ICT ADVANCEMENT INDEX FOR ENTERPRISE EVALUATION

CEZARY BOLEK, AGNIESZKA GRUDZIŃSKA-KUNA, JOANNA PAPIŃSKA-KACPEREK

Department of Computer Science, University of Lodz

The article aims the conceptualization and operationalization of the so-phistication of ICT use at firm level focusing on selection of indicators and measurement methods. Due to complexity of ICT implementation and adoption process, for constructive and detailed assessment, it is necessary to get many indicators analysed. However multi-indicator approach can be unintel-ligible for non-professionals. Therefore, authors have decided to employ composite indicator that can be synthetic form of enterprise ICT advancement measure as well as evaluation and comparison tool.

Keywords: ICT advancement measures, composite indicator

1. Introduction

Information and communication technologies (ICT) are widely used by organizations to enhance their competitiveness defined as ability to adapt to variable environment and to react quickly enough to the changes. Presently, solely assets and resources availability can be considered as insufficient to conduct business – there is a need for effective and efficient system that handle them in more productive way then the competition. Such a system can work only within ICT environment. Strategic advantage however cannot be achieved by simply deploying new technology. Application of ICT tools and further, their use and adoption in enterprise is multi-dimensional and complex process based on the combination of information technology and advanced management. It appears that sophistication of ICT use indicate higher overall enterprise value and its attractiveness to potential

partners and investors. Moreover under current conditions of economic downturn when enterprises consider cutting back on capital expenditure and delay systems upgrades, assessment of their own computerization status quo would support them in drawing up the correct strategy. When seen in this light developing of quantitative measure of ICT advancement for evaluation purpose seems to be justified.

Due to its complexity, ICT implementation and adoption process is difficult to measure. It is necessary to get many indicators analysed for constructive and detailed assessment. The article aims the conceptualization and operationalization of the process focusing on selection of indicators and measurement methods. However multi-indicator approach can be unintelligible for non-professionals. Therefore authors are going to employ composite index that can be synthetic form of enterprise ICT advancement measure as well as evaluation and comparison tool. Main difficulty in constructing final indicator is to make it universal, independent of such enterprise properties as size, capital, economic activity, line of business etc. on the one hand, and technology and enterprise information systems evolution on the other. As a result, considering factors mentioned above, appropriate selection of key sub-indicators forms the article main issue.

2. Measuring of ICT at firm-level

Measurement of ICT stems from the studies conducted on information technology impact and value since late 70s of 20th century. Researchers have adopted diverse conceptualizations of ICT artefacts extending beyond hardware and software to include range of contextual factors associated with its application within organizations. Early studies were focused on justifying IT investments. Intensity of IT investment was usually measured by variety of ratios based on expenditures on computerization and financial performance indicators (e.g. turnover). Latest indices take into account ratio of IT spending against not only revenues but also operating expenses to get a more accurate measure of spending level than in the traditional approach.

Another dimension of ICT value is its capability defined as ability to mobilize and deploy IT-based resources in combination with other resources and capabilities. This resource-based view of the firm argues that value of IT may depend on how IT is managed in conjunction with the others factors. IT creates competitive advantage by leveraging pre-existing complementary human and business resources, and valuable scarce resources such as knowledge, reputation, organizational culture etc. [4]. ICT impact and value can be also evaluated from the information system success perspective. Drawing on previous studies Gable presented a measurement model of enterprise system success. The model employs 27 measures of the four dimensions: information quality, system quality, individual impact, and organizational impact [7].

Success of any IS cannot be achieved without engagement of all stakeholders from top management to everyday users. ICT adoption/acceptance is a multifaceted construct that affect sophistication of ICT use. It has been widely researched in various contexts. Users' attitude towards taking up word processors, spreadsheets, electronic mail, database applications or LANs was examined in 80s, when their usefulness was not so obvious as today. Studies on the adoption of ICT have employed range of models including Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), Technology Acceptance Model (TAM), Motivational Model (MM), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT) and Social Cognition Theory (SCT) and Unified Theory of Acceptance and Use of Technology (UTAUT) [15].

ICT measures are used in different combinations to assess current status of ICT development at national or firm-level. They are analysed separately [13], [3] or constitute composite indicator.

3. Composite indicators

Composite measures are frequently used in quantitative research dealing with complex concepts that have no clear and unambiguous indicator. In such a case it is difficult for researches to develop single indicators before they actually do study – measurements have to be based on more than one data item that give a more comprehensive and more accurate indication. But manipulation of several or even about a dozen data items simultaneously could be complicated. Therefore quantitative data analysis has developed specific techniques for combining indicators into a single measure. Index (sometimes referred to as composite indicator [12]) rank-order the units of analysis in terms of specific variables. It allows for data-reduction, summarizing and obtaining some more general dimension [1].

Composite indicators are very common in economic and business statistic. They are used for measuring such multidimensional concepts as competitiveness, sustainability, quality of life, information society etc. They are useful in identifying trends, setting policy priorities and in benchmarking and monitoring performance. The number of indices in existence is growing year after year (there are currently more than 600 composite indicators developed by international organisations). Proliferation of composite indicators is associated with their medial attractiveness and easiness of use [12].

Index construction process involve some judgement: the selection of sub-indicators, choice of model, weighting indicators and treatment of missing values etc. Arbitrary decisions can lead to miscalculations and pose the risk manipulation. Composite indicators may oversimplify the reality treating in equal measure phenomena or objects that need additional distinction (e.g. developed and developing countries, small and large enterprises).

As far as sophistication of ICT use is concerned there are numerous studies employing composite indicators. They pertain to different aspects of ICT development at international, national, regional and in the end firm-level. International (International Communication Union, World Bank, United Nations Agencies) and commercial organisations (Word Economic Forum, International Data Corporation) have developed the most popular indicators such as ICT Development Index (ITU), ICT Diffusion Index (UNCTAD), Networked Readiness Index (WEF), Knowledge Economy Index (WB) [14]. Their studies covers hundreds of countries and indices comprise up to hundred items. They predominantly assess ICT infrastructure, its availability and use, but some of them have more holistic objectives [8]. Comparative analysis of many indices with regard to different domains and other criteria can be found in literature [2], [13], [8].

Particular researchers have used composite indicators to measure ICT development in their countries or regions [9], [10] to examine ICT impact on firm efficiency [11] and its interrelation with enterprise features [5], [6].

Recently it can be observed growing interest in employing indices for enterprise assessing. Some studies have put forward evaluation index models and tested their validity through the application example [16], [17].

4. Operationalization of ICT advancement

Main difficulty in constructing final indicator is to decide what items should constitute it. Due to the complexity of computerization process it is necessary to analyze many factors to guarantee constructive and thorough evaluation. This chapter discusses different aspects of enterprise ICT development.

Enterprise information systems have rapidly evolved over the last decade. Basic transaction processing or office support systems no longer provided strategic advantage to organizations. It could only be derived from close integration of ICT with business processes. This triggered the need for system that could control all major business processes (e.g., sales, accounting, finance, human resources, inventory and manufacturing) in real time via single software architecture on a client/server platform. Traditionally, enterprise information systems were limited in their support for intra-organizational business processes, but global markets and competition have forced companies to operate in a physically distributed environment. Therefore enterprise software is expanding its scope to link the enterprise with suppliers, business partners and customers to build an integrated supply chain. On the other hand growing popularity of various forms of outsourcing can be observed. They include hosting infrastructure (IasS) and/or software delivering as a service (SaaS) by external providers and are often referred to as cloud computing.

Taking into consideration aforementioned trends authors have decided to embrace five dimensions of enterprise ICT advancement: computers and networks,

database content and integration, enterprise ICT users, internal enterprise communication, digital security and last but not least IT expenditures.

Computers and computer networks

Demand for hardware depends on the profile of business activity and size of a company. Moreover it is subject to enterprise strategy. Firm can maintain its own computer infrastructure or it can employ one of the cloud computing services model. Thus more meaningful than the absolute number of devices considered as a computer (servers, desktop computers, notebooks, PDAs, smartphones) that company owns, is its relation to the other variables such as number of employees or range of usage. Computers interconnection is foundation of enterprise systems integration and resource and information sharing. Company's internal network does not have to (and perhaps in some cases should not) be directly connected to the Internet, but it can use Internet protocols to build intranet and extranet.

Internet use is also one of the main indicators of this dimension. It ranges from simple presence on the Web to the participating in integrated supply chains and e-commerce. At the basic level it is an access to company information via a website, a social network site or auction portal. Than it comprises Internet marketing (including search engine marketing) use to promote enterprise products and services. However with regard to ICT advancement it seems to be more important what electronic services the company offers to its customers and business partners and which services it uses itself; particularly those related to electronic transactions (automated order placing and receiving) and exchanging of information with suppliers and/or customers in order to coordinate the availability of products or services to the final consumer.

Manually typed e-mails are excluded as they require checking the warehouse and answering and thus cannot be processed automatically.

Although usage of e-administration services is examined in many reports (e.g. GUS and Eurostat) authors initially have questioned its relevance. On one hand in many countries some electronic services such as e-filing or sending statistical data are mandatory for all or exclusively large enterprises. Additionally they exploits IT tools offered by public authorities. On the other hand willingness to use optional e-administration services evidence the adoption of this form of administrative procedures and in consequence certain level of ICT advancement.

Database content and integration

For many years enterprise information systems have been mainly grounded on database systems. Since the database architecture is frequently outcome of enterprise systems evolution it is not considered as a determinant of ICT advancement. Authors suggest examining database content and the presence of integrated system instead. Coverage of business fields by stored data demonstrates what processes

have been or could be automated and present or potential software functionality. Software categories are not enumerated explicitly. Their definitions can be ambiguous because many functions are often implemented by one integrated system or several packages of software, qualified to different software categories, provide similar functionality.

Furthermore authors argue that it should be taken into account to what extend enterprise information systems support decision making at different level of management: from operational and tactical level to multidirectional analysis and strategic planning.

Internal enterprise communication

Electronic support for interpersonal processes appears to be salient feature of ICT advancement. It ranges from unstructured communication offered by e-mail applications through interactive collaboration by instant messaging, video and data conferencing, document and storage space sharing and electronic meeting systems to coordination and cooperation implemented by electronic calendars, project management applications and rigorous workflow systems.

Enterprise ICT users

Many surveys on ICT usage (e.g. Eurostat, GUS) ask questions about number of employees using computers at least once a week. However not every employee has to use a computer and even those whose job requires it, do it in different ways. Office workers use applications installed on desktop computers whereas the computerized production lines personnel sometimes uses only specially customized interfaces and sale representatives have remote access to stock control systems etc. Therefore it seems reasonable to examine rather number of computers to number of employees ratio, percentage of employees that potentially can use network or has got mobile access to company's IT resources than the absolute number of computer users. As far as ICT diffusion is concerned percentage of organizational units using IT tools in their everyday work appears to be appropriate measure.

Digital security

ICT development brings new threats to organizations. It is important if company is aware of these threats and tries to prevent them or at least minimize the effects when problems appear. Authors suggest that developing and adopting computer security policy can be relevant indicator of sophistication of ICT use. Security policy define not only authentication, authorization and data and physical assets protection mechanisms but it also should include training schedule for every employee, especially those, who have access to sensitive data. Security mechanisms are implemented mainly by data archiving and encryption, setting appropriate ac-

cess rights for users' accounts, using digital signatures and security software protecting company from malware and external attacks.

ICT expenditure

Growing trend to move towards subscription-base model with software delivered as a service and hosting of corresponding infrastructure convert capital expenses to operating ones. Therefore authors have decided to use rather ICT expenditure then investment measure.

5. ICT advancement index for enterprise evaluation

Creating composite indicators is a multistep process, where every phase is characterized by its specificity. Each of these steps, however, should remain consistent with the concept developed in the initial phase: called developing a theoretical framework. The framework should clearly define the phenomenon to be measured and its sub-components containing individual indicators and weights that reflect their importance. Next steps are as follows: selecting variables, imputation of missing data, multivariate analysis, data normalization, and finally formula forming including aggregation and possible weighting.

All of these steps are fully described in the literature [12]. However, the vast majority of the methods are based on an approach in which the first redundantly selected variables to the multivariate analysis stage are reduced. Methods like principal component analysis (PCA), factor analysis (FA) and others allow revealing a correlation between variables to reduce the redundancy. Next step, i.e. cluster analysis, forms the final set of sub-indices that are subjects to normalization and finally weighting in order to obtain the final index. Weighing method is the most widely used one for enhancement of individual factors in the final indicator and is to be chosen to reflect statistical quality of data.

The disadvantage of the above methodology is the need for large statistics sample for the selection and eventual elimination of variables, grouping and selection of weights, as statistical methods based on data redundancy can be used only in such a case to ensure a sufficient level of confidence of the model. This is the main reason why most of composite indicators rely on an equal weighing, where all variables are given the same weight. This essentially implies to give the same "value" to components in the composite, but also can disguise the absence of a statistical or an empirical basis. For typical composite indicator:

$$I = \sum_i w_i x_i \qquad (1)$$

where x_i is normalized variable and w_i a weight attached to x_i, with

$$I = \sum_i w_i = 1 \qquad\qquad (2)$$

and $0 \leq w_i \leq 1$ lead for equal weighting to:

$$\forall_{i,k} \, w_i = w_k \qquad\qquad (3)$$

But when variables are grouped into dimensions (sub-indices) and those are further into the composite, than applying equal weights to the variables may imply an unequal weighting of the dimension what can cause an unbalanced structure in the final index.

However, the study on phenomena, that depends on the value of strengthening co-operation of the tested subject in the context of the relationship and creating indices based on them, shows that the simple model of weighted sum does not reflect the correct value of the measured value. In this work authors decided to propose a different approach, where the main index is divided into sub-indices with the equal weighing, and the index is not a final outcome, but the weighed mathematical model of the relationship between the donors of the effect of different aspects, described by sub-indices. This approach can be found in the literature [5] and has a non-linear nature. In the proposed model there are four sub-indices, which are determined by using the traditional approach based on equal weighing and data normalization [12]. They relate to the four dimensions described above: computers and networks, database content and integration, internal enterprise communication and digital security. Each of them can be in the range [0,1], and the higher it is, the better enterprise implements those aspects. CI_{ICT} final index is divided into four components, which, despite the additive nature, consider non-linear part of mentioned above sub-indices. Additionally measures of the other two dimensions described in the previous chapter are included: enterprise ICT users and ICT expenditures:

$$CI_{ICT} = IS + IC + IM + IN \qquad\qquad (4)$$

IS – component in charge of the entire structure of the organization, connected with the various elements making up the sub-indices,

IC – component describing the cooperative nature of individual elements within the enterprise,

IM – component representing the expenditure on ICT in the enterprise,

IN – component showing the share of active computers connected to the network structure in the enterprise.

As a result of the simulation and analysis of the impact of individual variables relationships have been developed according to model creating, describing each of the factors. The final formula that determines the composite index is as follows:

$$CI_{ICT} = \sum_{i=1}^{N_S} S_i + N_S \sqrt[N_S]{\prod_{i=1}^{N_S} (\sqrt{P_{Con}} + S_i} + f_{SME}(C_{ME}) + f_{SCC}(\frac{N_{CC}}{N_E}) \qquad (5)$$

The next section describes the individual components connected to the relevant aspects of use of information technology in enterprises.

IS component

Main purpose of IS component is to give information on the various aspects of the use of mentioned above four groups. It is described by the sum of the following sub-indices: S_1 - computers and networks, S_2 – database content, S_3 - internal enterprise communication, S_4 – security. Each of sub-indices is determined by a sum of equally weighted measures represented by answers to the specific survey questions. Variables can be divided into the three groups: dummy variables, represented by simple questions, where „yes" is given as 1 and „no" by 0, interval variables given in the range [0, 1] representing questions about percentage of phenomena, categorical variables resulting from questions whose answers should be classified as a categorical scale to obtain the result value in the range [0, 1]. The final sub-index is determined according to formula:

$$S_k = \frac{1}{N_k} \sum_{i=1}^{N_k} x_{k,i} \qquad (6)$$

where: S_k – category sub-index $\forall k = 1, …, 4$, N_k – variables number of k sub-index, $x_{k,i} - i$ variable of a k sub-index. The maximum value of a component may be equal to 4.

IC component

IC component is usually related to the simple arithmetic average that allows an assessment of whether the evaluated enterprises provide for certain dimension of ICT. But weakness of one of the subsystems significantly reduces the quality of the entire system. The resultant index which is a simple sum of the sub-indices does not show that significantly underdeveloped system or even complete absence of one of the aspects can, even in this extreme case, down the level of the composite index by 25% only. The use of the geometric mean can significantly weaken the IC component when one of the indices is lower than the others. This gives the effect of synergy of peer subsystems making the indicator value high only when all the subsystems are on the same high level of development. To emphasize the communication dependence in the mention relation, sub-indices are strengthened by the P_{con} variable, describing the share of computer connected to internal network allowing resource sharing. Each value, which is calculated as an average may be in

the range [0, 2], and such a range of values is the resultant average. In the view of the fact that there is N_s sub-index to unify cooperative parts, the resulting average is multiplied by N_s. This results in a range of IC component [0, 8].

IM component

IM component is designed to take into account an important factor which is the operating and maintenance cost of the information system. In general, higher costs imply a higher ICT advancement but this is not a linear relationship. Increasing level of costs over a certain level only slightly allows maintaining a high quality of the entire system. That is for:

$$IM = f_{SME}(C_{ME}) \tag{7}$$

where: C_{ME} – ratio of IT maintenance and operation expenditures to all enterprise costs, a non-linear function, describing the cost saturation effect that is given by:

$$f_{SME}(C_{ME}) = L\left(1 - e^{-\frac{C_{ME}}{\tau_{MEA}}}\right) \tag{8}$$

where: L – constant that specifies the level of saturation equal to 2, τ_{MEA} – a constant value that specifies the saturation rate of growth function. The steepness of the curve of growth function refers to the average level in the industry of the expenditure on maintenance and operations – C_{MEA}. Assuming that the value of C_{ME} is equal to C_{MEA} function value should be 1, and for the C_{ME} equal to 1 (i.e. when all the expenses are costs of IT) value of the function should be close to 2, after substituting into the formula above the above-mentioned criteria, the relationship should look like:

$$\tau_{MEA} = -\frac{C_{MEA}}{\ln\frac{1}{2}} \tag{9}$$

what results in:

$$IM = L\left(1 - e^{\frac{C_{ME}\ln\frac{1}{2}}{C_{MEA}}}\right) \tag{10}$$

The value of this function is in a range [0, 2].

IN component

IN component is designed to take into account the number of computers connected to the network N_{CC} referring to the number of employees N_E, given by the ratio: $R_{CE} = \frac{N_{CC}}{N_E}$. Function $f_{SCC}(R_{CE})$ must be characterized by slow growth for small values of $R_{CE,}$ which has to take into account the fact that a small number of

computers results in a low value of the index factor in the final formula. Moreover a rapid increase in the value of $R_{CE,}$ close to the average value in the industry R_{CEA} and saturation to the level of $L = 2$ for high values of R_{CE}, which in this case is to prevent the revaluation for enterprises, such as the training companies. Therefore, the form of sigmoid function of $f_{SCC}(R_{CE})$ has been chosen for this component:

$$f_{SCC}(R_{CE}) = \frac{L}{1 + e^{-B(R_{CE} - R_{CEA})}} \tag{11}$$

where: B is a factor of saturation speed function, that defines the rate of growth of function at the inflection point, it means $R_{CE} = R_{CEA}$. In this point the value of the function is 1 and it is so, when the number of computers connected to the network in the surveyed enterprise is equal to the average numbers of connected computers in the sector.

To determine the value of B, the assumption can be made, that the change in spending on IT implies the number of computers, which is a function of value index derivatives at these levels and they are similar to each other:

$$\frac{\partial f_{SSC}}{\partial R_{CE}} \approx \frac{\partial f_{SME}}{\partial C_{ME}} \tag{12}$$

after that:

$$P_{ME} = \frac{\partial f_{SME}}{\partial C_{ME}} = -\frac{L \ln \frac{1}{2}}{C_{MEA}} \left(e^{\frac{C_{ME}}{C_{MEA}}} + \frac{1}{2} \right) \tag{13}$$

The derivative:

$$\frac{\partial f_{SSC}}{\partial R_{CE}} = \frac{e^{-BR_{CE}}}{(1 + e^{-BR_{CE}})^2} \approx P_{ME} \tag{14}$$

and assuming that the fastest growth of the function will be effecting for $R_{CE} = R_{CEA}$ then the dependence will be as follows:

$$B \approx 4P_{ME} \tag{15}$$

Ultimately determining the dependence allows B to be defined by the formula:

$$B = -\frac{4L \ln \frac{1}{2}}{C_{MEA}} \left(e^{\frac{C_{ME}}{C_{MEA}}} + \frac{1}{2} \right) \tag{16}$$

The value of a function $f_{SCC}(R_{CE})$ is given in the range [0, 2].

After taking into account all the components, value of the final composite indicator can range from 0 to 16, where 16 represents the best possible score of the enterprise characterized by advanced use of ICT.

6. Summary and conclusion

Objective of the paper is to provide synthetic tool for enterprise sophistication of ICT use assessment. Because of advantages of composite indicators and in spite of their disadvantages authors have decided to employ this measure. Proposed index requires verification but presence of vast collection of data is its prerequisite. Data can be obtained from official resources and diagnostic survey. The survey will be addressed to senior managers or other decision makers with responsibility to IT related issues. The questionnaire result will validate the appropriateness of the model by revealing index value patterns for different enterprise categories (hence the companies located in the same cluster should be characterized by the similar index value).

Under conditions of growing competitiveness only those enterprises survive on the market that have knowledge on their partners information needs and technologies they exploit. ICT Advancement Index can be synthetic form of communication enterprise current status in the field and evaluation and comparison tool as well.

REFERENCES

[1] Babbie E. (2006) *Badania społeczne w praktyce*, PWN, Warszawa.

[2] Bandura R. (2008) *A Survey of Composite Indices Measuring Country Performance*, Update. UNDP, New York.

[3] Basant R., Commander S., Harrison R., Menezes-Filho N., (2006) *ICT Adoption and Productivity in Developing Countries: New Firm Level Evidence from Brazil and India,* Institute for the Study of Labor IZA DP No. 2294.

[4] Bharadwaj A.S. (2000) *A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation*, MIS Quarterly Vol.24, No 1, pp. 169-196.

[5] Cudanov M., Jasko O., Javtic M., (2009) *Influence of Information and Communication Technologies on Decentralization of Organizational Structure*.

[6] Cudanov M., Jasko O., Savoiu G., (2010) *Interrelationships Of Organization Size and Information and Communication Technology Adoption*, Journal of Applied Quantitative Methods Vol.5, No.1, pp. 29-40.

[7] Gable G.G., Sedera D., Chan T. (2003) *Enterprise Systems Success: A Measurement Model*, In March, Salvatore T. and Massey, Anne and DeGross, Janice I., Eds. Proceedings Twenty-Fourth International Conference on Information Systems, pages pp. 576-591, Seattle.

[8] Goliński M. (2011) *Społeczeństwo informacyjne - geneza koncepcji i problematyka pomiaru*, Oficyna Wydawnicza, Szkoła Główna Handlowa w Warszawie.

[9] *ICT in England's Rural Economies, A Final Report to DEFRA* (2005) SQW Lmt., accessed from www.sqw.co.uk

[10] Kundu A., Sarangi N., (2004) *ICT and Human Development: Towards Building a Composite Index for Asia Realising the Millennium Development Goals*, Elsevier.

[11] Mouelhi R., (2008) *Impact of the adoption of Information and Communication Technologies on firm efficiency in the Tunisian manufacturing sector,* Equity and Economic Development, ERF 15th Annual Conference.

[12] Nardo M., Saisana M. et al. (2008) *Handbook on Constructing Composite Indicators: Methodology and User Guide*, OECD.

[13] Ssewanyana J., Busler M. (2007) *Adoption and usage of ICT in developing countries: Case of Ugandan firms*, International Journal of Education and Development using Information and Communication Technology (IJEDICT), Vol. 3, Issue 3, pp. 49-59.

[14] UNCTAD (2009), *Revisions and Additions To The Core List Of ICT Indicators.* http://unstats.un.org/unsd/statcom/doc09/BG-ICTIndicators.pdf .

[15] Venkatesh V. et al. (2003) *User Acceptance of Information Technology: Toward a Unified View*, MIS Quarterly, (27:3). pp 425-478.

[16] Zhi Liu; Hongjun Zhou (2012) *Performance Comprehensive Evaluation of Large Enterprise Information System Based on the BSC*, Computing, Measurement, Control and Sensor Network (CMCSN) 2012 International Conference, IEEE.

[17] Wei Gao, (2011) *Measuring and method of informatization level for manufacturing enterprise*, Information Science and Technology (ICIST), 2011 International Conference, IEEE.