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A New Equation for Human Intellectual Capital Management Intelligent Website for Managing Communities of Practice of Academic Organizations and Financial Investments by Using Adaptive and Dynamic Assessment Networks

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Abstract

In the forthcoming twenty century, economic system of each country should be driven based on sciences, technology and innovations developed by specific knowledge from specialists called knowledge workers. This is an important strategy of Thailand to develop new products and services for surviving in serious business competition. Therefore, essential knowledge in knowledge workers such as skills and experiences for developing new products, services and innovations are required. This tacit knowledge (knowledge in human) should be appropriately measured and managed in the perspective of intellectual capital or intangible capital management. This paper attempts to answer the question "How to appropriately measure tacit knowledge by using graph theory?". Thus, a new equation to measure intellectual capital for managing excellent centers and laboratories is presented in this paper. This is the novel impact factor equation which considers the dimension of time and frequency of published articles combined with the other impact factors of each published paper on Scimago Journal Rank website and Scopus. Moreover, it is not only the formula which is the quantitative intellectual capital assessment but the intellectual capital indicators and the intellectual capital analysis for university are illustrated in the form of qualitative intellectual capital assessment also. Moreover, intellectual capital management intelligent website for managing Communities of Practice (CoP) of academic organizations and financial investments by using new equation and Dynamic Assessment Networks (DANs) is developed also. The proposed concept and methodology is a basis for risk management in terms of human capitals and financial investments.

Keywords: Intellectual Capital Assessment and Management (ICAM), Dynamic Assessment Networks (DANs), Statistical analysis, Information processing, Communities of Practice (CoP), Knowledge Management (KM), Knowledge Management System (KMS), Intelligent Website, Control System, Risk Management, Financial Investments

1. Introduction

Nowadays, Knowledge Management (KM) plays an important role in almost organizations. Essential knowledge is required to operate business activities and strategic plannings. It is not only Explicit knowledge (knowledge in documents or databases etc.) but Tacit knowledge (knowledge in human) also. This knowledge is applied to discover and develop the new products, services and innovations to survive in the serious business competition. These outcomes are produced by knowledge workers or experts or specialists and Adam Smith who is a well-known economist, proposes that an economic system should be driven by specialists (Adam Smith, 1776).

Larry Prusak (a member of the IBM Consulting Group) states that "you may not be able to measure knowledge, but you can measure outcomes, which are knowledge proxies" (Liebowitz, 1999). This means that specific knowledge or complex knowledge is difficult to assess especially Tacit knowledge (knowledge in human). However, it can be measured from their outcomes. In particular, universities and hospitals, where advanced knowledge or special knowledge or complex knowledge of experts is required. As the reason that the

development and improvement of the new innovations, products and services are the results of experts in CoP, for instance excellent centers and laboratories in universities.

Moreover, "Wiig (1994) states that knowledge and IC is the most important asset in the twenty-first century" (Liebowitz, 1999). Among related KM approaches, IC assessment plays an important role to drive organizations for surviving in the serious business competition. The valuable knowledge in experts in CoP should be appropriate measured. In this study, a new equation for assessment this knowledge for selecting the suitable experts as well as establishing the appropriate excellent centers and laboratories for Chiang Mai University is revealed. A new concept and equation are presented as graphical and quantitative forms by using Dynamic Assessment Networks (DANs). DANs is a graphical method which can be used to represent both

qualitative and quantitative data, information and knowledge. This technique is applied to measure the IC of experts in universities and hospitals where the specific knowledge is required to diagnose disease and to conduct academic activities. Graph theory is widely applied to measure expert's knowledge and represent this knowledge in the forms of graphs and numbers before constructing Medical Expert Systems, Medical Knowledge-Based Systems and Medical Knowledge-Based Diagnostic Decision Support Systems. Graphical models are presented in several tacit knowledge such as the medical researches including,

- The research of Paokanta, Ceccarelli and Srichairatanakool (2010) reveals the using of Influence Network-Based Chi-squared test to represent expert's knowledge before using neural networks and statistics to discover the efficiency of data types for classification performance of Machine learning Techniques for screening β-Thalassemia. In this paper, they propose that the performance of KNN and MLP on a nominal scale is better than an interval scale. It means that most ANNBR techniques obtained satisfactory results when the data type was analyzed on a nominal scale.
- Moreover, in the research of Paokanta and Harnpornchai (2012) presents that the using of Diagnostic Bayesian Networks (DBNs) to represent tacit knowledge. Thalassemia screening indicators are filtered by Pearson-Chi squared before using DBNs to represent them.

On the other hand, in some graphical researches for medical systems, in the case that Artificial Neural Networks does not produce satisfactory results because the data types used to generate models are inappropriate for the given Knowledge Discovery (KD) algorithm. Other KD techniques such as Machine learning and Statistical methods require the specific methods following their assumptions to filter variables before proceeding in the next process. Graphical methods in the previous related researches including,

- DBNs-BLR (MCMC) -GAs-KNN: A novel framework of hybrid system for thalassemia expert system is proposed by Paokanta (2012). Moreover, a new methodology for Web-Knowledge-Based System using Systematic Thinking (ST), KM Process and Data and Knowledge Engineering Technology: FBR-GAs-CBR-C5.0-CART is proposed based on hybrid Decision Trees also (Paokanta, 2013).
- There are not only Diagnostic Bayesian Networks that are selected for representing knowledge before implementing inference engines but Decision Trees also. In the study of Hybrid Bayesian-Based Reasoning: Multinomial Logistic Regression Classification and Regression Tree for Medical Knowledge-Based Systems and Knowledge-Based Systems, the Bayesian-Mixed Probability Distributions are generated and improved the estimated parameters by using Markov Chain Monte Carlo with Methopolis Hasting and Gibbs algorithms. The obtained satisfy model is the model with Markov Chain error 0.0112-0.2473 for 500,000 iterations (Paokanta, 2014) and the algorithms of this paper are combined with Case-Based Reasoning (Paokanta, 2015).

These are the review of applied graph theory to managing Tacit knowledge. In the next section, the literature review of the using of graph theory to IC assessment.

The research of Nick Bontis (2001) reveals that the intellectual capital assessment methods including, Skandia navigator, IC-index, Technology Broker's IC audit, Intangible asset monitor, MVA and EVA, Citation-weighted patents and Research agenda. In this review, he proposes not only advantage points of each IC measurement methods but their disadvantage points also.

In addition to in the research of Jolanta Jurczak (2008) reveals that IC assessment methods include Direct Intellectual Capital Methods (DICM), Market Capitalization Methods (MCM), Return on Assets Methods (ROA) and Scorecard Methods (SC). Moreover, she presents IC measurement methodologies based on four main methodologies including,

1. ROA methodologies: Economic Value Added (EVA™), Human Resource Costing & Accounting (HRCA), Calculated Intangible Value, Knowledge Capital Earnings, Value Added Intellectual Coefficient (VAIC™)

and Accounting for the Future (AFTF).

2. MCM Methodologies: Tobin's q, Investor Assigned Market Value (IAMV™) and Market-to-Book Value.
3. DIC Methodologies: Technology Broker, Citation-Weighted Patents, The Value Explorer™, Intellectual Asset Valuation and Total Value Creation, TVC™.
4. SC Methodologies: Human Capital Intelligence, Sandia Navigator™, Value Chain Scoreboard™, Intangible Asset Monitor, Intellectual Capital Navigator and Intellectual Capital Index (IC Index™) and Value Creation Index.

According to the review of applications of graph theory for representing and assessing tacit knowledge especially medical knowledge and the review of types of IC measurement methods, in this paper, the authors will demonstrate and apply DANs to represent experts' knowledge as graphical and quantitative forms. Moreover, IC management intelligent website for managing CoP of university and financial investment by using the new equations and AANs and DANs is presented also. The organization of this paper is the review of IC, AANs and DANs, and Intelligent website are described in the second, third and fourth section, on the other hand, the new equations and the cases studies of human IC assessments for academic organizations and financial investments are illustrated in the fifth and sixth section and finally, conclusion is presented.

2. Intellectual Capital Assessment (ICA)

Human Intellectual Capital (HIC) is the intangible asset which the other people cannot see it. The conceptual roots of IC are presented in Figure 1. below,

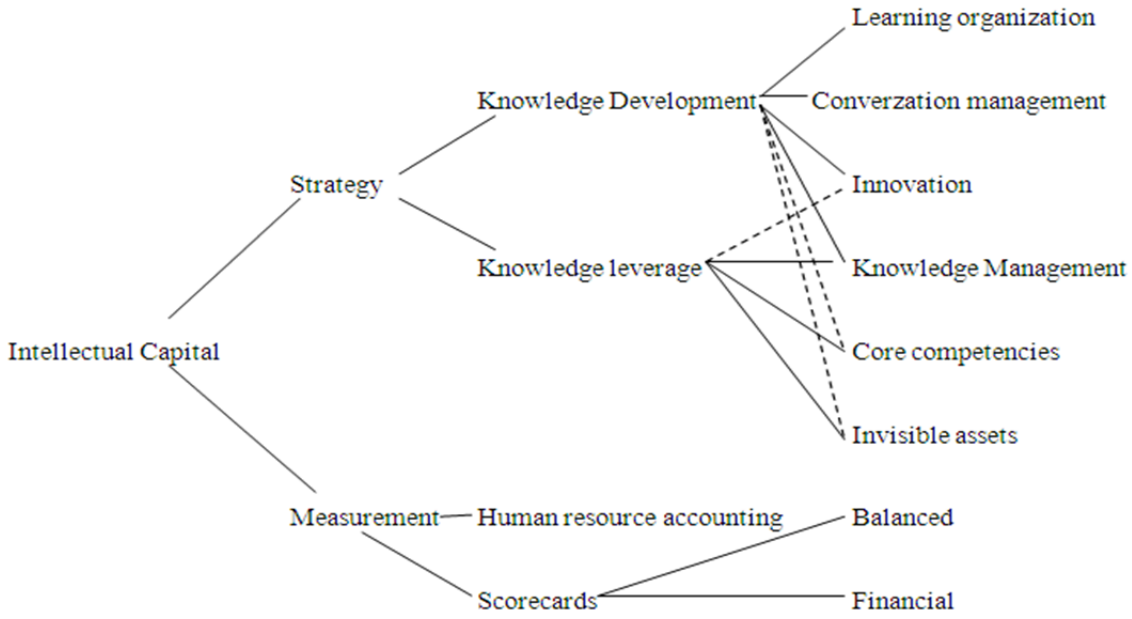


Figure 1. Conceptual roots of Intellectual capital (Johan Roos, Goran Rocs, Leif Edvinsson and Nicola Carlo Dragonetti, 1998)

3. Adaptive and Dynamic Assessment Networks (AANs and DANs)

Knowledge Representation (KR) model is a popular method to present the general and complex knowledge in the form that are easy for understanding and appropriate to develop the Knowledge-Based Systems (KBSs). One of the popular Knowledge representation techniques is Graphical model. Types of graphical models show in Figure 2 below,

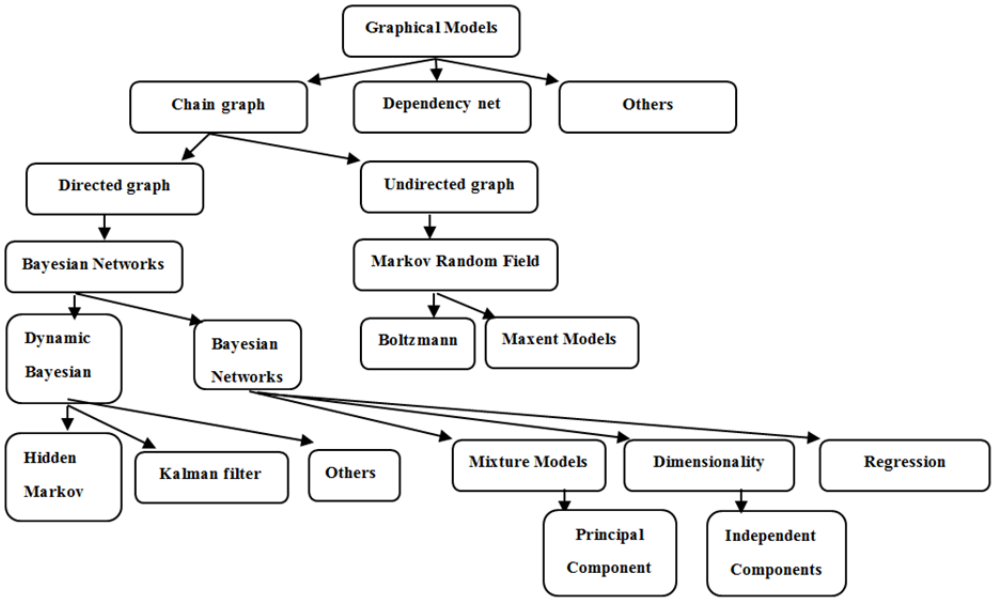
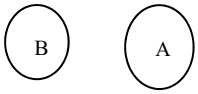


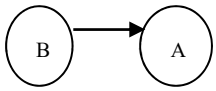
Figure 2. Types of graphical models (Kevin Patrick Murphy, 20002)

Among several graphical KR methods which are applied to assess the human IC, in this study Adaptive Assessment Networks (AANs) and Dynamic Assessment Networks (DANs) which are the directed acyclic graphs model (DAGs), are proposed. AANs and DANs are composed of

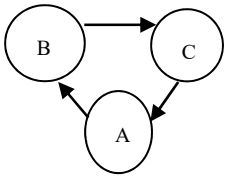
1. Nodes that are a set of random variables.

e.g. 

2. Directed links.

e.g. 

3. Directed acyclic graphs (DAG).



Each node in AANs and DANs is assigned by quantitative terms to represent knowledge. In this study, the results of using a new proposed equation are applied to each node of AANs and DANs. Each node is updated in its labeled time called DANs or Time Series Dynamic Assessment Networks (TDANs), besides each node may not be updated with time series data, but updated with functions called AANs.

4. Intelligent Website

Intelligent website is developed as the forms of website-based on tacit knowledge or human IC by using qualitative and quantitative knowledge representation. Intelligent website consists of rules, facts and inference engine. This component is the characteristic of Knowledge-Based Systems (KBSs) which all intelligent websites must have KBS for inferring tacit knowledge by using reasoning methods such as Fuzzy-Based Reasoning (FBR), Evolutionary-Based Reasoning (EBR), Statistical-Based Reasoning (SBR), Artificial Neural Networks-Based Reasoning (ANNBR) and etc.

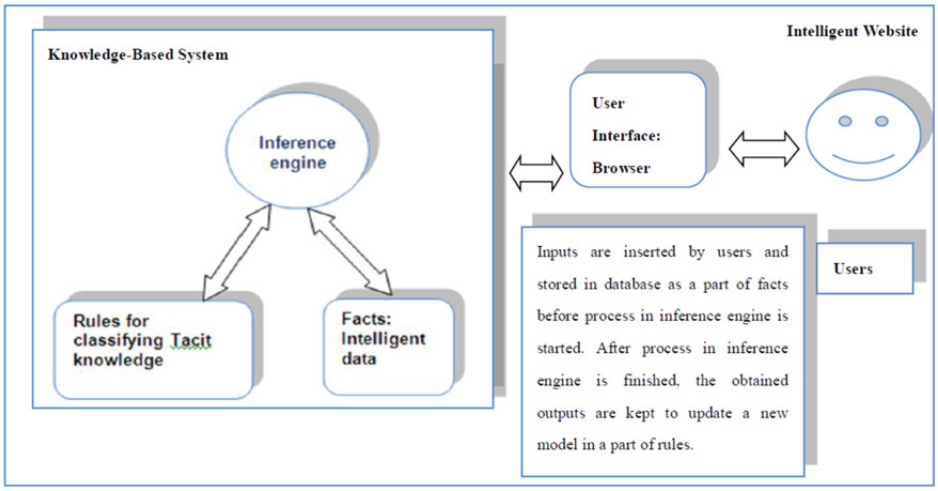


Figure 3. The architecture of Intelligent website

Data, information and knowledge are used to train for constructing model to discover new knowledge as well as clustering techniques are applied to manage Tacit knowledge.

5. Intellectual Capital Assessment Intelligent Website for Managing Academic Organizations: A Case Study of Excellent Centers and Laboratories in University

5.1 Data Set for Intellectual Capital assessment of University using Adaptive and Dynamic Assessment Networks

In this study, AANs and DANs are applied to IC assessment by using the areas that experts in the university and hospital have published their papers indexed on Scimago and Scopus website. The data set of this study is referred and collected from Scimago and Scopus website shown in Table 1 below,

Table 1. Data set

Variables	Data types
Name of Authors	Nominal scale
Name of published articles	Nominal scale
Name of published Books	Nominal scale
Types of articles	Nominal scale
Quintile ranking	Ordinal scale
Number of published articles	Interval scale
Number of published Books	Interval scale
Years of published paper	Ordinal scale
Subject areas	Nominal scale
Sub-areas	Nominal scale
Impact factors of subject areas	Interval scale
Impact factors of sub-areas	Interval scale
Ages of authors	Interval scale
Year of Published paper	Nominal scale

5.2 Methodology

Methodology used in this research is developed by using systems thinking presented below,

First step: research plan is designed and constructed by Knowledge Engineering (CommomKADs: Assessment template).

Second step: related factors are defined and collected.

Third step: IC measurement method is applied to assess tacit knowledge of university by using Adaptive and Dynamic Assessment Networks.

Fourth step: the obtain results are analyzed.

Fifth step: Intellectual Capital Assessment Intelligent Website for managing academic organizations (Excellent Centers and Laboratories in University) is constructed.

5.3 Adaptive and Dynamic Assessment Networks (AANs and DANs) Results

After all variables are defined, these indicators are defined with the abbreviations of subject areas referred from Scimago and SCOPUS website are shown in Table 2 below,

Table 2. Abbreviations of the subject areas

Subject areas	Abbreviations
Engineering	EN
Business, Management and Accounting	BMA
Computer Science	CS
Medicine	MD
Decision Sciences	DS
Mathematics	M
Materials Science	MS

The abbreviations of sub-areas refer from Scimago and SCOPUS website shown in Table 3 below,

Table 3. Abbreviations of the sub-areas

Sub-areas	Abbreviations
Business, Management and Accounting	BMA
Social Sciences	SS
Control and System Engineering	CSE
Computer Science	CS
Management Information Systems	MIS
Hardware and Architecture	HA
Theoretical Computer Sciences	TCS
Medicine	MD
Decision Sciences	DS
Mathematics	M
Materials Science	MS

According to the proposed abbreviations of subject areas in Table 2 and 3, the example of AANs and DANs of expert No. 1 is constructed and presented as Figure 4 and Figure 5 below,

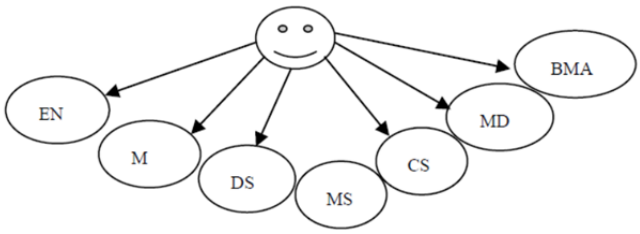


Figure 4. AANs and DANs of the subject areas of Expert No. 1

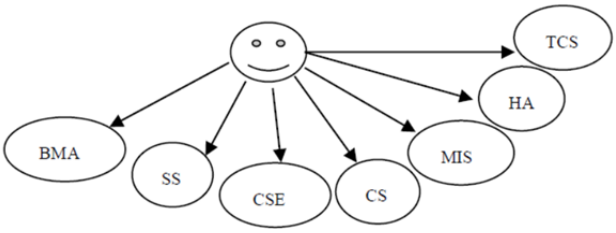


Figure 5. AANs and DANs of the sub-areas of Expert No. 1

On the other hand, the example of subject and sub-areas revealed in Table 2 and 3 is used to develop AANs and DANs of Expert No. 2 as Figure 6, and Figure 7.

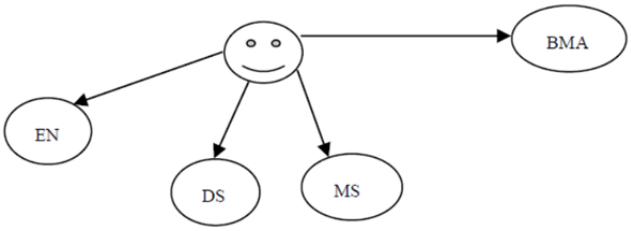


Figure 6. AANs and DANs of the subject areas of Expert No. 2

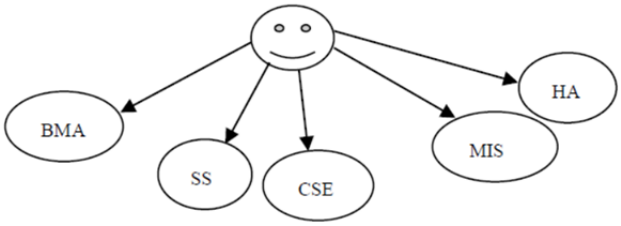


Figure 7. AANs and DANs of the sub-areas of Expert No. 2

Figure 6 and Figure 7 present AANs and DANs of the subject areas of Expert No. 1 as well as sub-areas. These models are proposed and presented for the quantitative calculation through using a new IC equation which the detail are revealed in equation (1) below,

Human Intellectual Capital Value per capita with self-citation

$$HICV = (\sum^{n}_{i=1} I_i * \sum^{n}_{j=1} Q_i * \sum^{m}_{k=1} C_{\text{included self-citation}})/A \quad (1)$$

I is an impact factor and i is the counter for each branch or sub-branch.

Q is quintile rank and j is the counter for each branch or sub-branch.

C is number of citation with self-citation and k is the counter for each paper.

A is age of an author.

n is total number of branch and sub-branch

m is total number of published papers

The new way of Knowledge Discovery and Patterns Recognition is applied to assess the IC per capita to manage the intangible asset in human for universities, hospitals and stock markets and etc. where specific knowledge of experts is required for developing a new products, services and innovations to drive these organizations to be survival in the serious business competition in the forthcoming twenty-first century.

Example of applied this methodology is proposed to measure human intellectual capital of universities and hospitals in this paper. Moreover, the trend or direction of excellent centers, laboratories, and individual are discovered based on this new equation. Although this formula considers only self-citation because it can measure the continuous research of authors and the contribution of their research to related communities, but it can be adopted to measure tacit knowledge in the form of citation without self-citation also. This equation can be adopt to apply for time series data, for instance if consider HICV of each expert in each year. It called Time Series Dynamic Assessment Networks (TSDANs). On the other hand, if this approach is applied to measure the other intellectual capital problems such as experts in financial investment such as stock market investments which the using of this new graphical model will be demonstrated in the next section.

6. Intellectual Capital Assessment Intelligent Website for Managing Financial Investment: A Case Study of Stock Market Investment

6.1 Data Set for Intellectual Capital Assessment of Stock Market Investment Using Adaptive and Dynamic Assessment Networks

In this study, AANs and DANs are applied to IC assessment by using the financial investment records of brokers in international and Thai stock markets. Experts in the stock market investments such as brokers who have the

records of their investments and the stock monitoring information on website. The data set of this study is referred and collected from Thai and international stock market website shown in Table 4 below,

Table 4. Data set

Variables	Data types
Types of Market	Nominal scale
Name of brokers	Nominal scale
Name of stocks	Nominal scale
Name of portfolios	Nominal scale
Return ratio	Interval scale
Profit	Interval scale
Ages of brokers	Interval scale
Year of investment	Nominal scale

6.2 Methodology

Methodology used in this research is developed by using systems thinking presented below,

First step: research plan is designed and constructed by Knowledge Engineering (CommomKADs: Assessment template).

Second step: related factors are defined and collected.

Third step: IC measurement method is applied to assess tacit knowledge of financial investments by using Adaptive and Dynamic Assessment Networks.

Fourth step: the obtain results are analyzed.

Fifth step: Intellectual Capital Assessment Intelligent Website for managing financial investments in stock markets is constructed.

6.3 Adaptive and Dynamic Assessment Networks (AANs and DANs) results

After all variables are defined, these indicators are defined with the abbreviations of stocks or portfolios referred from Thai set index website are shown in Table 5 below,

Table 5. Abbreviations of the Portfolios

Subject areas	Node Number
K-Equity Mutual Fund	1
K-Fif Mutual Fund	2
K-Fixed Income Mutual Fund	3
K-Lifestyle Mutual Fund	4
K-Tax Saving Mutual Fund	5

The abbreviations of stocks refer from Thai set index website shown in Table 6 below,

Table 6. Abbreviations of the stocks

Stocks	Node Number
K-BANKING	1
K-ENERGY	2
K-EQUITY	3
K-FEQ	4
K-ICT	5
K-MIDSMALL	6
K-SELECT	7
K-SET50	8
K-STADE	9

K-STAR	10
K-STEQ	11
K-VALUE	12
K-AEC	13
K-AGRI	14
K-ASIA	15
K-CHINA	16
K-CHX	17
K-EUROPE	18
K-EUSAGE	19
K-GA	20
K-GB	21
K-GEMO	22
K-GHEALTH	23
K-GHEALTH(UH)	24
K-GINCOME	25
K-GLOBE	26
K-GOLD	27
K-GPROP	28
K-INDIA	29
K-INDX	30
K-JP	31

Table 6. Abbreviations of the stocks (Continuous.)

Stocks	Abbreviations
K-MENA	32
K-OIL	33
K-SGM	34
K-USA	35
K-USXNDQ	36
K-CASH	37
K-CBOND	38
K-FIXED	39
K-MONEY	40
K-MPLUS	41
K-TREASURY	42
K-2500	43
K-2510	44
K-2520	45
K-2530	46
K-PLAN1	47
K-PLAN2	48
K-PLAN3	49
K20SLTF	50
K70LTF	51
KDLTF	52
KEQLTF	53
KGLTF	54
KSDLTF	55
KBLRMF	56
KEQRMF	57
KEURMF	58
KFIRMF	59
KFLRMF	60
KGARMF	61

KGBRMF	62
KGDRMF	63
KGHRMF	64
KJPRMF	65
KMSRMF	66
KS50RMF	67
KSFRMF	68

According to the proposed abbreviations of portfolios and stocks in Table 5 and 6, the example of AANs and DANs of expert No. 1 is constructed and presented as Figure 8 and Figure 9 below,

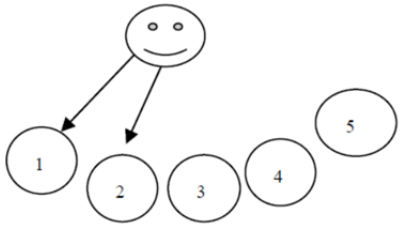


Figure 8. ANNs and DANs of the portfolios of Expert No. 1

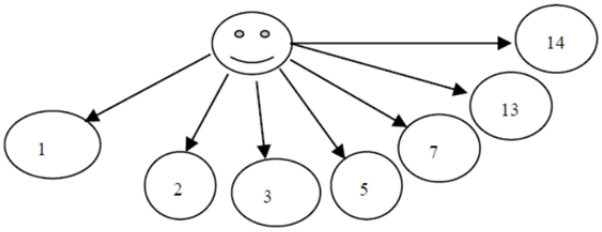


Figure 9. ANNs and DANs of the stocks of Expert No. 1

On the other hand, the example of portfolios and stocks revealed in Table 2 and 3 is used to develop AANs and DANs of Expert No. 2 as Figure 10, and Figure 11.

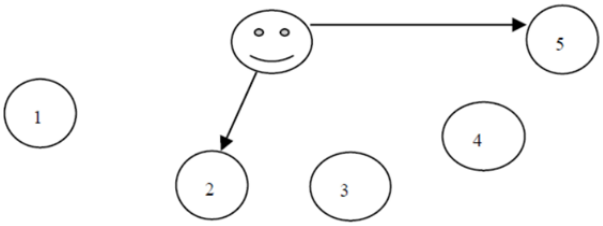


Figure 10. AANs and DANs of the portfolios of Expert No. 2

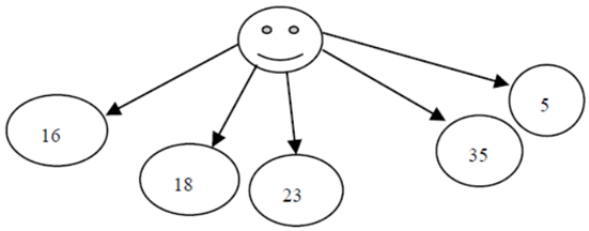


Figure 11. AANs and DANs of the stocks of Expert No. 2

Figure 11 and Figure 12 present AANs and DANs of the portfolios of Expert No. 1 as well stocks. These models are proposed and presented for the quantitative calculation through using a new IC equation which the detail are revealed in equation (1) below,

Human Intellectual Capital Value per capita

$$HICV = (\sum^{n}_{i=1} R_i * \sum^{n}_{j=1} Q_i * \sum^{m}_{k=1} P)/A \quad (1)$$

R is a return ratio and i is the counter for each portfolios or stocks.

Q is quintile rank and j is the counter for portfolios or stocks.

P is amount of profit and k is the counter for each portfolios or stocks.

A is age of a broker.

n is total number of portfolios or stocks.

m is total number of portfolios or stocks.

This proposed equation is considered in both point calculation and compared of the obtained values in each time changing. This is TSDANs, This is the implementation of online systems which if the function of HICV of university are changed to the function of HICV of Financial investment, it is called Adaptive Assessment Networks. For the time dimension consideration, it is Time Series Adaptive Assessment Networks (TSAAN).

The new way of Knowledge Discovery and Patterns Recognition is applied to assess the IC per capita to manage the intangible asset in human for universities, hospitals and stock markets and etc. where specific knowledge of experts is required for developing a new products, services and innovations to drive these organizations to be survival in the serious business competition in the forthcoming twenty-first century.

Example of applied this methodology is proposed to measure human intellectual capital of universities and hospitals in this paper. Moreover, the trend or direction of excellent centers, laboratories, and individual are discovered based on this new equation. Although this formula considers only self-citation because it can measure the continuous research of authors and the contribution of their research to related communities, but it can be adopted to measure tacit knowledge in the form of citation without self-citation also. This proposed concept and methodology can be analyzed and processed under the assumptions of the data and information is in the forms of Normal Probability Distribution and the other probability distributions.

7. Conclusions

According to the proposed a novel way of IC assessment for academic organizations (university) and Financial investment (stock markets) through using a new equation, TSDANs, AANs and TSAANs, the important factor of this proposed equation is the dimension of time such as ages and years of published paper. The advantage points of this new IC measurement method is it can not only represent IC assessment in the term of quantitative perspective but qualitative term also. Moreover, this new equation can be used to manage the experts' knowledge of university, hospital and stock market etc. in the future. In addition to this proposed equation may stimulate the organizational learning and knowledge sharing in academic institutes to produce the new products, services and innovations. Moreover, it may correct the corruption problems of Thailand especially, in the areas of academic institutes as the reason that this equation put the dimension of time which these ideas are presented in the forthcoming papers in the future. The proposed concept and methodology is a basis for risk management in terms of human capitals and financial investment.

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