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Desirability of Knowledge Management in Civil Engineering Consulting Firms

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Abstract: KM (knowledge management) has in the recent past been promoted as a means of harnessing and utilising intellectual resources and to improve innovation, business performance and client satisfaction within the construction industry. However, there has been no attempt to ascertain the required level of KM within any given firm. The study reported in this paper aimed at establishing a general equation for assessing a firm's required level of KM. Through literature review and a questionnaire survey, a total of 22 key indicators of KM were established. The interaction and effects of the key indicators against turnover and employee base were established, yielding an elliptic paraboloid fitted graph over which desirability could be calculated. It was observed that there is a continuous relationship among the firm's turnover, employee base and the identified key indicators. In practice, firms have different combinations of the employee base and turnover. The derived equation fits well with the different combinations. Firms can, through the use of such equations, determine the level of effort and investment required to implement KM.

Key words: Knowledge management, civil engineering, consulting industry, desirability.

1. Introduction

As a fledgling academic discipline, KM (knowledge management) has been promoted within the construction industry as a means of harnessing and utilising intellectual resources to address the challenges that face business entities such as: increasing competition; globalisation of the market; demands from clients, customers and society; the pace of change in ICT (Information Communication Technology); and the need to maintain a highly skilled workforce at all levels from operative and technical, to managerial and professional [1]. It has also been promoted as a means to improve innovation, business performance and client satisfaction within the construction industry. Interest in KM has stemmed from a number of issues which include among others [2]:

- a dramatic improvement in data processing capabilities and communications technologies;
- an increased recognition that businesses must continuously improve; and
- an acknowledgement of learning as a core strategic competency.

In a study of KM in North American construction organisations, Robinson et al. [3] identified the primary driver for KM as the need to leverage knowledge to win work and provide a better service to their clients. However, the environment within which construction organisations operate exhibits some distinct characteristics which make the management of knowledge difficult such as:

- the temporary project based nature of construction projects inhibits knowledge-sharing [2, 4]. Sommerville et al. [5] asserted that the construction project environment is "hostile" to the promotion of knowledge management and learning;
- the geographical dispersion of sites from the organisation's central and regional offices has a further detrimental effect, particularly in relation to forming social networks and contacts [6]; and

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• the pressures to complete projects often leave little time for reflection and learning [2].

The most valuable form of knowledge for construction organisations is tacit, the accumulated experience of construction professionals, which manifests itself through social interaction [7]. The project based nature of the industry, however, inhibits participation in, and limits contact between different projects [8]. With the increased pressure from clients to improve the quality of projects while reducing cost and time of work completion, the construction industry faces many challenges of how to implement and apply successful KM systems that provide desirable results and benefits [9]. Successful KM implementation requires a major change in organisational culture and commitment at all organisational levels [10].

The lack of employee and management awareness of the importance and future benefits of KM to their organisations is a significant challenge to KM application in the construction industry [2]. Some empirical studies proved that construction companies, especially small and medium enterprises, suffer many problems in applying KM and lack awareness of many important issues associated with knowledge capturing and its benefits for construction organisations [6].

While KM has value for every type of organisation, it plays a crucial role in professional service firms, where knowledge is a primary driver of competitive advantage and content is the main deliverable. Implemented effectively, KM helps such organisations put their full institutional resources to work for their clients and ensures that the information gathered and lessons learned in each appointment are retained and made available for efficient future re-use [11].

Scholars and researchers have argued that KM is a key ingredient for competitiveness and continued success of an organisation [12-15]. There is, however, uncertainty about how to devise and implement a viable and cost effective KM initiative [16]. This is mainly due to uncertainty regarding the required level of KM within any given organisation.

The aim of the study presented in this paper was to establish the relationship that exists between desirability of KM and the firm's attributes such as experience, average annual turnover and employee base.

2. Methodology

A mixed design approach was adopted for the research. The aspect of the study reported in this paper is, however, only based on quantitative data analysis. Questionnaire surveys were adopted as a means of data collection.

2.1 Survey Sample and Inclusion Criteria

The survey sample was drawn from civil engineering consulting firms that have business presence in Africa. The respondents were drawn from the FIDIC (Fédération Internationale Des Ingénieurs-Conseils) affiliates within Africa such as the ACEZ (Association of Consulting Engineers Zambia), CESA (Consulting Engineers South Africa), and ACEN (Association of Consulting Engineers Nigeria), ACEK (Association of Consulting Engineers Kenya), ACET (Association of Consulting Engineers Tanzania) and ACEB (Association of Consulting Engineers Botswana). The inclusion criteria were that the firm should have had an operational footprint in at least five countries in Africa and should have been in existence for at least 10 years. A total 40 respondents were targeted.

2.2 Questionnaire Design

The questionnaire was designed to have two parts. The first part was aimed at collecting the responsive organisation's attributes while the second part required the respondents to rate the key indicators of KM. The measurement used to collect data was ordinal. The characterisation of key indicators of KM was based on mean score rating as such numerical values were assigned to the ordinal scale with 5 being very important, 3 moderately important and 1 unimportant.

The formula for calculating the mean score was based on weighted averages and is shown as Eq. (1) below:

$$Mean\ Score = \sum_{j=1}^{5} I_j R_j \Big/ \sum R_j \quad (1)$$

where, I_j is the importance weight (1, 2, 3, 4 or 5) assigned to option j; R_j is the number of respondents who provided responses to option j. The mean score values were further interpreted to reflect the responding rating to aid conversion of continuous data into discrete categories [17]. The discrete categories were classified as follows:

- 4.500 < mean score ≤ 5.000, very important as an indicator;
- 3.500 < mean score ≤ 4.500, important as an indicator;
- 2.500 < mean score ≤ 3.500, moderately important as an indicator;
- 1.500 < mean score ≤ 2.500, of little importance as an indicator;
- 0.000 < mean score ≤ 1.500, unimportant as an indicator.

3. Survey Results

3.1 Questionnaire Administration and Response Rate

The survey was conducted between March and May 2014. The data was collected using both online methods as well as paper based surveys. The online data collection was undertaken via the MonkeySurvey website. The questionnaire was accompanied by a cover letter identifying: the type of research, sponsoring organisation and the researcher's name; explaining the purpose and the benefits of the study; and informing the participants that their name, department, or company name will not appear in the study documentation. Follow ups were made to non-responding firms at intervals of 4 weeks to remind the executives of the questionnaire and request their response.

Out of the 40 questionnaires that were circulated, 29 responses were received giving a response rate of 72.5%. This was deemed to be acceptable based on the sectorial and industrial norms where response rates are normally between 20% to 35% [18].

3.2 Profiles of Respondent Firms

An assessment of the respondent firms was undertaken. Of interest was the categorisation of responses by firm size and experience.

3.3 Experience of Respondent Firms

The respondents were predominantly working for firms that had been in existence for 10 to 60 years. Only four firms had less than 10 years of experience. Fig. 1 shows the experience in civil engineering consultancy of all the responsive firms.

3.4 Employee Base

The majority of responsive firms had between 51 and 250 employees. Only ten firms had less than 50 employees while five had more than 250 employees. The distribution of responsive firms' employee base is presented in Fig. 2.

3.5 Turnover

With regards to annual turnover, the majority of the responsive firms had average annual turnover of between US$3 million and US$15 million. Four firms had annual turnover between US$15 million and US$75 million while nine had turnover of less than US$3 million. The distribution of the responsive firms' annual turnover is presented in Fig. 3.

3.6 Key Indicators of KM

Indicators of KM identified from literature were analysed with respect to their relevance in an organisation. Mean scores and variances of the indicators were observed among the respondents. The means and variances observed are presented in Table 1.

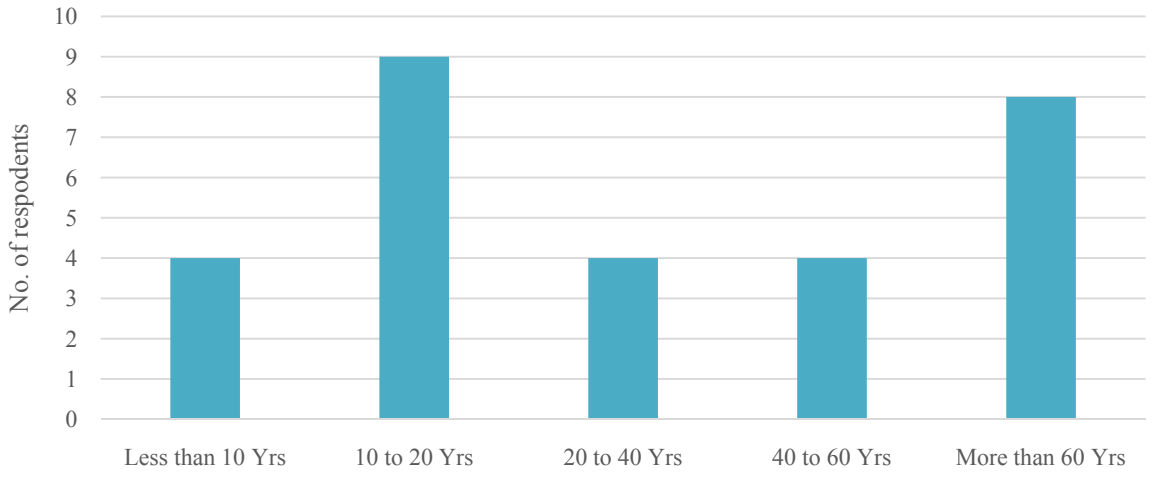

Fig. 1 Experience of respondent firms.

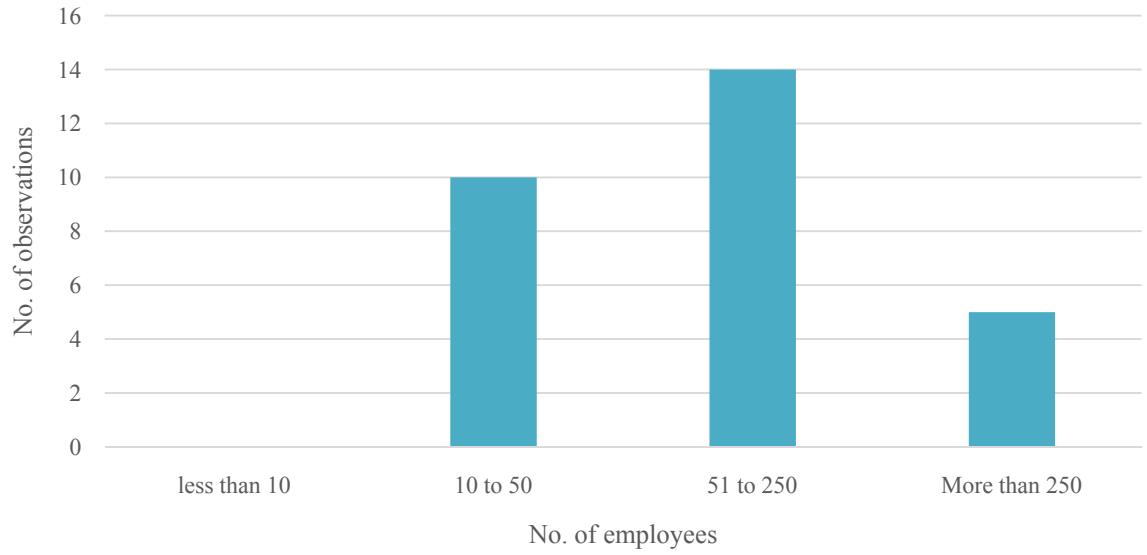

Fig. 2 Distribution of the employee base of surveyed firms.

Further analysis of the indicators presented in Table 1 was undertaken so as to identify those which were either important or very important. The cut off point for the mean score was set at 3.5 as any score above it would be classified as being important. Out of the 32 indicators, 24 were found to have a mean score greater than 3.5. Fig. 4 illustrates the indicators with overall mean scores greater than 3.5.

The indicators whose mean scores were greater than 3.5 were further tested for significance using the standard t-test. It was established that 22 out of the 24 indicators were statistically significant at $p < 0.05$. The statistical test results are presented in Table 2.

3.7 Inferred Desirability of KM

The results of the descriptive statistics were used to understand further how the choices of indicators were influenced by the organisation's annual turnover as well as the employee base. A concept was borrowed from industrial design regarding the idea of quality of a product or process that has multiple characteristics. When one of the characteristics falls outside of some

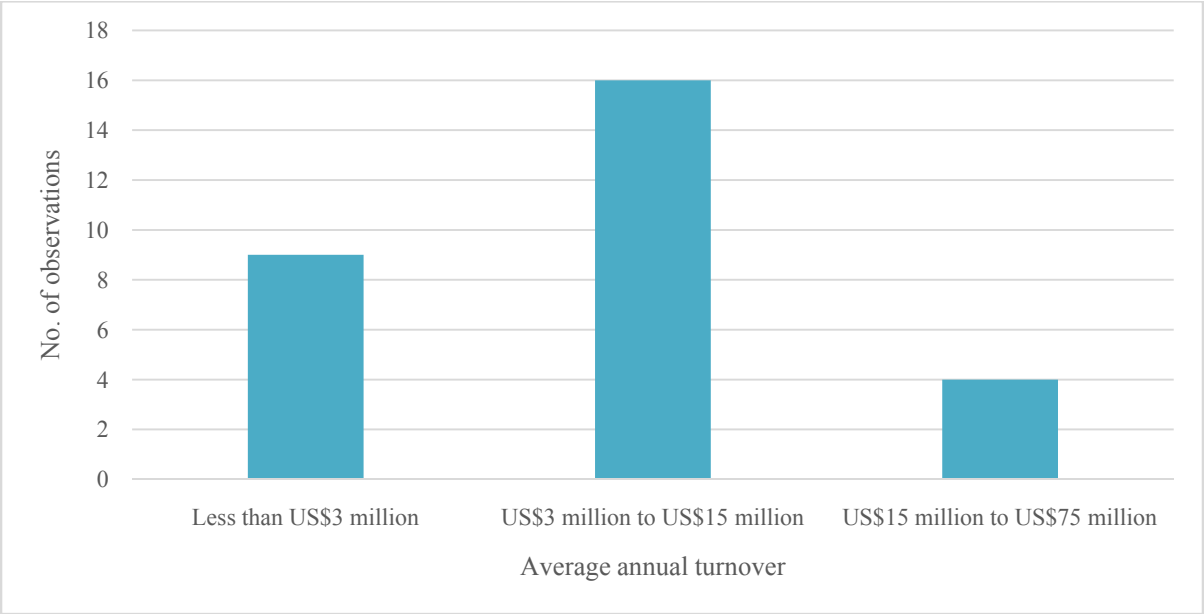

Fig. 3 Distribution of annual turnover of surveyed firms.

Table 1 Descriptive statistics of KM indicators.

S/N	Indicator	Mean score	Variance
1	Ability of the organisation to protect knowledge from inappropriate use	4.793	0.170
2	Amount of non-assigned working time within an organisation	2.552	3.185
3	Amount of time assigned to project meetings	3.793	0.170
4	Availability of monitoring and evaluation systems	4.586	0.251
5	Availability of policies for protection of knowledge at corporate level	4.621	0.244
6	Codification of knowledge such as know-how, technical skill, problem solving, etc.	4.414	0.251
7	Firm's flexibility to accommodate experimentation within a work place	3.264	1.251
8	Frequency of use of the knowledge base	3.621	0.244
9	Number of communities of practice within an organisation	3.793	0.170
10	Number of management/leadership who are aware of KM	4.414	0.251
11	Number of new ideas implemented	3.000	0.429
12	Number of new ideas submitted by staff	4.172	0.576
13	Number of staff pursuing further studies	2.759	3.118
14	Number of staff who are able to give example of incremental innovations	4.207	0.170
15	Number of staff with direct linkages to experts in a given field of work	4.414	0.251
16	Number of workshops/seminars attended by staff	3.172	3.148
17	Number of workshops/seminars organised by the organisation	2.759	3.118
18	Proportion of current project documents that make reference to previous documents	4.793	0.170
19	Proportion of organisational policies which make reference to KM	4.414	0.251
20	Proportion of outgoing staff who complete an exit interview which includes knowledge handover	2.963	2.680
21	Proportion of staff that are current and knowledgeable within their field of work	4.414	0.251
22	Proportion of staff that have a sense of ownership in what they do	4.379	0.244
23	proportion of staff that know a lot about their fellow staff's field of work	4.793	0.170
24	Proportion of staff who are aware of the organisation's KM policies	4.000	-
25	Proportion of the organisation's budget available/spent on research and new designs	2.931	2.852
26	Quantity of project data stored in electronic format	4.207	0.170
27	Quantity of project records kept by the organisation	4.586	0.251
28	Reduction of staff time spent looking for information	4.621	0.244

(table 1 continued)

S/N	Indicator	Mean score	Variance
29	Regulated use of the knowledge base	3.793	0.170
30	Regulated socialisation within an organisation	3.793	0.170
31	Retention of staff for longer period of time within an organisation	4.793	0.170
32	Years of experience of staff within the industry	3.793	2.313

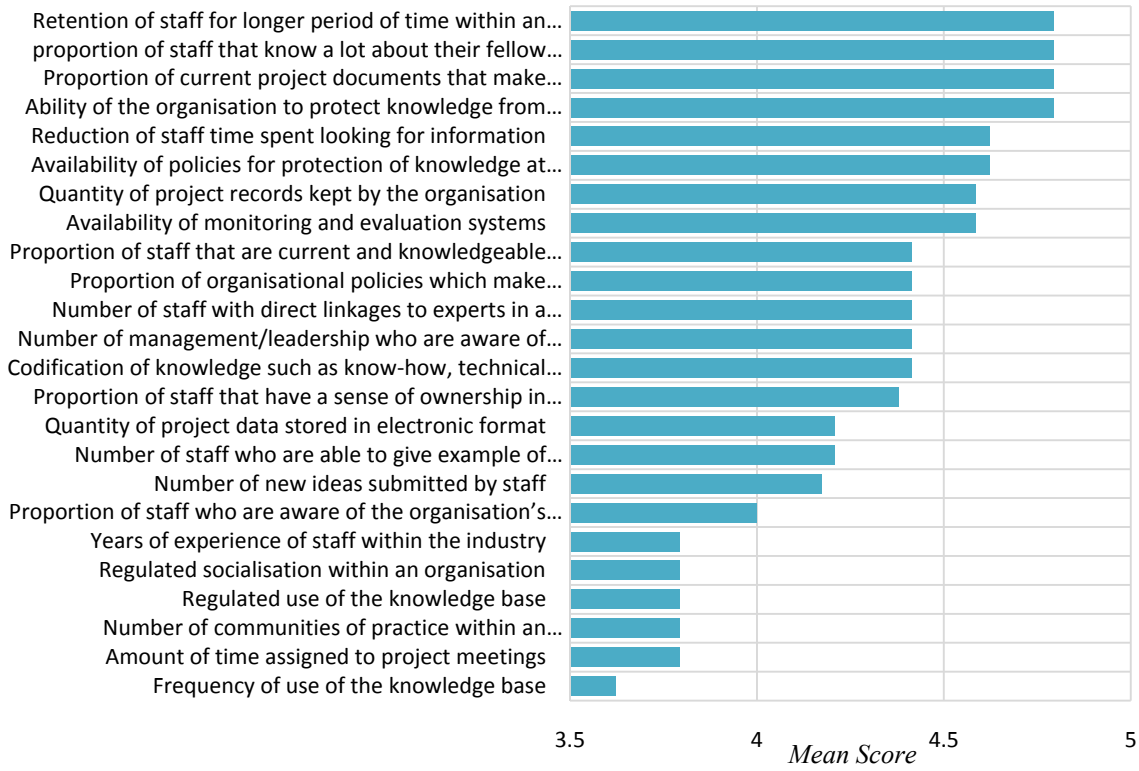

Fig. 4 Indicators of KM having an overall mean score greater than 3.5.

desired limits, the product or process is completely unacceptable [19]. Desirability functions help to solve such optimisation problems. Desirability functions and indices are powerful tools for multi-criteria optimisation and multi-criteria quality control purposes [20]. The method finds effective conditions that provide the most desirable response values through the analysis of variance [19, 21, 22]. These functions have been applied extensively in design and production of tangible products. These concepts were used in this study to help measure intangible yet comprehensible components of KM. As is the case within quality control environments, the goal may be to find the levels of the quality characteristics of the process so that the quality of the product or responses has the desired characteristics [23].

The indicators of KM whose importance score was greater than 3.5 were analysed for desirability. Of interest was the effects and interaction of KM indicators with the firm's turnover and employee base. This is very important for civil engineering consulting firms because their sales are dependent on the employee base as well as the expertise within the firm.

It was noted that desirability of KM is continuous in nature. This is observable in a fitted elliptic paraboloid generated from the key indicators shown in Fig. 5. The green colour represents lower desirability while the deep red colour represents the highest level of desirability.

When the factors in the design are continuous in

Table 2 Standard t-test results for key indicators of KM.

Indicator	Mean	Std.Dv.	N	Std.Err.	Reference	t-value	*df*	*p*
Ability of the organisation to protect knowledge from inappropriate use	4.79*	0.412	29	0.077	3.5	16.892	28	0.000
Amount of time assigned to project meetings	3.79*	0.412	29	0.077	3.5	3.829	28	0.001
Availability of monitoring and evaluation systems	4.59*	0.501	29	0.093	3.5	11.670	28	0.000
Availability of policies for protection of knowledge at corporate level	4.62*	0.494	29	0.092	3.5	12.222	28	0.000
Codification of knowledge such as know-how, technical skill, problem solving, etc.	4.41*	0.501	29	0.093	3.5	9.818	28	0.000
Frequency of use of the knowledge base	3.62	0.494	29	0.092	3.5	1.316	28	0.199
Number of communities of practice within an organisation	3.79*	0.412	29	0.077	3.5	3.829	28	0.001
Number of management/leadership who are aware of KM	4.41*	0.501	29	0.093	3.5	9.818	28	0.000
Number of new ideas submitted by staff	4.17*	0.759	29	0.141	3.5	4.770	28	0.000
Number of staff who are able to give example of incremental innovations	4.21*	0.412	29	0.077	3.5	9.234	28	0.000
Number of staff with direct linkages to experts in a given field of work	4.41*	0.501	29	0.093	3.5	9.818	28	0.000
Proportion of current project documents that make reference to previous documents	4.79*	0.412	29	0.077	3.5	16.892	28	0.000
Proportion of organisational policies which make reference to KM	4.41*	0.501	29	0.093	3.5	9.818	28	0.000
Proportion of staff that are current and knowledgeable within their field of work	4.41*	0.501	29	0.093	3.5	9.818	28	0.000
Proportion of staff that have a sense of ownership in what they do	4.38*	0.494	29	0.092	3.5	9.589	28	0.000
Proportion of staff that know a lot about their fellow staff's field of work	4.79*	0.412	29	0.077	3.5	16.892	28	0.000
Proportion of staff who are aware of the organisation's KM policies	4.03*	0.186	29	0.034	3.5	15.500	28	0.000
Quantity of project data stored in electronic format	4.21*	0.412	29	0.077	3.5	9.234	28	0.000
Quantity of project records kept by the organisation	4.59*	0.501	29	0.093	3.5	11.670	28	0.000
Reduction of staff time spent looking for information	4.62*	0.494	29	0.092	3.5	12.222	28	0.000
Regulated use of the knowledge base	3.79*	0.412	29	0.077	3.5	3.829	28	0.001
Regulated socialisation within an organisation	3.79*	0.412	29	0.077	3.5	3.829	28	0.001
Retention of staff for longer period of time within an organisation	4.79*	0.412	29	0.077	3.5	16.892	28	0.000
Years of experience of staff within the industry	3.79	1.521	29	0.282	3.5	1.038	28	0.308

*Significant at $p < 0.05$.

nature, it is often also useful to look at surface and contour plots of the dependent variable as a function of the factors. The desirability function derived from Fig. 5 was established to be as presented in Eq. (2):

$$D_{km} = -0.172 + 0.249n + 0.534t - 0.160n^2 + 0.198nt - 0.233t^2 \quad (2)$$

where, D_{km} is the desirability of KM, n is the parametric equivalent of the average number of employees N (where $N = 2e^{1.6094n}$), t is the parametric equivalent of the annual turnover T (where $T = 6 \times 10^5 e^{1.6094t}$).

Solving the above equation to determine the maxima shows that:

$$\max\left\{-0.172 + 0.249n + 0.534t - 0.16n^2 + 0.198nt - 0.233t^2\right\} = \frac{(110883 - 27479n)n + 31213}{233000}$$

$$\text{for } t = \frac{1}{233}(99n + 267)$$

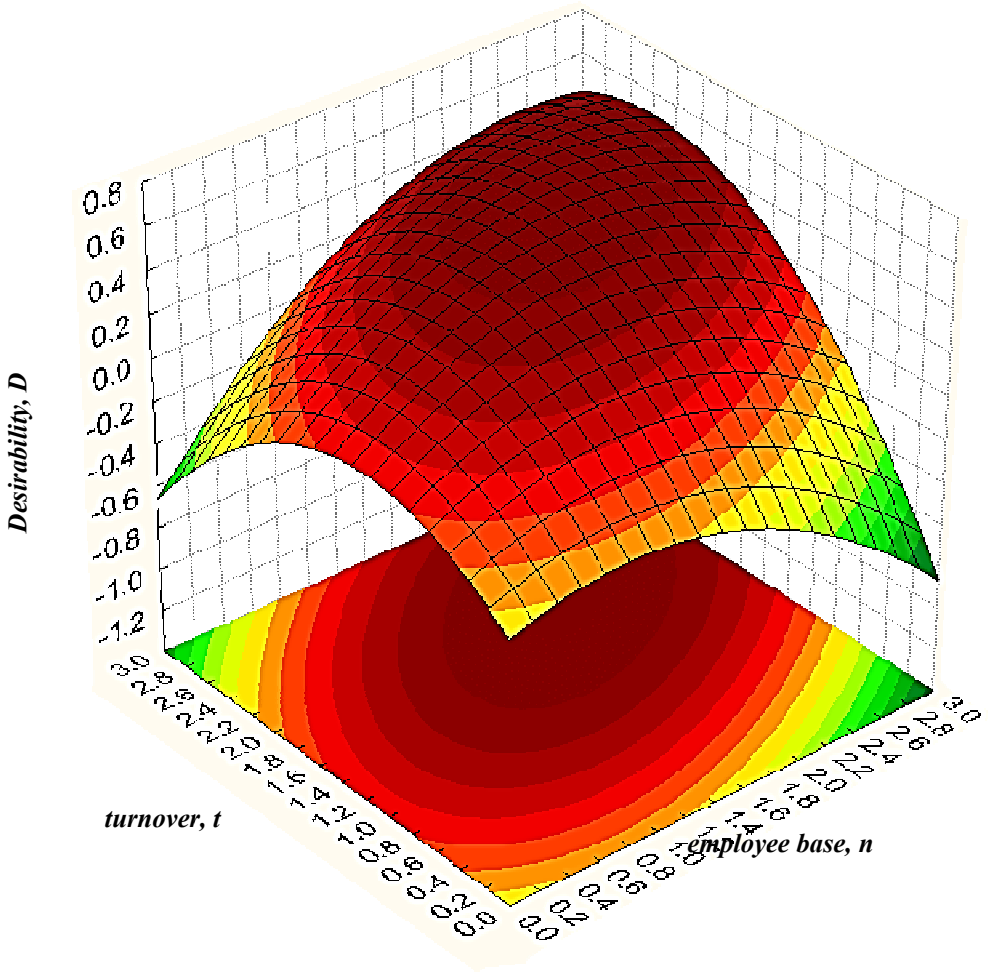

Fig. 5 Desirability plot of KM.

4. Discussion

Most of the KM programs focus on a critical business problems facing companies. However, many firms fail to align their knowledge efforts with their most pressing business issues by adopting recommended KM strategies without evaluating the level of requirement. When this occurs, significant time and effort with minimal impact is spent on projects, while key needs are not addressed or are completely overlooked.

Scholars have argued that KM must be linked to economics, meaning that its value must be made apparent [24]. The intangible nature of knowledge [25] and the fact that value creation is often indirect and long-term [12] makes such an assessment very difficult. Performance indices are crucial for management to continue investing in knowledge efforts [26, 27]. The development of performance indices can therefore be made possible through an understanding of the interaction and effects of the firm's turnover, employee base, experience and key indicators of KM. The derived equation provides a building block for linkage between the intellectual capital and the firm's financial values in terms of annual turnover.

5. Conclusions and Recommendations

The study reported in this paper established the equation which governs the interaction among key indicators of KM, the firm's annual turnover and employee base. Through the general governing equation, it can be deduced that KM is highly desirable

for firms with high turnover and a large employee base. In practice, firms have various combinations of turnover and employee base yet the common goal is often the drive for profitability and sustainability. Establishing the level of KM effort required is one sure way of maximising the use of the firm's resources, thereby contributing to its sustainability. It is recommended that the desirability function be expanded and tested for its validity in other industries. Further, the development of organisation performance indices with regards to KM can be made possible through the use of the governing equation discussed in this paper.

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