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Intellectual capital based performance improvement, study in insurance firms

Amir Zakery Abbas Afrazeh

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Amir Zakery
Department of Industrial Engineering and Systems Management, Amirkabir University of Technology, Tehran, Iran, and
Abbas Afrazeh
Industrial Engineering and Systems Management, Amirkabir University of Technology, Tehran, Iran

Abstract
Purpose – Intangible resources are the most distinctive firms' assets in competitive environments especially in service businesses. Insurance firms seeking more efficient performance than competitors should improve their intellectual capital (IC) strategies in both aspects of IC creation and utilization. The purpose of this paper is to investigate and improves IC participation in insurance firms' efficiency.
Design/methodology/approach – A two-phase framework: "explaining IC role in efficiency" and "measuring efficiencies of IC creation and application" is developed in order to find IC strategies increasing firms' efficiency and though competitiveness. Efficiency is measured using data envelopment analysis and the generalized estimating equations is used as the regression method in order to explain efficiency with IC measures.
Findings – Empirical results in Iran insurance sector (during a seven-year period for 17 Iranian insurers) show some IC components influence firms' efficiency and could be intervention points for performance improvement. Then the firms are categorized into four zones in terms of IC efficiency and strategies are recognized for each category.
Research limitations/implications – Although the research is initiated by the need to embed intangible resources in performance improvement in insurance sector, the research framework could be strongly applied in other knowledge-based industries.
Originality/value – This paper embeds an innovative link between classic efficiency and IC which aligns resource management with competitiveness strategies.
Keywords Performance, Efficiency, Intellectual capital, Productivity, Insurance companies
Paper type Research paper

1. Introduction
Efficiency is a basic concept used to indicate the proper utilization of a firm's resources. Efficiency improvement is said to be the right key for wealth creation (Sink, 1983) and is usually defined by the ratio between outputs and inputs. An important question in the field is the quality of transforming firm's input resources efficiently into desirable outputs (Käpylä *et al.*, 2010). The answer might be sought in the inner capabilities of the firm on the basis of the resource-based theory (RBT) (Wernerfelt, 1984). Efficiency is usually measured by the use of classic production factors (mainly capital and labour) as business inputs, and selected performance indicators as outputs. This orientation towards tangible inputs and outputs in efficiency (here called classic efficiency) is derived from industrial era characteristics, not sufficient for knowledge age.

In knowledge-based economy, capital and manpower are no longer main sources of sustainable competitive advantage; the most important resources are intangible resources, usually named intellectual capital (IC) (Sveiby, 1997). IC constitute an important

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part of firms' assets in the service sector (Kianto *et al.*, 2010) and therefore, in the insurance industry. Insurance firms perform mostly on the basis of intangible resources including different human, structural and relational capital; therefore, IC could be the good source of competitive advantage. On the other side, research concerning efficiency measurement in insurance industry had been mostly oriented towards efficient use of classic and tangible labour and financial resources (Jalali Naini and Nouralizadeh, 2012; Cummins and Xie, 2013), neglecting the considerable role of IC resources in efficient performance.

There are several researches in IC efficiency in some industries (Leitner *et al.*, 2005; Campisi and Costa, 2008; Chang *et al.*, 2013), but they could hardly be repeated in insurance industry. Because of the considerable body of efficiency measurement literature in insurance (especially the popular input and output measures that form the efficiency ratio), any related contribution should be based on this background. This becomes more important because most of researches in IC efficiency have selected efficiency measurement indicators (inputs and outputs) from too many different IC measures without a clear logic; and therefore, the validity of efficiency measurement is under question because of anarchy in index selection.

This paper tries to answer the question of "how to establish an IC perspective towards efficiency measurement" in order to extend the efficiency concept in order to include IC role, while preserving and utilizing the validated classic efficiency studies in insurance firms, for example, in selecting proper input/output measures. In other words, how the blended effect of traditional resources and IC resources in efficiency measurement could be considered. The authors will show that the presented framework establishes a conceptual link between IC and efficiency through trying to explain the firm's efficiency with IC measures. This enables the identifying of IC strategies for improving firm's performance and competitiveness.

The paper covers two sequential phases via the proposed framework: "explaining IC role in efficiency" and based on the proven role, "measuring IC creation and IC application efficiencies" in order to find IC strategies leading to higher efficiencies. In the first phase, the prevalent definition of efficiency (classic efficiency) has been regarded as a subjective concept which could be further explained through IC and therefore improved through better IC management. Then, based on selected IC components' role in firms' efficient performance, the authors propose a two-stage IC efficiency evaluation practice. In the first stage, IC components are regarded as internal resources which should be created and produced by the firm, so the efficiency of IC creation is evaluated. In the second stage, IC components are regarded as inputs that are the source of producing competitive results, so IC application efficiency is measured. In this way, while classic efficiency is measured using prevalent input and output indices, IC creation and IC application efficiencies are measured and investigated inside of it and in the direction of its improvement.

Although this framework is established to develop the body of efficiency measurement with emphasis on IC role in the scope of insurance sector, it could be used in other knowledge-based industries because it is based on strong pillars of RBT and general rules of efficiency measurement. This paper directs the attentions of researchers of the knowledge management and IC community to seek value creation from intangible resources in the firm's efficient performance (better ratios of derived outputs to used inputs in relation with competitors); it also sheds new light on the concept of productivity and efficiency of intangible resources, as the new-economy assets.

The paper is structured as follows: in Section 2, theoretical literature is reviewed in relation to IC efficiency; in Section 3, the research framework is explained and two applied methods, DEA and GEE, are briefly discussed. The deployment of the framework in an insurance empirical study is articulated in Section 4; followed by the discussion of findings and research conclusion in the last sections.

2. Theoretical basis

2.1 IC

In recent decades, knowledge-based economy and the special position of knowledge resources in business success have distinguished IC from all other resources (Nonaka and Takeuchi, 1997). Researchers, in an attempt for improving IC management, proposed a variety of methods for measuring the value of IC (Andriessen, 2004). IC is usually categorized into three main components (Stewart, 1997; Sveiby, 1997; Martín-De-Castro *et al.*, 2011): human capital including knowledge, experiences, skills and attitudes possessed by personnel; structural capital (sometimes named technological capital) including business processes, patents, technologies, communications and networks, which are possessed by the company; and finally, relational capital which concerns relational assets between the firm and its external stakeholders, especially customers and owners.

The idea of IC as a lever to create value had been developed in recent years (Marr *et al.*, 2004; Kianto, 2007). IC participation in value creation sometimes referred to as "dynamics of IC" is studied in a broad range of models including process models (Carlucci *et al.*, 2004), causal maps (Dumay and Cuganesan, 2011; Montemari and Nielsen, 2013) and causal loop models (Jhunjhunwala, 2009). However measuring the productivity of IC explains the level of success in achieving valuable results from IC (Chatzkel, 2002). The productivity of traditional resources such as capital and labour as a key success factor has a considerable scientific background (Tangen, 2005), however, knowledge and IC productivity is an emergent issue (Drucker, 1999; Dahooie *et al.*, 2012) requiring more elaboration.

2.2 Efficiency and IC

Efficiency is usually defined by the ratio between outputs and inputs (Sink, 1983); it is a basic concept used in the proper utilization of firms' resources. Comparative efficiency measurement determines which units (companies) have established the best proportion between produced outputs and used inputs, that is, using fewer resources while producing better/more outputs. The most important question in efficiency researches is the quality of transforming input resources in order to produce desirable outputs efficiently. Further, issues such as ranking similar units based on efficiency, recognition of efficient frontier inputs and outputs for inefficient firms and attempts to discover the causal relation between inputs and outputs are discussed in related studies.

There is an important conceptual relationship between productivity, including both efficiency and effectiveness, and IC. Productivity improvement is the key of wealth creation (Sink, 1983), as IC is the crucial factor for gaining competitive advantage (Sveiby, 1997). Käpylä *et al.* (2010) believe that some of the main questions and gaps in relation to productivity research concern IC, such as how different kinds of IC resources affect productivity or what are the inner competencies and functional business chains impressing productivity and how do they perform. Kujansivu and Lönnqvist in a comprehensive conceptual model enumerate six different issues pertaining to productivity and IC interrelations. Some of these are (Kujansivu and Lönnqvist, 2007): the influence of quantity, quality and utilization of IC on efficiency, different complexities in IC efficiency measurement, the relation between IC management and productivity improvement and the probable role of IC in either parts of input, output and catalyst in firms' performance.

Productivity is sometimes used with a broad approach and can include every improvement (Pritchard, 1995). Near to this usage, "knowledge productivity" is defined and developed by some authors as the ability that empowers people and teams acquiring knowledge-based improvements (Harrison and Kessels, 2004; Stam, 2007). Another general application of the term "efficiency" is applied in the value-added intellectual coefficient (VAIC) method by (Pulic, 2000). He introduced IC efficiency as one of two main parts of value creation efficiency (the other part is capital efficiency). This method uses accounting-based figures and has been deployed for IC measurement in several researches (Díez *et al.*, 2010; Laing *et al.*, 2010).

Pulic (2004) emphasized the importance of IC efficiency as a proper indicator of the company's value creation. However, some serious defects exist in the measurement of and even the concept of IC efficiency in this method. Andriessen (2004) challenges some parts of VAIC logic, including dividing the value added by human capital or capital employed separately does not show which one produces how much value added; also the way indicators are calculated and applied; for example, assuming that the effect of structural capital is the inverse of human capital. Ståhle *et al.* (2011) also discussed that VAIC relates more to the company's staff or capital intensity than efficiency of IC. These defects threaten the method's validity at least in the IC research domain (Iazzolino and Laise believe some methodological debates about VAIC arise from semantic differences between Pulic's perception of human and structural capital and the meaning commonly intended by IC research community; Iazzolino and Laise, 2013). Altogether VAIC seems not to be a satisfactory method for measuring IC efficiency in this paper.

IC efficiency has been followed with a direct and explicit approach to the issue of "efficiency" as the ratio between outputs and inputs; vs former introduced approaches of knowledge productivity and VAIC which pay indirectly or implicitly to the issue of efficiency. Here, efficiency measurement is based upon the popular "output to input ratio". RBT which attends the important role of firm-specific resources in achieving competitive advantage (Wernerfelt, 1984; Barney, 1991), forms the theoretical background for this approach. The special position of intangible resources among other resources (Grant, 1996), results in focus on these kind of resources. Data envelopment analysis (DEA) is the dominant method for measuring IC efficiency in these papers (Lu *et al.*, 2010).

Among researches with direct or explicit approach to IC efficiency, Leitner applied DEA as a method for evaluating IC in universities (Leitner *et al.*, 2005). Investigating IC management in Taiwanese companies, Wu applied indices like research and development (R&D) budget, number of patents, IC at the beginning as inputs, and IC at the end of the period and some financial indices as outputs (Wu *et al.*, 2006). IC performance and the role it plays in companies' profitability have been studied in the Istanbul stock exchange market (Yalama and Coskun, 2007). Campisi and Costa (2008) applied DEA and proposed a method for IC management improvement. They identified the company's key resources through identification of cause and effect relations between IC and business performance. Lu proposed a two-stage method for evaluating IC efficiency and showed that IC capability is more important than IC creation in the case of fabless companies in Taiwan (Lu *et al.*, 2010). Kuo and Yang (2012) also combined IC theory with financial data for performance evaluation by means of a two-stage DEA and analysed the statistical effect of IC on performance.

Evaluating the efficiency of intangible resources in firms' value creation, as the focal theme of this paper, has been considered explicitly and directly in this latter approach, but two main gaps exist: although a new concept sometimes titled "IC efficiency" is applied, the relationship between this concept and the popular efficiency (entitled here classic efficiency) has not been discussed and clarified; in classic efficiency measurement literature, there exists rather accepted indices for input and output parts of efficiency ratio for different industries, while not the same in IC efficiency. When a mass of IC measures become alternatives for inputs (or both inputs and outputs) index selection, the problematic issue of valid index selection arises. A short review on the mentioned papers reveals that a variety of IC and tangible resources indices are used in either input or output sides of the efficiency ratio, resulting in a kind of tumble and disorganization in efficiency measurement. In order to assist filling these gaps, a combined method for classic and IC efficiency evaluation is presented; this is a method which relates classic efficiency with IC components and provides a pattern for evaluating the efficiency of an organization's IC.

3. Methodology

3.1 Conceptual model/research framework

This paper concentrates on two important organizational concepts in value creation: efficiency and IC. Classic efficiency, measured as a ratio of performance results (such as return on equity (ROE) in production factors (like labour and capital), is a subjective concept. Although its measurement is usually based on tangible resources and results, it refers to an intangible ability or competency to have better results using the same or fewer inputs than the competitors. This competency is a complex of what is titled "IC resources" including the three main groups of human, structural and relational capital. Classic efficiency as a dependent variable might be explained by IC components as independent variables, and regression analysis can determine which IC components are significantly effective in the efficient performance of organizations.

On the other hand, IC contribution to efficient performance may be tracked through a process of clarification of the classic efficiency black box. IC creation and its participation in value creation is a complicated issue; however, in this study a simple pattern is taken which assumes IC is created or developed within the organization by utilization of traditional production factors; then IC (for example, in the form of skilled staff, product diversity and skilled sale networks) is the source of producing desired outputs or results. So, two stages of IC creation and IC application could be differentiated in IC participation in business value creation.

The research framework encompassing the above factors is illustrated in Figure 1 and contains two phases: explaining IC role in efficiency and measuring IC creation and IC application efficiencies in order to find IC strategies leading to higher efficiencies.

In order to apply the above framework to study IC efficiency in a specific case, a practical procedure is used. This procedure is useful for studying the status of IC efficiency in comparison with similar firms in a specific industry. First, IC role in firms' efficiency is investigated over a period of time. For this purpose, IC indicators should be selected in consideration of the industry's characteristics. Each firm's efficiency is also calculated using the DEA method with inputs and outputs commonly used in related literature of the specified industry. Afterwards, the regression analysis determines whether firms' IC components can explain their efficiency and if they can what the effective components are. These components are critical resources and deserve more precision in IC management monitoring, especially in relation to how efficiently they are created and applied.

In the second phase, IC creation and IC application efficiencies are evaluated for each firm through a two-stage DEA in order to find ways for improvement of IC role in efficiency. The outputs of the first stage, which are also inputs of the second stage, are selected from critical IC components. Determining firms' efficiencies in relation to IC creation and IC application means that firms can be grouped into four categories: firms performing well in both creation and application of critical IC; firms underperforming in both stages; and firms performing well in one and weak in another. Finally, IC management strategies for critical components can be proposed for each group of firms in order to move firms to higher levels of IC efficiency.

The main quantitative methods required for deployment of the proposed framework are introduced in the following section. DEA is the popular method for measuring efficiency; it is used as the main quantitative method of the paper in measuring classic efficiency in the first phase also for the measurement of IC creation and IC application efficiencies in the second phase. Generalized estimating equations (GEE) is a regression model used as a supplementary method to identify IC components required for IC efficiency measurement. It is capable of handling time-correlated data of firms' IC components and efficiencies within years of empirical study.

3.2 DEA

DEA, a way of mathematical programming, is the dominant method used in efficiency studies. It is a non-parametric method which measures relative efficiency of similar decision-making units (DMUs) based on calculating weighted ratios of outputs to inputs. This method has been developed extensively since the first publication (Charnes *et al.*, 1978) and various models for efficiency measurement have been presented and applied over the years (Cook and Seiford, 2009). In the simplest form, efficiency is measured for a set of DMUs, with each DMU $J) j=1, \ldots, n$ (using m inputs x_{ij} $(i=1, \ \ldots, m)$ and generating s outputs $y_{\mathrm{rj}}(r=1, \ \ldots, s)$. Usually the price or multipliers of inputs and outputs are not known, so the benefit to cost ratio cannot be easily calculated. Charnes developed a non-linear programming model to derive

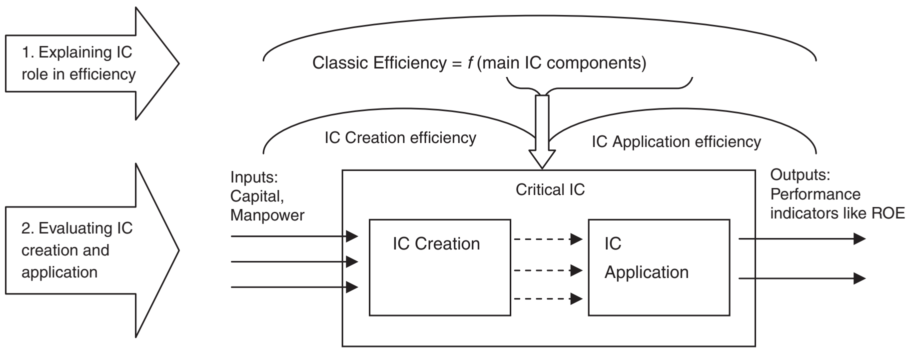

Figure 1.
Framework for intellectual capital-based efficiency improvement

appropriate multipliers for a given DMU, known as the CCR model. Technical efficiency for DMU0 is given by the solution to the problem (Charnes *et al.*, 1978):

$$\begin{aligned} &e_o = \max \sum_r u_r y_{ro} / \sum_i v_i x_{io} \\ &s.t. \sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leqslant 0 \; all \; j \\ &u_r, v_i \geqslant \epsilon \; all \; r, \; i. \end{aligned} \tag{1}$$

This model is a constant return to scale (CRS) input-oriented model which tries to minimize inputs required for generating outputs. For simplicity, and considering that the efficiency measure is an input to further analysis in this paper, the CCR model in forms of input/output oriented forms (as needed) is applied in this paper.

3.3 GEE

The GEE an extension of the quasi-likelihood approach, is used to analyse longitudinal and other correlated data (Liang and Zeger, 1986). In this research, efficiencies of insurance firms during the years of study are regarded as a sample for longitudinal data. Correlation within data clusters (firms here) imperils the validity of the estimation of regression parameters based on regular maximum likelihood estimation (MLE) methods; however, GEE is designed to solve this problem (Myers *et al.*, 2010). Liang and Zeger (1986) considered a model containing different observations of a dependent variable Y_{it} and K independent variables X_{it} (i refers to the number of data clusters, and t refers to the number of periods for correlated data). Assuming Y_i is the vector of dependent variables and X_i is the matrix of independent variables; function h defines the relation between x_i and y_i:

$$E(y_i) = \mu_i = h(X_i \beta) \tag{2}$$

β is a $k \times 1$ vector of parameters which its inverse is known as link function. Also the variance of the variable Y_i is stated with another function of μ_i. Quasi-likelihood estimation of β is derived from solving k below difference equations:

$$U_k(\beta) = \sum_{i=1}^{N} D_1' V_i^{-1} (Y_i - \mu_i) = 0 \tag{3}$$

In GEE model, working correlation matrix is a substitute for unknown correlation of observations. Recognizing an appropriate structure for this matrix is important but difficult. (Pan, 2001) developed an estimator named quasi information criterion (QIC) for comparing models with different working correlation matrices. QIC is a modification of the well-known Akaike information criterion for the quasi-likelihood estimations; the smaller QIC shows better fitness. Furthermore, residual distribution function should be normal as a sign of good fitness. GEE have been applied in different areas such as management. For instance, the relation between firms' resources and competitive initiatives on the performance has been studied by Ndofor using the GEE model (Ndofor *et al.*, 2011).

4. Deployment of the framework

4.1 Insurance industry

In service industries business processes are more hinged on intangible resources than tangible ones (Kianto *et al.*, 2010).The insurance industry, as an advanced financial service, is a knowledge-based industry. Here the product is a simple paper called the "policy", but designing, marketing and selling this paper and providing the associated services requires a combination of knowledge, processes and systems and networks of relations with customers, agencies and investors. IC, including human, structural and relational capital plays a crucial role in creating competitive advantages for insurer firms (Alipour, 2012). The stream of efficiency researches in the insurance industry is rich, but the worthy role of IC is not realized yet.

Insurance has been a growing market in the financial services of Iran in recent years, and the amount of the total premiums sold in 2012 exceeded seven billion dollars (Iran, 2012). After deregulation policies in Iran's insurance system, private insurance companies were established; and since 2001, the number of insurers increased to 22 from four. Also reforms in tariff and pricing policies have intensified competition between insurance firms. Evaluating the IC role in insurers' performance in the more competitive markets after deregulation policies, would be interesting and instructive for both policy makers and firms' managers. As it is expected, in a rather competitive market more firms figure on investing on intangible assets, seeking ways towards more efficient performance than competitors. Proof of more investment in R&D units, brands, sales staff and network skills, and so forth may be observed between Iranian insurers in recent years. Furthermore, the move to a knowledge-based economy is emphasized in many of the country's development plans including insurance industry vision, which highlights the necessity of IC management initiatives.

In this study, all Iranian mainland insurer firms active in the main insurance fields with more than two years history are included (which involved 17 insurers or 99.8 per cent of the market share of Iran's insurance in 2012). Time scope of the study is a seven-year period in order to reinforce data quality, especially from the aspect of finding effective IC components in relation to efficiency.

4.2 Efficiency and IC measures

Measures for DEA in insurance: efficiency measurement based on DEA method has been under study from different viewpoints in insurance industry (Emrouznejad *et al.*, 2008). Dionne *et al.* (2000) showed there is a relative consensus between related papers for selecting inputs; but for the outputs selection there are two main approaches to measure insurer outputs: value-added and financial intermediary. Cummins and Weiss following the value-added approach recognized outputs based on main insurer's products for both company owners (financial performance indicators such as ROE) and customers (sum of losses incurred) (Cummins and Weiss, 2000). On this basis Jalali Naini and Nouralizadeh (2012) used manpower, owned (financial) resources and administrative costs as inputs and ROE and losses incurred as outputs and they achieved good results in Iran's insurance industry. The same measures are used in this study, as they cover main key assumptions relating to the input/output set (Dyson *et al.*, 2001).

IC measures: in order to identify IC components and the appropriate industry-specific measures in the insurance industry, related literature in insurance industry was reviewed (Outreville, 1998; Mouritsen *et al.*, 2001; Hasanzadeh and Zare, 2008) among others; and interviews were held with experts. Altogether, identified IC components in insurance reach to 19 groups across three categories of human, structural and relational capital; mainly including expertise and knowledge in areas such as loss assessment, financial management, investment, actuary, management and marketing/sales skills (human capital); brand, R&D committees, new products, technical rating instructions and operational software (structural capital) and relationships with customers (quantity and quality), agencies and owners (relational capital).

In this research quantitative IC measures are needed which are available or can be calculated using formally published data for Iranian insurance firms during the seven-years period. Using data published in the Annual Report of Central Insurance of Iran as the most inclusive and valid report, nine IC components were selected that could be calculated with available data. Selected components (rechecked with several IC lists) include education level (Ordóñez De Pablos, 2003), experience level (Mouritsen *et al.*, 2001) and a proxy for sales skill (Jhunjhunwala, 2009) in human capital category, company's age (Shih *et al.*, 2010), new products (Ordóñez De Pablos, 2003) and product portfolio diversity (Bianchi and Bivona, 2005) in structural capital category and the number and skills of agencies (Hasanzadeh and Zare, 2008) and market share (Mouritsen *et al.*, 2001; Bianchi and Bivona, 2005) in relational capital. One or two measure(s) is selected for each component and reported in Table I.

4.3 *Practical steps of the study*

The required steps for deploying the research framework are articulated here in two distinct phases: regression analysis between efficiency and IC indicators; and evaluation of critical IC creation and application (Figure 2).

Phase 1: regression analysis between efficiency and IC:

(1) Calculating IC measures: the main IC components were recognized and relative measures in consideration of data accessibility limitations proposed (Table I). These measures cover all three IC categories and were calculated for all 17 firms during a seven-year period (2006-2012).

IC categories	IC components	Measures	Max.	Min.	Mean	SD
Human capital	Education	Percent of graduated staff (Edu)	0.862	0.278	0.586	0.114
	Experience	Percent of staff with more than 10 years' experience (Exp)	0.718	0.012	0.2441	0.196
	Sales staff skill	Policies produced per insurer's staff (SSK)	11,708.9	3.481	1,873.27	1,918.61
Structural capital	Company's reputation	Company's age (Age)	82	1	16.650	21.793
	New products	Number of new products generated by insurer (NP)	8	0	0.764	1.470
		New products' share in insurer's sales portfolio (NPS)	0.5197	0	0.091	0.111
	Product portfolio diversity	Inversed of Herfindahl Index (PPD)	7.988	1.396	4.348	1.600
Relational capital	Market share	Insurer's market share (MS)	52.700	0.030	6.599	11.846
	Agencies	The number of insurer's agencies (AN)	6,958	0	910.457	1,185.02
	Agencies' skills	Commissions paid per premiums earned (specialized skills) (ASS)	21.8	0.008	9.5246	4.218
		Insurer's earned premiums per agencies (general skills) (AGS)	18.569	0.005	2.155	2.402

Table I. Selected IC components and related descriptive statistics

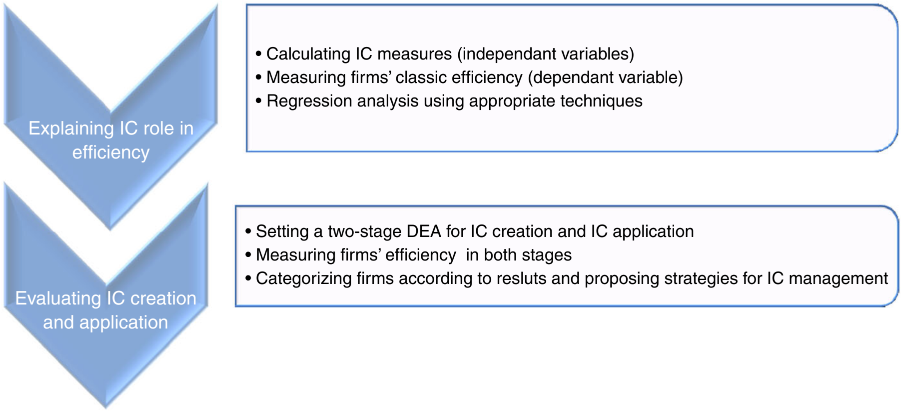

Figure 2.
Practical steps for the study

(2) Measuring firms' classic efficiency: firms' efficiency in each year of the period of study is measured using the DEA-CCR input-oriented model. The input-oriented model was selected because firms usually have direct authority on setting input amounts.

(3) Regression analysis using appropriate technique: firms' efficiency is formulated as a regression function of IC components and the following equation is solved as proposed by Coelli *et al.* (1998) with the difference that explaining variables are firms' resources, not contextual variables:

$$\hat{\delta}_{it} = \beta_1 + \beta_2 \times Edu_{it} + \beta_3 \times Exp_{it} + \beta_4 \times SSK_{it} + \beta_5 \times Age_{it} + \beta_6 \times NP_{it} + \beta_7 \times NPS_{it} + \beta_8 \times PPD_{it} + \beta_9 \times MS_{it} + \beta_{10} \times AN_{it} + \beta_{11} \times ASS_{it} + \beta_{12} \times AGS_{it} \quad (4)$$

$\hat{\delta}_{it}$ refers to the efficiency of insurer i in time t , other variables are IC components introduced in Table I.

Efficiency is the dependent variable here. Efficiency measures for a firm in different successive years are naturally correlated, because many tangible and intangible infrastructures are unchanged; other independent variables (IC components) are correlated for the same reason. The whole data are segmented into clusters in relation to firms; GEE models are capable of considering correlation within clusters. In order to select and deploy an appropriate GEE model, dependent (response) variable distributions, link function and especially the working correlation matrix should be defined. Efficiency is a scalar variable; therefore, a normal distribution for a response variable and identity link function for calculating the mean and variance may be suitable. Because of the importance of attaining a proper correlation matrix in GEE models (Ballinger, 2004), the authors examined the model with all popular structures (autoregressive, exchangeable or uniform correlation, M-dependent with M between 1 and M-1 = 6 (number of data periods minus one); and unstructured). Regression procedure is performed according the backwards method; all independent (explanatory) variables enter the model at first, and the one with the highest error (those with sig > 0.05) exits; the model is run repeatedly as long as all remaining variables are significant at 5 per cent error.

In selecting a proper correlation matrix from mentioned popular structures, the Quasi-likelihood information criterion statistics is used, as the smaller QIC shows better statistical modelling. In addition, the dependent variable's residual distribution should be normal in an appropriate model. For different correlation matrices analysed in this paper, exchangeable and $M = 3$ structures were omitted because they can result in non-normal residuals for dependent variables. Among others, the unstructured model was selected for three reasons (look at Table II for the main statistics of each model): this model had the least QIC (15.135), the normal distribution test is significant (at 0.325 sig), and generally speaking, an unstructured model has the least constraints or presumptions about correlation, although it has the ability to adapt to different structures of correlated data.

Consequent iterations of stepwise regression procedure based on an unstructured correlation model are shown in Table III and the variable rows remaining in the final regression equation are highlighted.

In the selected GEE model, *staff education* (Edu) from human capital and *number of agencies* (AN) from relational capital proved to have a positive influence on efficiency. *New product* (NP), *product portfolio diversity* (PPD) and *new products' share* (NPS) – all from the structural capital category – influenced efficiency negatively; other components (variables) are not statistically significant. IC components with positive influence are those resources that cause efficient performance by partaking in business competencies; furthermore, IC components with negative influence could not match firms' competencies and take part in value creation effectively. However, IC components which considerably influenced firms' efficient performances could be considered critical resources. Monitoring and evaluating critical resource formation and application is the subject of the next phase.

Phase 2: IC creation and application evaluation:

(4) Measuring firms' efficiency using a two-stage DEA: empirical results in phase 1 showed that firms' efficiency can be explained using IC components in relation to Iranian insurance. Efficiency measurement in this phase directly follows IC resources as types of intra-organizational assets, and how efficiently these are created and applied in generating performance results. Therefore, a two-stage IC evaluation practice is proposed using the DEA method. The first stage evaluates the creation of selected IC indicators, and in the second stage IC application in producing performance results is evaluated (the logic behind this two-stage approach to consider IC role in transforming traditional resources into final outputs is mentioned in the research framework section). Considering the limitations in the number of input and output variables in DEA, three IC components are selected from critical resources: *staff education*, *agencies* and *product portfolio*, which cover all the three main IC categories. Inputs and outputs deployed in two-stage DEA are showed in Table IV.

The DEA model is input oriented in the first stage (IC creation), but in the second stage (IC application), the output-oriented model is more coincident with the logic of

Table II. Comparison between models with different colouration structures

Model selection statistics	AR(1)	M(6)	M(5)	M(4)	M(2)	Unstructured
	Colouration structures					
QIC	17.6	21	15.7	39.12	17.5	15.13
Asymp. sig. for residuals	0.085	0.093	0.215	0.337	0.061	0.325

Table III. Iterations of stepwise regression procedure based on an unstructured correlation model

	Iterations 1		2		3		4		5		6		7	
	β	Sig	β	Sig	β	Sig	*B*	Sig	β	Sig	β	Sig	β	Sig
Intercept	−0.289	0.11	−0.27	0.196	−0.126	0.555	−0.211	0.24	–		–		–	
Edu	1.542	0.000	1.702	0.000	0.958	0.001	1.694	0.00	2.04	0.000	1.029	0.000	1.058	0.000
Exp	−0.276	0.042	−0.288	0.026	0.197	0.19	−0.288	0.028	0.143	0.436	–		–	
SSK	0.018	0.518	–		–		–		–		–		–	
Age	−0.033	0.42	−0.019	0.593	−0.115	0.009	–		–		–		–	
NP	0.062	0.000	0.063	0.000	−0.059	0.000	0.065	0.000	0.024	0.2	−0.074	0.000	−0.076	0.000
NPS	−0.611	0.000	−0.668	0.000	−0.734	0.000	−0.725	0.000	0.526	0.045	−0.708	0.000	−0.69	0.000
PPD	−0.054	0.000	−0.058	0.000	−0.021	0.223	−0.06	0.000	−0.069	0.001	−0.031	0.000	−0.023	0.008
MS	−0.004	0.33	−0.004	0.416	–		–		–		–		–	
AN	0.083	0.001	0.079	0.006	0.152	0.000	0.066	0.008	−0.09	0.000	0.087	0.000	0.096	0.000
ASS	0.012	0.001	0.013	0.000	0.004	0.507	0.014	0.000	0.012	0.17	0.008	0.089	–	
AGS	0.013	0.024	0.01	0.081	0.019	0.258	0.008	0.136	–		–		–	
QIC	44.401		44.044		25.213		35.637		42.559		15.769		*15.138*	
Sig													*0.325*	

generating more results using existing IC levels. The efficiency in IC creation and IC application for each firm in each year of study is calculated:

(5) Categorizing and analysing the results: the authors need to categorize the measurement results in order to get further insights into how companies can improve their IC management strategies to achieve better efficiencies. To summarize the results: the average amount of IC creation and IC application is calculated for each firm during the period. Then the status of each firm is illustrated as a point in a two-dimension coordination system (firms' position in IC efficiency plot depicted in Figure 3). The horizontal axis states the efficiency of IC creation and the vertical one states the efficiency of IC application. Two dividing lines on the average points of the axes create four zones. For simplicity, firms with more than average efficiency are named (rather) efficient and those with less than average efficiency are named (rather) inefficient. Zone 1 (IC-disabled) contains inefficient firms (numbers 4 and 9) in both IC creation and application. Zone 2 (IC utilizers) contains firms (5, 7, 8, 15, 17) rather inefficient in IC application but rather efficient in IC creation; unlike zone 3 (IC creators) firms (1, 2, 3, 10, 11, 12) which are rather efficient in IC application and

Table IV.
Inputs and outputs deployed in two-stage DEA

IC creation (first stage)		IC application (second stage)
Inputs	Outputs Inputs	Outputs
Owned (financial) resources	Staff education	Return on equity (ROE)
Number of employees	number of agencies	Losses incurred
General and administrative expenses	Product portfolio diversity	

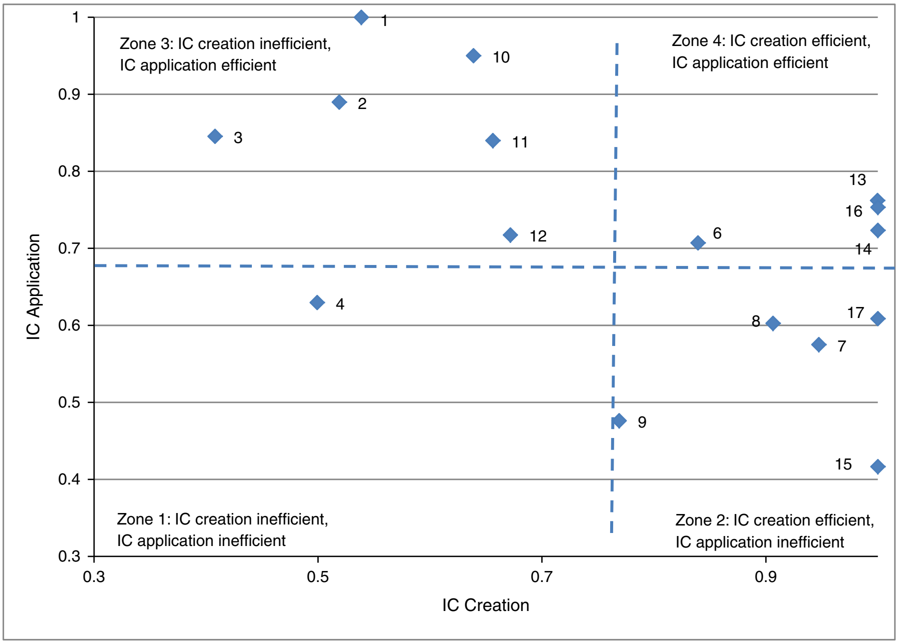

Figure 3.
Firms' position in IC efficiency plot

rather inefficient in IC creation. Zone 4 (IC-enabled) firms (6, 13, 14, 16) are efficient in both dimensions. Efficient firms in IC creation could create good levels of IC, consuming fewer resources than the competitors; in addition, efficient firms in IC application could generate better outputs using existing IC.

DEA defines efficiency frontier and the relative inputs and outputs for efficient firms with target outputs and inputs: thus, shortage and surplus (excess) amounts for inefficient firms moving towards efficiency frontiers can be calculated. Here, with focus on IC output/input amounts, shortage means shortage in creating the specific IC (as output) and surplus means excess in the specific IC that has not been applied (as input) in generating outputs. Table V shows the average amount of slack variables for firms of each zone. The biggest amounts in IC creation efficiency relate to zone 3, which was expected because these firms are robust in creating IC resources, while weak in making value from them. Product diversity has bigger amounts in IC shortage in comparison with IC application (except for zone 3) indicating that most companies need to apply and utilize this asset much more than to increase its level; as was mentioned in relation to its negative coefficient in efficiency regression. Also, the average classic efficiency of each zone is shown in the last column, which indicates the efficiency increases between zones as IC creation and IC application efficiencies improve.

Using IC shortage and surplus amounts, strategies can be designed for improvement of IC creation and IC application (see Table VI). These strategies can be differentiated in terms of zones and IC components. The strategies in column "IC creation" are on the basis of creating more IC, while using the same levels of production factors (labour, owned financial resources and administrative costs) thus leading to decreasing IC shortage and so improving IC creation efficiency. The strategies in column "IC application" are on the basis of better activation and utilization of existing IC in order to generate higher final results (ROE and incurred losses) which cause decrease in IC surplus and so improvement of IC application efficiency.

Table V. Average amount of slack variables for firms of each zone

	IC shortage (in IC creation)			IC surplus (in IC application)			
Zone	Education	Number of agencies	Product portfolio diversity	Education	Number of agencies	Product portfolio diversity	Efficiency
1	0.24	0	0.33	0.00	8.2	2.12	0.594
2	0.00	0	0.21	0.06	3.57	1.09	0.74
3	0.55	11.5	4.14	0.02	0	0.57	0.835
4	0.014	0	0.26	0.12	5.02	1.04	0.908

Table VI. Proposed IC strategies for efficiency improvement

Transmission	IC creation	IC application
1-2	Staff education increase Portfolio diversity increase	Agencies activation Better utilization of portfolio diversity
2-4	Different per firm	Different per firm
3-4	Staff education increase Agencies increase Portfolio diversity increase	–

In order to improve efficiency, firms in zone 1 should achieve higher levels of staff education and more product portfolio diversity. These firms do not need to increase their agencies, but to activate the existing ones more, and utilize the benefits of product portfolio diversity to reach higher performance. Common strategies for improving firms located in zone 2 cannot be recognized because these firms are a little inefficient in IC application, in comparison with firms in zone 4. Zone 3 firms should create more from all IC components. Therefore, portfolio diversity increase or utilization is repeated in all proposed strategies, because this variable could not meet the target. This observation is in compliance with negative influences of portfolio diversity in classic efficiency.

5. Discussion

Findings of this paper are investigated and discussed in two parts: the proposed method could recognize efficiency improvement initiatives based on effective IC components on Iranian insurance firms' efficiency; and findings related to the general application of the proposed method.

In the first part, the empirical results from 17 Iranian insurance firms (in a seven-year period) show selected IC components could explain efficiency. Variables with significant positive effect are *staff education* (human capital) and *agencies* (relational capital) (with coefficients 1.058 and 0.96, respectively) and *portfolio diversity* and *new products* (the number and its share in insurer's portfolio all from structural capital) have negative influence (with coefficients −0.023, −0.076 and −0.69, respectively). Because of bigger coefficients of positive-effect variables one could conclude that IC positively affects efficient performance in Iran insurance, which is rather similar with Iswati and Anshori's (2007) results in Indonesian insurers. It is observed in this study that indicators from human and relational capital have been effective in establishing efficiency in insurance firms, but structural capital indicators could not motivate insurers' efficient performance.

Then, based on measuring firms' efficiency in IC creation and IC application, the firms were categorized into four categories: IC-enabled firms (zone 4) are efficient in both creation and application of IC; IC creators (zone 3) are just efficient in creating IC; IC utilizers (zone 2) are just efficient in applying IC; and IC-disabled firms (zone 1) are not efficient in creation nor in application of IC. This categorization of firms deems to be sound because firms with higher (classic) efficiency are located in zones with bigger numbers (look at the first and the last columns of Table V). Higher (classic) efficiency of zone 3 relative to zone 2 could have similar implications to the findings of Lu *et al.* (2010) that IC application (capability) is more important than IC creation. Further, the fact is that efficiency in IC application is more difficult and less met than IC creation as observed in Figure 3 is similar to Lu *et al.* (2010) findings.

The negative effect of structural capital measures on efficiency may be relevant to the nature of structural capital as a rather perfect resource, that is, a form of packaged knowledge in business processes and products and its development and utilization takes place gradually (Roos *et al.*, 2012). Furthermore, sometimes the effect of intangible resources on performance arises with delays (Sydler *et al.*, 2014) or out of the company in the form of the spin-off industry effects (Lönnqvist, 2007). Another study involving Iran's insurance firms shows that the value added by structural capital is not as great as human capital (Chavooshi *et al.*, 2010). However this result differs from that of (Cummins and Xie, 2013) showing that both product line and geographical diversification (relating to structural capital) have favourable impacts on productivity and efficiency change in the US property-liability insurance industry; nevertheless they refer to some studies reporting contrary findings.

In the second segment relating to the general application of the framework, the authors showed that the framework could propose proper position for both tangible and intangible resources in efficiency measurement in insurance industry. So, the problem of anarchy in measures selected for the efficiency ratio in domain of IC that is observed in several researches (e.g. Wu *et al.*, 2006; Lu *et al.*, 2010) is fixed; furthermore the findings obtained from classic efficiency studies could be adjoined to IC targets and strategies. This embeds a different perspective to intangible resources management and strategy based on efficiency measurement from the "alignment verification" proposed by Campisi and Costa (2008). This framework's application is useful in other knowledge-based industries at least when classic efficiency measures are determined and identical/similar in most of studies in order to link between the established literature of efficiency with new IC researches in that industry.

6. Conclusion

Nowadays, knowledge and IC are firms' most distinctive assets and the process of deriving value from these resources is very important. For this reason, Drucker (1999) recognized knowledge productivity as a big challenge in the twenty-first century. This paper quests in the common area between two important concepts in relation to firm's performance: efficiency and IC. The outcome of this research includes development of a research framework and its deployment in an empirical study. The research framework is focused on analysing and improving IC participation in efficiency establishment. This framework constitutes two connected dimensions: the explanation of efficiency as a dependent variable with IC components as independent variables, and investigating the classic efficiency black box from the viewpoint of IC contribution to efficient performance in two stages of creation and application of critical IC. Implementing-related practical steps in Iran's insurance industry provides an analysis on IC engagement in efficient performance of firms and recognizes IC strategies in improving IC management.

This paper's approach to IC measurement is an indirect approach with an emphasis on IC participation in firms' efficient performance. Efficiency is the selected perspective to IC measurement considering both classic efficiency and IC efficiency. Though the research framework considers an appropriate role for both tangible and intangible resources, tangible resources are the primary factors of production and intangibles are more perfect resources which form competencies and are intermediates for generating final products. Besides the above contribution to theoretical aspects of IC, this paper directs the attention of managers to seek IC profitability and value creation in more efficient performances, not exclusively in amplifying results.

This paper investigates and improves IC participation in firms' efficiency. Although the primary needs for developing a framework which could establish a proper position for both classic resources (production factors) and IC resources in efficiency measurement were originated from insurance industry, the framework is not specially developed for this industry. The application of the proposed framework helped linking IC and efficiency and led to identification of IC strategies for improving efficiency in the tested context of Iranian insurance industry.

However, limitations exist in the research framework and related practical steps which constrain the findings and might be the starting point for future researches. Evaluating the IC role in efficiency was based on an industry-based view and it is assumed that the IC role is identical in firms of a specific industry. IC components that influence efficiency were recognized according to this industry-based view, while the specific characteristics of IC in each context (firm) should be noticed more. Also, data limitations in this research confined IC measures that were used in the method; while an inclusive list of IC components for insurance firms were recognized in primary studies. In fact, selected components could be extracted from a principal component analysis in the case of more available IC measures in order to represent better the concept of IC. Although the scope of the empirical study is limited to Iranian insurance industry, research could be expanded through several countries with the same presented model to gain international findings in other knowledge-based markets, especially those less affected by market regulations and restrictions as insurance is.

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About the authors

Amir Zakery is a PhD Candidate of Industrial Engineering. His major areas of research are Intellectual Capital Management, Knowledge Management, Systems Dynamics and Technology Management. He has practical experiences and also published several papers in these areas.

Abbas Afrazeh is an Associate Professor in the Amirkabir University of Technology, Tehran, Iran, Faculty of Industrial Engineering and system management. His major areas of research and teaching are as follows: Knowledge management, Human Resource (Knowledge Worker) Management and Productivity, Motivation and Reengineering. He has written a book on knowledge Management (2005, 2nd ed., 2007 3rd, 2010). He has published about 105 scientific papers (also 74 KM papers) in different Iranian and international journals and conferences. Abbas Afrazeh is the corresponding author and can be contacted at: afrazeh@aut.ac.ir

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