Report 2003* (Robinson, S. 2003). The final allocation of our sample (n=54) according to industry sector and firm size is illustrated as follows (Table 1):

Table 1: Distribution of Interviews by Firm Size and Sector

Industry Sector	**Sub-sector – Two Digits Allocation**	**Micro Firms (0-9)**	**Small Firms (10-49)**	**Medium Firms (50-249)**	**Total**
Other Services	K 70, K 72, K74	13	8	2	23
Manufacturing	D15, D 22	2	5	2	9
Wholesale Trade	G 52	7	3	3	13
Hotels	H 55	1	6	2	9
Total		**23**	**22**	**9**	**54**

This table shows the final allocation of our sample (n=54) according to industry sector and firm size.

Finally, the ICTs examined were classified into five main categories. Each category includes those technologies that are more frequently used. More specifically, the main categories of ICTs, as well as the technologies – systems included in each category are the following:

Table 2: ICT Classification

Main ICT Categories	**Technologies - Systems**
Enterprise Systems	Enterprise Resource Planning - ERP Customer Relationship Management - CRM Supply Chain Management - SCM
Information Systems	Transaction Processing Systems - TPS Management Information Systems - MIS Decision-Support Systems - DSS Executive Support Systems - ESS
Digital Technologies	E-Business (includes transactions of enterprise activities only) E-Commerce (includes transactions of commercial activities only)
Telecommunication Networks	Wired Wireless
Identification and Data Capture Technologies & Telematics Technologies	Portable Data Collection, Hand Held Readers, Magnetic & Smart Card Readers, RFID etc.

This table shows the main categories of ICT and the technologies-systems that are included in each ICT category.

It should be re-emphasized that the research was conducted as part of a PhD research; therefore, the survey sample size was necessarily limited, due to financial and time constraints but the authors believed that it would shed some light on the current perceptions of SMEs about the application of ICTs.

EMPIRICAL RESULTS

First, we examine the statistical information from the use of each ICT by Firm Size. Next, we investigate the significance of the differences between firm size, industry sector and each ICT. Finally, we explore the development of SMEs, which was created through the adoption – use of ICTs. The development was evaluated based on the increase in income stemming from the ICTs after the adoption – use of ICTs.

Statistical Information from the Use of Each ICT by Each SME Category

The application study of the information systems TPS, DSS, MIS and ESS produced the following results. First, the information system TPS is used by the 100% of the SMEs of all three categories. The general use of the TPS is totally justified because the specific information system supports the administrative executives in the monitoring of the basic activities and transactions of the enterprise (i.e.: sales, receipts, deposits, payroll, credit decisions and the flow of materials in a factory). Second, the DSS is used only by the small enterprises at a rate of 36.4% and not at all by the micro and the medium-sized ones. The low application of the system by the small firms and the absence of its application by the micro and medium-sized firms were justified by the interviewees through the use of the MIS. More specifically, they claimed that the DSS, as well as the MIS, both serve the administrative level of the firm, and therefore, they prefer to choose the MIS due to limited financial resources. It is true that the MIS is applied by the 34.8% of micro, the 50% of small and the 77.8% of medium firms. Finally, the Executive Support Systems – ESS is used only by the category (10-49) of the SMEs, and not at all by the small and medium firms. The micro firms are expected not to use the ESS because these systems serve the strategic level of decision making of the firm, and their creation is recommended to financially and operationally bigger firms. On the other hand, the absence of use of the ESS by the medium firms constitutes an element for further study because the firms of this size are usually interested in examining strategic matters and long term trends both in their internal and their external environment, which is not confirmed in the specific case.

The Enterprise Resource Planning system is applied at a small rate by the micro firms (13%), while its rate of use by the small firms (59.1%) and the medium ones (88.9%) increases dramatically. With the use of ERP applications, the SMEs achieve the complete and utterly programmed utilization of their resources, by having a complete picture of the people the firm deals with, their human resources, their inventory of products, machinery, storage rooms, etc. It is for these reasons that its wide use is observed especially in the two big categories where the needs for completion of information both horizontally and vertically are greater. The specialized use of the ERP and its adoption cost constitute constraints according to the answers given by the micro enterprises.

The enterprise system CRM is applied at a rate of 34.8% by the micro, of 45.5% by the small ones and of 55.6% by the medium firms. The use of CRM is deemed particularly low in all three categories of SMEs, especially if we take into account that the handling of customers is directly related to the development and the profitability of every enterprise. For the use of the CRM, what is required is the completion of business processes, changes in the organizational processes and in data management, so as to achieve inter-operational completion throughout the enterprise. Sales, marketing and customer service, which may be considered as separate operations, have to be completed. Employees, business partners and third service organizations must share the customers. Many SMEs underestimate the degree to which all company departments can contribute to customer relations, as well as the degree of the required completion. Technology cannot handle customer relations if these administrative and organizational matters are not resolved first. (Day, G. 2003).

For the analysis of the enterprise system for the supply chain management (SCM) the SMEs, which belong to the Sector "Other Services" were not included, as these do not use the specific system due to the nature of their business activity. The study, in the remaining three sectors (manufacturing, wholesale trade and hotels) showed that the SCM is used by the 40% of the micro, and the 28.6% of the small and the 28.6% of the medium firms, which of course surprises us because the micro firms use the SCM more than the small and medium ones, while we would expect the opposite. Even in this case, the application rates are particularly low because the specific enterprise system is not restricted simply to the execution of

orders, but it is connected to strategic matters, such as the ability to create and deliver new products or to create and materialize as new business models (Kopczak & Johnson, 2003).

In general, the SCM is used by the 32.3% of the SMEs, while the CRM by the 42.6% and the ERP by the 44.4%. These three percentages give the indication of low use of the enterprise systems by the SMEs despite their usefulness on both an operational and administrative level, as well as on a strategic one.

For the Technologies of e-business and e-commerce, high rates of use were observed. More specifically the technologies of e-Business are used by the 100% of SMEs of all three categories. This use of e-Business is justifiable because it provides the SMEs with the opportunity to conduct faster and with fewer mistakes their business activities. The technologies of e-commerce are used by the 73.9% of the micro, the 86.4% of the small and the 77.8% of the medium-sized firms. The rates are very high in all three categories, which prove the SMEs interest in approaching new markets and creating new commercial activities at a low cost.

As for the Telecommunication Networks Technologies, the SMEs were asked if they use wired networks and/or wireless networks, or if they do not use Telecommunication Network Technologies at all. According to the given answers, the micro-firms at a rate of 52.2% do not use communication networks. This rate decreases to 18.2% in the small firms and to 22.2% in the medium firms. From the percentages in the three categories arises that one out of three SMEs (33.3%) does not use network technologies at all. This percentage is particularly high; especially if we take into account that information sharing in this day and age is considered to be of vital importance for the development and the competitiveness of enterprises. Finally, as for the use of Identification and Data Capture Technologies & Telemetric Technologies, an increase of application from a category to category is observed, starting from 39.1% by the micro, 63.6% by the small and 77.8% for the Medium Sized ones. The increased use of these technologies is to be expected as they cover daily executive needs by simplifying processes, which in the past were time-consuming, and clerical errors.

From the personal interviews, we observed that the perception of SMEs of the use of ICTs has a dual character, which arises from the executive use of technology, that is the use which directly relates to operational use, and managerial use that lead the enterprise to a higher level of effectiveness and efficiency. The adoption of ICTs starts, of course, from the executive use of every technology that is imported to the organization, and its results are tangible in the short run, while the management use of ICTs sets mid-term goals, and for this reason, its results are tangible on the long run. It is only logical that the SMEs, particularly the micro ones, are more interested in technologies that offer immediate tangible results and less so in results, which will require time to produce results, even if these results will elevate the entire enterprise to a higher business level.

Analysis of Association between ICT and SMEs

To test whether or not the use of each ICT depends on the firm size, we performed a Chi-square test for independence between the two categorical variables. It was found that there is dependence between the two only in the following three cases.

- Firm size and ERP
- Firm size and wired networks
- Firm size and wireless networks

Table 4 tells us that the Pearson Chi-Square statistic equals 18.296 with 2 degrees of freedom (d.f.) and its related p-value is less than 0.0005 (0.000 on the output). It follows that we can reject H_0: Firm size and ERP are statistically independent at the 0.05 level of significance, since the p-value is less than 0.05.

Table 3: Firm Size & ERP, Wired Networks, Wireless Networks Contingency

			ERP		Wired Networks		Wireless Networks		Total
			Applied	Not Applied	Applied	Not Applied	Applied	Not Applied	
Firm Sizes	0-9	Count	3	20	10	13	9	14	23
		% within Firm Size	13.0%	87.0%	43.5%	56.5%	39.1%	60.9%	100.0%
		Adjusted Residual	**-4.0**	4.0	**-2.6**	2.6	**-2.6**	2.6	
	10-49	Count	13	9	17	5	17	5	22
		% within Firm Size	59.1%	40.9%	77.3%	22.7%	77.3%	22.7%	100.0%
		Adjusted Residual	1.8	-1.8	1.8	-1.8	**2.2**	-2.2	
	50-249	Count	8	1	7	2	6	3	9
		% within Firm Size	88.9%	11.1%	77.8%	22.2%	66.7%	33.3%	100.0%
		Adjusted Residual	**2.9**	-2.9	1.0	-1.0	.5	-.5	
Total		Count	24	30	34	20	32	22	54
		% within Firm Size	44.4%	55.6%	63.0%	37.0%	59.3%	40.7%	100.0%
Industry Sectors by NACE									
Industry Sectors (by NACE)	Other Services K 70, K 72, K 74	Count			17	6			23
		% within Firm Size			73.9%	26.1%			100.0%
		Adjusted Residual			1.4	-1.4			
	Manufacturing D15, D 22	Count			3	6			9
		% within Firm Size			33.3%	66.7%			100.0%
		Adjusted Residual			**-2.0**	2.0			
	Trade G 52	Count			6	7			13
		% within Firm Size			46.2%	53.8%			100.0%
		Adjusted Residual			-1.4	1.4			
	Hotels H 55	Count			8	1			9
		% within Firm Size			88.9%	11.1%			100.0%
		Adjusted Residual			1.8	-1.8			
Total		Count			34	20			54
		% within Firm Size			63.0%	37.0%			100.0%

This table shows the count, percentage use and the adjusted residuals of ERP, Wired and Wireless Networks within each firm size as well as the count, percentage use and the adjusted residuals of Wired Networks within the different four industry sectors.

The Chi-square test tells us that there is some departure from statistical independence, but it says nothing about the nature of this departure or how strong it is. Post hoc analyses of the contingency table cells are based on adjusted residuals that are calculated by dividing the residual (i.e., the difference between observed and expected cell frequency) by the standard error of the contingency table cell. The adjusted residuals (table 3) of the categories 0-9 and 50-249 are greater than 1.96 in their absolute magnitude, indicating significant deviations from the independency assumption. In addition, the sign of the adjusted residuals supports the association model since the micro firms that use ERP and medium-sized firms that do not use ERP are both fewer in number than would be expected by chance, as indicated by the negative sign, while the micro firms that do not use ERP and medium-sized firms that use ERP are both more than would be expected by chance, indicated by the positive sign.

Table 4: Chi-Square Statistic for Firm Size and ERP, Wired Networks and Wireless Networks. Fisher's Exact Test for Industry Sector and Wired Networks

					Monte Carlo Sig. (2-sided) 95% Confidence Interval		
	Statistic	**Value**	**df**	**Asymp. Sig. (2-sided)**	**Sig.**	**Lower Bound**	**Upper Bound**
Chi-Square Statistic for Firm Size & ERP	Pearson Chi-Square	18.296(a)***	2	.000			
	Likelihood Ratio	20.334***	2	.000			
	Linear-by-Linear Association	17.645	1	.000			
	N of Valid Cases	54					
Chi-Square Statistic for Firm Size & Wired Networks	Pearson Chi-Square	6.523(b)**	2	.038			
	Likelihood Ratio	6.579**	2	.037			
	Linear-by-Linear Association	5.016	1	.025			
	N of Valid Cases	54					
Chi-Square Statistic for Firm Size & Wireless Networks	Pearson Chi-Square	7.021(c)**	2	.030			
	Likelihood Ratio	7.169**	2	.028			
	Linear-by-Linear Association	4.020	1	.045			
	N of Valid Cases	54					
Fisher's Exact Test for Industry Sectors & Wired Networks	Pearson Chi-Square	8.740[d]	3	.033	.031[e]	.027	.034
	Likelihood Ratio	9.105	3	.028	.042[e]	.038	.046
	Fisher's Exact Test	8.359**			.036[e]	.032	.039
	Linear-by-Linear Association	.000[f]	1	.993	1.000[e]	1.000	1.000
	N of Valid Cases	54					

This table shows the statistical results of the Chi-square test between firm size and ERP, firm size and wired networks and firm size and wireless networks and the statistical results of the Fisher's exact test between industry sectors and wired networks.

a. 1 cell (16.7%) has expected count less than 5. The minimum expected count is 4.00.
b. 1 cell (16.7%) has expected count less than 5. The minimum expected count is 3.33.
c. 1 cell (16.7%) has expected count less than 5. The minimum expected count is 3.67.
d. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 3.33.
e. Based on 10000 sampled tables with starting seed 2000000.
f. The standardized statistic is .009.
* The value is significant at the 0.1 level.
** The value is significant at the 0.05 level.
*** The value is significant at the 0.01 level.

Looking at the data in Table 4, it appears that the Pearson Chi-Square statistic equals 6.523 with 2 d.f. and its related p-value is 0.038. It follows that we can reject H_0: Firm size and Wired networks are statistically independent at the 0.05 level of significance, since the p-value is less than 0.05. The adjusted residuals of the category 0-9 are 2.6 (greater than 1.96) in their absolute magnitude, indicating significant deviations from the independency assumption.

Similarly, examining the data taken from Table 4 the Pearson Chi-Square statistic equals 7.021 with 2 d.f. and its related p-value is 0.030. It follows that we can reject H_0: Firm size and Wireless networks are statistically independent at the 0.05 level of significance, since the p-value is less than 0.05. The absolute values of the adjusted residuals of the categories 0-9 and 10-49 are 2.6 and 2.2 (greater than 1.96), indicating significant deviations from the independency assumption.

Then, the four Industry sectors were examined as to the use, or absence thereof, of the ICTs. More specifically, we wanted to statistically examine the importance of the influence of the Industry sector in relation to the use of the ICTs. It was found that there is a statistically significant association only between the Industry sectors (by NACE) and wired networks.

For the examination between the four sectors and the wired networks, *Fisher's Exact Test* was used as an alternative to the Chi-square test. Recall, that when using Chi-square test, no cell in the contingency table should have an expected count less than 1, and no more than 20% of the cells should have an expected count of less than five; otherwise a Fisher exact test will be more appropriate.

Looking at the data in Table 4, it appears that the Fisher's Exact Test statistic equals 8.359 and its related p-value is 0.036. It follows that we can reject H_0: Industry sector and Wired networks are statistically independent at the 0.05 level of significance, since the p-value is less than 0.05. The adjusted residuals (table 3) of Manufacturing are 2.0 (greater than 1.96) in their absolute magnitude, indicating significant deviations from the independency assumption. In addition, from the comparison of rates of use of wired networks in the four sectors of SMEs, it arises that these are used mostly in the hotel and other services sectors, while in the sectors of wholesale trade and manufacturing, they are used significantly less.

Development of SMEs through the Effective – Efficient Use of ICTs

The development of SMEs, which arose from the effective – efficient use of ICTs, was evaluated based on the increase in the SMEs' income, which was generated by the adoption-application of ICTs. This is income, which would not have been generated if the application of ICTs by the SMEs was not effective – efficient.

The potential for development of the SMEs was evaluated with the help of a model of logistic regression, where the dependent variable is the increase in income of an enterprise after the use of the ICTs (yes, no), and where the independent variables are the presence of a specific ICT strategy for their use (yes, no), the potential of approaching new markets or segments after the adoption of ICTs (yes, no) and the investment in ICTs in 2006 (in thousands of euros).

The table 5 of the analysis is the most important as it provides us with the parameters of the final model together with the equivalent inductive verifications and their validity boundaries. Based on the Wald criterion, a significant influence on the shaping of the dependent variable values stems from the variables *ICT-Strategy* (p-value = 0.003) and *Approach New Markets* (p-value = 0.007), that is the presence of a specific ICT strategy and the potential for approaching new markets or segments. The variable InvestICT_Scale_2006 moves away from the model since its p-value is equal to 0.375.

The reason for maintaining the *InvestICT* variable is to show that the development of the SMEs stemming from the effective – efficient application of ICTs is the result of the adoption of a specific Information and Communication Technologies strategy, and not just the result of the investment in information technology. In reality, it is proven that the development of the SMEs stemming from the effective application of technologies is a matter of strategic planning and the need of approaching new markets-segments thereof.

Table 5: Parameter Estimates

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(B)	95% Wald Confidence Interval for Exp(B)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	-4.660***	1.5892	-7.774	-1.545	8.597	1	.003	.009	.000	.213
[ICT-Strategy=1= YES]	3.809***	1.2833	1.294	6.325	8.811	1	.003	45.123	3.648	558.147
[ICT-Strategy=NO]	0[a]	.	.	.	.	.	.	1	.	.
[Approach_NewMarkets=YES]	3.769***	1.3881	1.048	6.490	7.372	1	.007	43.337	2.853	658.322
[Approach_New Markets=NO]	0[a]	.	.	.	.	.	.	1	.	.
C4.5_InvestICT_Scale_2006	0.000006811	0.00000 76693	- 0.000008221	0.0000218 4	.789	1	.375	1.000	1.000	1.000
(Scale)	1[b]									

This table gives the estimated value of the second category of ICT-Strategy = NO and Approach New Markets = NO when the covariate is equal to 0. The ICT-Strategy=YES and Approach New Markets=YES coefficients subtract the ICT-Strategy=NO and Approach New Markets=NO predicted value from the ICT-Strategy=YES and Approach New Markets=YES predicted values, respectively. Adding one of these coefficients to the intercept estimate gives the estimated value for that level of ICT-Strategy and Approach New Markets, again when the covariate is equal to 0.
a. Set to zero because this parameter is redundant.
b. Fixed at the displayed value.
**** The estimated regression coefficients are significant at the 0.01 level.*

According to the estimated parameters, through the presence of a specific ICT strategy, the odds of income increase for an enterprise with ICT strategy are 45 times ($e^{3.809} = 45.123$) the odds for an enterprise without ICT strategy, irrespective of the potential of approaching new markets or segments. In addition, the odds of income increase of an enterprise that has the potential to approach new markets or segments is equal to $e^{3.769} = 43.337$ times the odds for an enterprise which has not the ability to approach new markets, irrespective of the adoption of a new strategy.

Therefore, the model that is evaluated through the sample data for the development of the SMEs stemming from the use of ICTs, has the following form:

$$\ln\left[\frac{p}{1-p}\right] = -4.660 + 3.809(\text{ICTStrategy} = \text{YES}) + 3.769(\text{App.NewMarkets} = \text{YES}) + 0.000006811(ICTinvest)$$

Where p is the estimated probability of income increase of an enterprise following the use of ICTs, *ICT-Strategy = YES* is the dummy variable which indicates the presence of a specific strategy (in contrast to the SMEs, which do not have a specific strategy for the use of ICTs) and *Approach New Markets = YES* is the dummy variable which indicates the potential of approaching new markets or segments following the adoption of ICTs (in contrast to the other SMEs).

Following the evaluation of the logistic model parameters, what remains is the evaluation of its fit to the sample data. A significant measure of good fit is the goodness of fit test (table 6).

Table 6: Goodness-of-Fit Statistics

	Value	df	Value/df
Deviance	**21.958**	**36**	.610
Scaled Deviance	21.958	36	
Pearson Chi-Square	39.264	36	1.091
Scaled Pearson Chi-Square	39.264	36	
Log Likelihood	-10.979		
Akaike's Information Criterion (AIC)	29.958		
Finite Sample Corrected AIC (AICC)	31.101		
Bayesian Information Criterion (BIC)	36.713		
Consistent AIC (CAIC)	40.713		

This table compares the predicted values of the outcome variable with the actual values. It is the fit of the observed values (Y) to the expected values (Ŷ). The bigger the difference (or "deviance") of the observed values from the expected values, the poorer the fit of the model.

The value of the deviance is equal to $21.958 > X^2_{0.95,36} = 50.998$ and the p-value is equal to $0.9683 > 0.05$. This constitutes an indication that the fit of the logistic regression model that was applied is satisfactory.

An additional measure for the evaluation of the fit of the model to the sample data is achieved through the ratio of the maximum values of the likelihood ratio statistic for the complete model (L_F) and the model which includes only the fixed term (L_0). The value of the ratio is $-2\ln\left(\frac{L_0}{L_F}\right) = 31.883$ (Model Chi-square) with 3 degrees of freedom (p-value < 0.001). We can conclude, that is, that the two independent variables, when combined in the form of the logistic model, significantly contribute to forecast the values of the dependent variable.

CONCLUSION

The purpose of this paper was the examination of the use of ICTs within the operation of SMEs, the association between firm size and ICTs and between industry sectors and ICTs, as well as the contribution of ICTs to the development of the SMEs sector. In addition, an important research objective of this chapter is the role of business strategy in the development and operation of SMEs through the use of ICTs.

From the data which arose from the research in Greek SMEs and according to the categorization of ICTs applied (see Table 2), it was revealed that the SMEs use quite a few and various technologies. More specifically, the micro enterprises (0-9 employees) are more interested in technologies, which produce direct and tangible results and less so in those which produce results that will require quite a lot of time to materialize, while the small enterprises (10-49 employees) and the medium enterprises (50-249 employees) have the tendency to integrate their business processes through the use of ICTs.

From the research conducted, as well as from the results which arose in this chapter, we come to two major findings. The first one is that the perspective of SMEs regarding the use of ICTs is threefold as it arises from the operational use of technology, namely the use that is directly related to elementary activities-transactions and aims at the development within the firm (internal horizontal development), from the managerial use which relates to functions on an administrative level (internal vertical development) and from the strategic use, that is the use leading the firm to the unification of the internal environment of the firm with the external environment of the market.

The second finding is that the adoption-use of ICTs is not so much linked to the size of SMEs, but rather to the functions and the objectives that each firm sets. It is natural that the more firm-size increases, the

more its potential, as well as its needs for the use of advanced technologies also increases, without their constituting the determining factor for their implementation. The determining factors for the effective implementation of ICTs are the drawing up of a specific ICT-Strategy, as well as the need to approach new and/or distant markets, which in the past were impossible without the use of ICTs. Naturally, investment on ICTs has its purpose and its role in the successful development of SMEs, but we now have to grasp the fact that we have transcended to the next level of technology use, which does not concern itself with whether the businesses, the societies and/or the people should invest in technology (this is a given fact), but rather with which technologies they will invest in, how they will use them, which purpose or purposes they wish to serve, and finally, to where they will be led through the use of each technology.

The logistic regression model of SMEs can be used for further academic research in other sectors and sub sectors of SMEs, as well as by the administrators of SMEs as a guide to the successful use of ICTs, which depends on the strategic factor and on the factor of extension-globalization in new markets. In essence, the logistic regression model, which was created, shows the SMEs that their development in today's economic-business era is the result of logical planning and programmed action that is expressed through the implementation of a specific ICT strategy, as well as through the need to expand business activities beyond the usual geographical borders.

At this point, we should not omit to mention that the findings of the specific study are limited to the following four sectors of economic activity, namely 'Other Services', 'Manufacturing', 'Trade' and 'Hotels' as well as to the following seven sub-sectors ICT 'Service-K72', 'Business Services-K74', 'Real Estate Services-K70', 'Publishing & Printing-D22', 'Food-Beverages-D15', 'Retail Trade-G52', and 'Tourism-H55'. Therefore, the findings that arose from the study can be generalized only for the SMEs belonging to these seven sub-sectors.

As it is known, technology constantly evolves and with it must evolve those who are related to it. Therefore, this particular study lends itself to further research, initially in more industrial sectors and sub sectors (two-digit NACE codes) in order to identify as many ICT factors affecting SMEs as possible, and secondly, to investigate the way (qualitative elements) in which SMEs create and develop their ICT-Strategy. Research is already in progress by the authors in the above directions.

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