Globalized Service Providers' perspective for Facility Management Outsourcing Relationships: Artificial Neural Networks

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Abstract

Purpose - The Contingency Outsourcing Relationship Model (CORE) originated from the Four Outsourcing Relationship Types (FORT) model; the CORE model is used in the globalized Facility Management (FM) industry while the FORT model is originally used in the global Information Technology (IT) industry. The aim of this paper is to analyse the CORE model through the rankings of relationship between a client and a globalized FM service provider from the perspective of the FM service provider in one of the four categories (i.e. in-house, technical expertise, commitment and common goals) with the aid of artificial neural networks (ANNs).

Methodology - A quantitative methodology using a survey is used to analyse the four types of outsourcing categories. Firstly, the background theory and a set of rules of the CORE model is introduced and discussed regarding the proper ways to identify the rankings collected from the survey.

Findings - The study reveals that an interesting understanding of the outsourcing categories can be systematically implemented into the FM outsourcing relationships through the scientific methodology of artificial intelligence. FM outsourcing categorization may help to define the appropriate relationship; as either not too aggressive or too passive.

Originality/Value - The outcome generated from the ANN can be considered a strong and solid reference to assess and define the existing outsourcing relationships between the stakeholders and the service providers with the goal to assign an outsourcing category to the service provider based on the learnt rules.

Keywords: Artificial Neural Networks; Global Facilities Management; Evolution of Outsourcing Relationships

1. Introduction

This study focuses on the investigation of FM outsourcing relationships between the clients and service providers globally. There are many reasons of the outsourcing failures and successes. The main theme for this paper is to examine the four FM outsourcing relationships of the bespoke FM outsourcing model for the multinational corporations. The understanding on the application of the outsourcing categorization on outsourcing relationship types in the Facility Management (FM) industry is new. A very aggressive or a very passive globalized FM service provider may not do the right job, thus leading to an outsourcing failure. If the globalized service provider is too aggressive, the service may not be satisfactory from the client's point of view because what is claimed cannot be achieved. If the globalized service provider is too passive, efficiency is low, and opportunities are missed. As more organizations make the transition from in-house to outsourced FM services, the number of reported cases of failure has been increasing (Brown, 2002; Chan, 2008). Baithelemy (2003) addresses seven

common problems for most failed outsourcing efforts, and that is a fact that most firms are generally reluctant to report outsourcing failures due to losing face and embarrassment. However, Plane and Green (2012) also explain that, the relationships between globalized clients and contractors do not always prosper as anticipated.
Hence, there is still possibly a hidden problem on outsourcing failure not yet been observed and solved. Kavcic and Tavcar (2008) claimed that, outsourcing can increase an organisation's short-term gains, especially in financial terms. However, it may also ruin the company's reputation and success because of poor-quality performance and hidden difficulties. Marshall et al. (2004) report that, process studies of outsourcing are rare and suggested to use a structured procedure capable of controlling the evolution of a generic outsourcing process (Kakabadse and Kakabadse, 2000). However, there is only limited research on structured partnerships in the field of FM services (Lehtonen and Salonen, 2005). It is necessary not only to develop new skills for managing outsourcing relationships but also to develop the capability to utilise these skills effectively (Harland et al., 2005).
In addition, insufficient attention has been paid to outsourcing failures from the perspective of hidden outsourcing relationships in the entrepreneurial environment (Ikediashi et al., 2012 and 2013). Hence, the relationship between the client and the service provider should be considered when addressing facility-related services (Cigolini et al., 2011).

Generally, the global FM services providers can provide specific FM outsourcing services for catering, cleaning, security and maintenance in the higher education institutes. The performance of globalized service providers can affect the quality of FM services, which in turn influences client satisfaction. There is a missing link in the knowledge between outsourcing arrangements and service provider performance or client satisfaction (Cigolini et al., 2011; Jensen et al., 2012; Lehtonen and Salonen, 2005; Plane, and Green, 2012). It is believed that organisations often do not consider how the performance of their outsourced service providers and the types of outsourcing relationship affect their own business success (Lok and Baldry, 2015). Scholars are still investigating why so many outsourcing failures are reported if it is long believed that FM outsourcing can provide an optimal relationship between global clients and service providers.
There are three crucial reasons for the need to build on these global intelligent FM outsourcing services from the perspective of service providers. Firstly, outsourcing is one of the procurement approaches used to provide building operation support services in FM. The use of this sourcing strategy in the higher education sector was scarce but more efficient (Adegoke and Adegoke, 2013). Secondly, organisations currently need to adopt outsourcing to take care of built environment in their tertiary institutions because they want to save money (Ferris and Graddy, 1991). Universities UK (2009) report indicates that, expenditure on estates and facilities are the second largest cost item after salaries. Thirdly, very little empirical research has been conducted in this area. Vidalakis et al. (2013) claim that further research is required to reveal the strategic aspects of FM and defines the role of facilities as part of the organisational strategy and culture on improving value for money.
More understanding of the categories of outsourcing relationships between the global client and service providers is equivalent to more understanding of the selection of appropriate outsourcing manoeuvres.

This study posits that the categories of outsourcing relationships can affect the outsourcing relationships types and the quality of outsourcing performance of the globalized service providers, and thus affect operational cost-and-profit equations of globalized organisations. The study therefore develops a scientific framework to manipulate the process of categorizing outsourcing relationships for the globalized FM industry. Obviously, globalized organisations

can improve their revenue by increasing user satisfaction with FM services, thus attracting more customers as addressed at service profit chain by Tranfield and Akhlaghi (1995).

Application of the outsourcing relationship model for the globalized FM industry may not be the final answer, but it can at least play some role in helping the FM sector to find out and discover the possible solution to outsourcing failures.

2. Literature Review

2.1 Working mechanism for the Four Outsourcing Relationship Types model

The Four Outsourcing Relationship Types model proposed by Kishore et al. (2003) is an important model for the evolution of Information Technology (IT) outsourcing relationships. The FORT framework classifies the client-provider outsourcing relationships into four; the four relationship types are depicted in terms of the competencies and monitoring mechanisms required to effectively manage them, and then the movement of global client-vendor relationships within and across relationship cells is traced over time as illustrated in Figure 1.

[Insert Figure 1 here]

By understanding the principal characteristics of an outsourcing relationship, the model helps in understanding this change. Table 1 indicates the characteristics of the Four Outsourcing Relationship Types model. But it should be noted that FORT model is mainly for the IT industry. In the FM industry, FORT has to be modified, but still with four categories, as detailed in later sections of this paper.

[Insert Table 1 here]

Assessing the extent of substitutes by globalized service providers are based on a number of key issues including: routine day-to-day operation; managerial control and decision-making authority; planning, development, and implementation of new application systems; ownership of hardware, software and other physical infrastructure; data reside on hardware platforms; replacement of in-house Information Technology and System (ITS) personnel and restricted to off-site activities. Again, there are a number of key issues for assessing strategic impacts of outsourced ITS portfolio, these are: competitive advantage, long-term competitiveness of client, close partnership, development of strategic inter-organizational relationships, identification of value leveraged points, business process improvements and new revenue.

Figure 2 represents the movement within the FORT framework of each of the four relationships. Kishore et al. (2003) explained that, outsourcing relationships are not static and likely to change and evolve over time due to changes in the external environment and in clients' internal requirement. The relationships may directly jump from "Support" to "Alignment", or to "Reliance", or even to "Alliance".

[Insert Figure 2 here]

The FORT model which is used in the globalized IT industry can provide insight into the types of outsourcing relationships that exist between clients and globalized FM service providers. The most interesting trait of this model is that, it examines the evolution of

companies' outsourcing relationships. According to Lok and Baldry (2015), five outsourcing relationship models are updated in various industries but each of which has its own deficiencies. Unlike the FORT model, those models are not dynamic in nature and do not explore the development of companies' outsourcing relationships. Kishore et al. (2003) explain the mechanism of the FORT model when the level of service-provider involvement is low. In the case of support and alignment relationships, clients make little investment in service provider specific assets. In such cases, globalized client-provider relationships usually operate in the short term and are fairly specific to outsourced projects and services. However, when the level of globalized service-provider involvement is high, clients make large investments in globalized service provider specific assets. For example, clients become more committed to financing globalized service providers' equipment, technology, systems and skills as part of reliance and alliance connections, which leads to a locked-in relationship and Williamson (1981) describes this phenomenon as 'small numbers opportunism'. Within the alliance relationship, trust is an important mechanism for ensuring that service providers' interests coincide with the clients' interests (Sabherwal, 1999). The FORT model is suitable and original because the proposed model covers the relationships between outsourcing types and outsourcing practices. Further arguments are provided to support the model of four outsourcing-relationship types. Every outsourcing model has its own advantages, due to its particular characteristics and theoretical underpinnings, but also its own disadvantages. Determining which model is generally best is rather a complicated process. Table 2 presents the Contingency Outsourcing Relationship (CORE) model based on the four outsourcing categories in dimensions of relationships in FM outsourcing. The CORE framework is proposed specifically for the FM industry.

[Insert Table 2 here]

2.2 Conversion of IT Four Outsourcing Relationship Types (FORT) model into FM Contingency Outsourcing Relationship Types (CORE) model

In the context of the globalized IT industry, the FORT framework is contingent in nature. Finch (2012) explains that outsourcing relationships have increasingly come to entail processes of mutual support and nurturing. Such a relationship may undergo significant change within the life of an individual contract as the service provider acquires an increasing diversity of professional capabilities. Figure 3 show the CORE model adopted from the FORT model while Table 3 details a comparison between the two models. The vertical axis in Figure 3 measures the extent of responsibility or ownership substitution on the part of an outsourcing service provider as a result of substitution strategies. The horizontal axis measures the strategic effect of an outsourced FM portfolio due to impact strategies. Finch (2012) further explains that the outsourced portfolio adds value to key business processes. This may include the enhancement of customer relations, improved supplier relationships and the improvement of product or service offerings.

[Insert Figure 3 here]

[Insert Table 3 here]

2.3 The advantages of applying the CORE model in the FM industry

As previously explained, the outsourcing category of a company is classified in the CORE model in FM industry. What are the benefits to the FM industry by identifying the outsourcing category of a globalized service provider professionally? This section introduces the benefits of the application of the CORE model for the stakeholders from the service providers' point of view. Understanding the rationale of the CORE model reflects the importance of the outsourcing category of a company. Moreover, Lok and Finch (2012) state that the FORT model is particularly applicable to the FM sector, with some modification, because of the specific advantages. Table 4 indicates the advantages of the CORE model in the context of outsourcing relationships in an FM contract.

[Insert Table 4 here]

2.4 Assignment of an Outsourcing Category to a Service Provider

The concept of outsourcing categorization is certainly new in the globalized FM industry. As explained above in the FORT model, its origin is mainly from the globalized IT industry. Analogously, it is believed that the rationale for outsourcing categorization can also be applicable to the globalized FM industry. As mentioned, the whole concept of IT outsourcing category is about the consideration of four outsourcing relationships between the clients and service providers. Similarly, it follows a rational that, there could also be four outsourcing relationships between the clients and service providers in the globalized FM industry.

Concerning the working mechanism of the CORE model, it is suggested to similarly apply the mechanism adopted in the FORT model as shown in Figure 2. It is expected that a service provider can be upgraded without sequence from Outsourcing Category (OC), OC1 to OC2 or to OC3 directly or even to OC4 directly as four relationships can be considered as of equivalent weighting with reference to their capabilities.

Each of the four outsourcing categories is interrelated with the relationship dimensions of substitution of ownership and control of globalized service providers and also strategic impact of the outsourced services on competitive position and long-term plan, but the evolution to a higher level outsourcing category of the globalized service provider is not necessarily originated from the upgrading of an immediately lower level outsourcing category with regard to the numerical sequence; i. e. from OC1 to OC2 and then to OC3 etc. The mechanism is that the evolution to a high level outsourcing category of the service provider is measured independently from the relationship dimensions of substitution of ownership and control of service providers and also strategic impact of the outsourced services. Therefore, the evolution from OC1 to any higher level outsourcing category is based on the capability of the service provider with respect to the result of measurement of the relationship dimensions independently as shown in Figure 3.

Rationally, a proper identification of the outsourcing category between a global client and the service provider can ensure that there is not excessive expectation of such relationship from both the client's and provider's points of view. The global FM client and the service provider also need to put effort to strengthen their relationship and then get upgraded from one category to another so that, failures can be mitigated. This feature of the CORE model is also very much similar to that of the FORT model. Each service provider, through a survey, can be capable of identifying one out of the four outsourcing categories. Outsourcing success by the service providers can be achieved through the proper matching of the outsourcing strategies to the four outsourcing categories from the CORE model if no other outsourcing problem existed.

3. Methodology

Lok and Baldry (2016) investigated the FM CORE model through the Analytic Hierarchy Process (AHP) methodology using quantitative questionnaire analysis. AHP which was used to categorise FM outsourcing relationships types with respect to the FM drivers is an analytical tool that uses the deductive approach. The use of the AHP basically serves two purposes: (1) assigning weights to a set of predetermined criteria or measures; and (2) prioritising or ranking elements to identify the key elements.

Two questionnaire surveys to clients and service providers were carried out with experienced industry practitioners in Hong Kong. The prospective respondents were located from various sources including the universities, tertiary institutes, private companies, quasi-government organisations and professional institutions of FM. On clients' side, the response rate was 41.3 per cent whiles on the service providers' side, the response rate was 40.9 per cent. In the questionnaire survey, the criteria of the outsourcing strategy definition were explained to ensure that the interviewees understood the interpretation of outsourcing strategy. For example, regarding the category of FM outsourcing relationship types, the interviewees were asked to compare "ownership and control" with "long-term plan and competitive position" with respect to each of the FM drivers, such as "co-ordination".

This section further introduces the rationale for applying an Artificial Neural Network (ANN) in contingency outsourcing relationship types modeling for the globalized FM industry. The tailor-made proposed FM Contingency Outsourcing Relationship (CORE) model can also be learnt by an artificial neutral network. It is not difficult to visualize that the rule base for identifying the OC of a service provider in the CORE model, it's mainly a knowledge base. Once it is a knowledge base, it can be learnt either by human or by machines. Learning by human may come up with some subjective conclusion while learning by machines is always objective.

Here, there are basically four categories, OC1, OC2, OC3 and OC4, each assessed by one of five ranks, "1", "2", "3", "4", or "5". Hence, there are totally $5^4 = 625$ combinations. One can say that "table lookup" could possibly be the easiest way to utilize this rule base. What is the purpose of complicating the issue by introducing ANN here? Firstly, the four categories may be extended to five, six or more categories while the number of ranks may also be extended to six, seven or more in future. Under this situation, the table will be getting longer and longer making it inconvenient for human use.

Secondly, when one participant in the survey fills up the questionnaire, integers are used for the rank, e.g. "1", "3" or "4" etc. When several participants of the same service provider are involved in the survey, their answers may not be consistent with one another. Then, we may come up with decimal points in the ranks, which cannot be interpreted properly by human.

Thirdly, in the table, each combination is independent of others and each combination represents one rule only. If a researcher wants to study the trend or sensitivity by slightly altering the rank of a particular OC while keeping that of others constant, it is inconvenient to work on a table. With these three concerns in mind, it is worth to build the whole rule base into an ANN for future application. In summary, the purpose of using ANN is to help analyse the existing FM outsourcing relationships between the clients and service providers and to produce some new findings to improve the chance of success of the outsourcing business. The service providers who can manipulate the outcomes properly are capable of designing and managing the outsourcing strategies for achieving a more satisfactory performance through the understanding of the outsourcing categories.

3.1 Rules for determining Outsourcing Categories (OC) of companies based on survey

Four categories were used in the surveys, namely OC1 for "In-house", OC2 for "Technical expertise", OC3 for "Commitment" and OC4 for "Common goals". For every service provider under the survey, a number of key managerial personnel is selected and are requested to assign a rank to each category. There are totally five ranks to be chosen by the respondent, from "1" to "5", meaning of which will be discussed in the rules. The set of rules to be developed can give a final category, i.e. either OC1, OC2, OC3, or OC4, based on the results of survey, as detailed below. The set of rules is designed for the determination of the FM outsourcing categories of companies based on the surveys. In the survey questionnaire, there are four questions which are used for identification of the outsourcing relationship types from a service provider's point of view. The five ranks for each question can be considered on a 5-likert scale. The five ranks contribute on the determination of outsourcing categories with reference to the magnitude of each. The higher the magnitude of the rank is, the more important the rank will be. The effect of determination of rank "3" can be observed as a minimum judgement in the process of outsourcing categorization. In other words, the inputs of rank "1" or "2" on other outsourcing categories are normally insignificant. In these cases, any outsourcing category with the rank "3" or higher can be considered as dominant. The rules are shown below;

i) The magnitude of stability of four outsourcing categories is naturally as follows.
OC1 < OC2 < OC3 < OC4

ii) The stability of OC1 is the smallest while the stability of OC4 is the largest correspondingly. The stability of outsourcing categories is measured by the relationship dimensions of substitution of ownership and control of service providers and also the strategic impact of the outsourced services on competitive position and long-term plan. Stability is about the locked-in relationship of the specific outsourcing category.

iii) The rank of “1” as “very unsatisfactory” and “2” as “unsatisfactory” are insignificant for determination. Hence, those combinations are ignored or considered inapplicable.

iv) The rank of “3” as “neutral”, “4” as “satisfactory” and “5” as “very satisfactory” are significant for determination, and they are seriously included in the assignment of category and the ANN training.

v) The final designated outsourcing category (i.e.) is (are) chosen when the rank of each of them is at least one of the three ranks, i.e. “3” or “4” or “5”.

vi) The final OC is determined to be OC1 = “In-house” if the rank of OC1 is “3” or “4” or “5” and is larger than the ranks of OC2, OC3 & OC4.

vii) The final OC is determined to be OC2 = “Technical expertise” if the rank of OC2 is “3” or “4” or “5” and is larger than the ranks of OC1, OC3 & OC4, or if the rank of OC2 is “3” or “4” or “5”, and is equal to the ranks of OC1 and larger than the ranks of OC3 & OC4.

viii) The final OC is determined to be OC3 = “Commitment” if the rank of OC3 is “3” or “4” or “5” and is larger than the ranks of OC1, OC2 & OC4, or if the rank of OC3 is “3” or “4” or “5” and is equal to the rank of OC1 or OC2 or both.

ix) The final OC is determined to be OC4 = “Common goals” if the rank of OC4 is “3” or “4” or “5” and is larger than the ranks of OC1, OC2 & OC3, or if the rank of OC4 is "3", "4" or "5" and is equal to the rank of OC1 or OC2 or OC3 or all of them.

x) The final OC is determined to be OC5 = “Unclear category” if all the ranks of OC1, OC2, OC3 & OC4 are either “1” or “2”.

The theory and detailed working procedures of artificial neural networks in this research are addressed as follows.

3.2 A Quick Review on Artificial Neural Networks (ANNs)

Artificial Neural Networks (ANNs) are the mathematical simulation of neuron operation inside the human brain (Aggarwal, 2018; Graupe, 2013; Hassoun, 1995 and 2003). The basic element inside a human brain for thinking and memory is called "neuron and there are around 44 billion neurons in the human brain".

[Insert Figure 4 here]

The neurons, shown in Figure 4, inside the human brain are interconnected so that chemical and electrical signals can be passed from one neuron to another neuron across the brain. It consists of the cell body, with dendrites like the hair on the human head. The tip of a dendrite of one neuron is very close to the tip of an axon terminal of another neuron. The gap is called a synapse where the electrical signals being converted into chemical signals, i.e. ion exchange, get through the gap. In this way, one neuron can receive information from another neuron nearby. In other words, neurons are not hard-wired to one another. There is always a small gap between a dendrite and an axon terminal. In general, one neuron can send information to several receiving neurons. The dendrites receive electrical impulses from several other neurons. The cell body then adds up all these signals and determines what to do next. If there is enough stimulation, it decides to fire a pulse down its axon. The axon has connections to several other neurons. When the computer mimics our brain, it relies on the construction of an ANN. The neuron in the brain is analogous to the node of the ANN while the connection between neurons to the connection weight of the ANN. An example showing a node that receives three inputs is depicted in Figure 5.

[Insert Figure 5 here]

In Figure 5, x_1, x_2 and x_3 are the inputs, w_1, w_2 and w_3 the weights, b the bias and finally, y the output. This represents neuron inside the human brain. The process is mathematically given by equation (1).

$$v = w_1x_1 + w_2x_2 + w_3x_3 + b \qquad (1)$$

$$= \begin{pmatrix} w_1 & w_2 & w_3 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + b$$

$$= \mathbf{WX} + b$$

Hence, if $w_2 >> w_1$, the effect of x_2 on the node is much larger than that of x_1. Equation (1) looks very linear in nature, which cannot be used to simulate any real system that is virtually non-linear. Before the output y, is obtained, an activation process, ϕ, is needed to be applied to the weighted sum, as shown in equation (2).

$$y = \phi(v) = \phi(\mathbf{WX} + b) \qquad (2)$$

The most widely used activation function is called the sigmoid function defined in equation (3). The choice of the sigmoid function is that the derivative of it, ϕ', is equal to the product of itself and one minus itself, i.e. $\phi' = \phi\ (1 - \phi)$ and also it must return a value between 0 and 1.

$$\phi(x) = \frac{1}{1 + e^{-x}} \qquad (3)$$

When many nodes of this kind are interconnected to one another in the computer, an ANN has been created, as shown in Figure 6, and it can be used to learn knowledge and patterns fed from the external world.

[Insert Figure 6 here]

All inputs are given by the user and fed to the input layer. Such inputs are multiplied by the weights and fed to the nodes of the hidden layer. For a simple problem, one hidden layer is usually good enough, called a shallow neural network. For complicated problems, very often, more than one hidden layer is involved and it is called a deep neural network. Most of the contemporary ANNs used in practical applications are deep neural networks. The output is usually known by the user and fed to the output layer. However, all w's are unknown right after the ANN is newly developed. So, the key process to make the ANN useable is to train it so that it can simulate the performance of a real system in the world based on known inputs and outputs. Training an ANN is equivalent to finding all the w's that can make the ANN adapt to all inputs (x_1, x_2, ..., x_n) and outputs (y_1, y_2, ..., y_m).

The most standard method to train a "feed-forward" ANN is called "backpropagation of errors under supervised learning" (Werbos, 1974 and 1994). A number of training data sets formatted as {input, correct output} is fed to the ANN, one at a time. The training procedures can simply be listed as follows;

i) Initialize the weights of the whole ANN with appropriate initial values.
ii) Take the "inputs" from the first set of training data, i.e. x_1, ..., x_n, and feed it to the input layer. Obtain the outputs, i.e. y_1, ..., y_m, from the ANN based on the current weights.
iii) Cross compare the outputs of the ANN with the correct outputs from the training data sets to obtain the total error.
iv) Adjust the weights to minimize the error.
v) Repeat steps (ii)-(iv) for all training data sets.

The whole process is the modification of the ANN model, i.e. its weights, to fit the training data sets.

4. Analysis of Results and Discussions

4.1 The ANN for Outsourcing Categorization

The theory regarding outsourcing categorization was discussed in the previous section. There are four categories, namely OC1, OC2, OC3 and OC4, which can be fed into x_1, x_2, x_3 and x_4 of the ANN model. Based on the surveys of service providers, for each OC, there can be five grades, namely "1" for "very unsatisfactory", "2" for "unsatisfactory", "3" for "neutral", "4" for satisfactory" and "5" for "very satisfactory. There is only one output, y = OC1, OC2, OC3 or OC4, which is the final category of the company based on the survey. The rules of manually determining the output were discussed in the previous section. For 4 categories, each with 5 ranks, there are totally 625 combinations. However, based on the rules mentioned before, the data set is ignored if none of the four inputs is 3 or above. Hence, 2 x 2 x 2 x 2 = 16 combinations are not included in the training process, leaving behind 609 valid data sets. A computer program was compiled using the "Neural Network" Toolbox of Matlab™ as shown in Figure 7 and the zoomed structure of the resulting ANN is shown in Figure 8.

[Insert Figure 7 here]

[Insert Figure 8 here]

It can be seen from Figure 8 that there are four nodes in the input layer and 25 nodes in the hidden layer. Each node in the hidden layer is associated with a bias and the weighted sum of all nodes in the hidden layer is activated by a sigmoid function. There is only one node in the output layer while the activation function is just linear. Hence, between the input layer and the hidden layer, there are 4 x 25 = 100 weighted connections, shown in Figure 9(a). And between the hidden layer and the output layer, there are 25 x 1 = 25 weighted connections, shown in Figure 9(b). The bias to each of the 25 hidden nodes is shown in Figure 9(c) while that to the output layer is shown in Figure 9(d).

[Insert Figure 9a-d here]

Only less than 600 iterations were needed to arrive at the well trained ANN net of609 in this case, where every ANN output agrees with the known output. However, a well-trained ANN can 100% mimic the raw data sets. In order to show the power of the ANN, the data sets are handled by polynomial curve fitting. It is assumed that the output can be evaluated from the inputs with the following equation (4) where a, b, c, d, e, f, g, h, i are all unknown parameters to be estimated by using least squared sum optimization with the curve fitting tool solver in Excel.

$$y = a + bx_1 + cx_2 + dx_3 + ex_4 + fx_1^2 + gx_2^2 + hx_3^2 + ix_4^2 \qquad (4)$$

Some results are shown in Figure 10(a) and the nine resulting unknown parameters are shown in Figure 10(b). It can be seen from Figure 10(a) that the results of the fitted polynomial cannot agree with most known outputs from time to time, meaning that the problem is far too non-linear to be fitted by a simple polynomial to a 2nd order only.

[Insert Figure 10a/10b here]

At this stage, the ANN is considered well trained for real application. Since rules to determine the OC rank of each data set are available, the question of why an ANN technically is needed is brought up again. Of course, the first reason is obvious; it seems that only an ANN is able to learn such a highly non-linear system. But there is another main reason why table lookup cannot be used. During a real survey, several key officers in a service provider are interviewed and their answers may not be consistent with one another. For example, if two officers give a rank "4" to OC1 while one officer gives a rank "5" to OC1; such scenario cannot be handled by the rule base. An average rank, (2 x 4 + 1 x 5) / 3= 4.33, can be used for OC1 but in the rule base, there is no rule taking care of decimal rank. Under this condition, the ANN may be helpful, as shown by several examples in the next section.

4.2 Application of the ANN

This section demonstrates how the FM Contingency Outsourcing Relationship (CORE) model can be applied to the FM services through the categorization of the FM outsourcing relationship types. It shows how the trained ANN can be used to tackle newly retrieved raw data from surveys of the service providers so that a fair rank can be given to each provider. A survey was conducted with six FM service providers and the raw data sets are given in Table 5. Some abbreviations are listed below again for clarity.

1) Possible comments from a Respondent:
1=Very unsatisfactory; 2=unsatisfactory; 3=Neutral; 4=satisfactory; 5=Very satisfactory.

2) Types of Outsourcing Category:
OC1=In-house; OC2=Technical expertise; OC3= Commitment and OC4=Common goals.

[Insert Table 5 here]

By feeding Table 5 into the trained ANN, ann_609, the following results are obtained as shown in Table 6. From Table 6, it can be seen that the well trained ANN agrees with the majority of the opinion.

[Insert Table 6 here]

In this study, the FORT model is first considered as an instrument to identify the four FM outsourcing relationships between clients and service providers in the IT industry. The FORT model is designed to identify and examine the four kinds of client-service provider relationships in the outsourcing contracts (Kishore et al., 2003). However, the concept of the evolution of the outsourcing relationships types has its limitation if the backgrounds of the clients and service providers have different cultures.

5. Conclusion

The study attempts to solve one of the unseen problems of poor performance of globalized FM service providers in the FM contracts. For sure, it is more effective for the service providers to understand more about their own capabilities and relationships with the clients. If the service providers can apply the outsourcing strategies with their own capabilities appropriately corresponding to the specific outsourcing category of the CORE model, outsourcing failures may possibly be eliminated. The application of the ANN technique is helpful for detailed analysis of the specific outsourcing category of the CORE model intelligently, in terms of Outsourcing Category (OC) assignment and sensitivity analysis. The involvement of ANNs can help the global FM industry to work on strategies beyond the human capacity based on table look-up. Similarly, clients can understand more about their relationships with their service providers through the same testing procedures and analysis via the application of the ANN technique on the CORE model. The rule base has been detailed in this paper and examples have been used to illustrate how the ANN technique can be applied to OC assignment based on surveys.

In this case, both the global clients and service providers can design and implement their own outsourcing strategies appropriately. More mutual compromise of the FM outsourcing strategies between the global clients and service providers means more opportunities of successful FM outsourcing practices.

The significance of this paper is to highlight the rationale for identifying the four outsourcing categories in a globalized FM industry. The globalized companies (service providers) are required to identify their own positions in one of the four outsourcing categories in the FM industry. The identification of four outsourcing categories is useful to the globalized service providers who can design and develop their own outsourcing strategies according to their current outsourcing status; not too aggressive nor too passive. In other words, the globalized service providers can understand their outsourcing categories better from the CORE model and effectively implement the appropriate outsourcing strategies in alignment with their own outsourcing categories.

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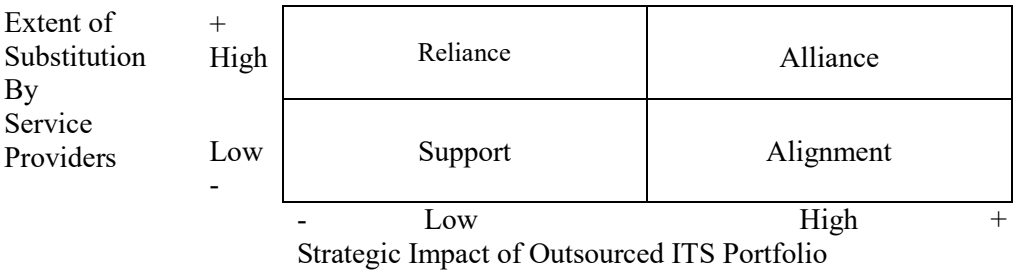
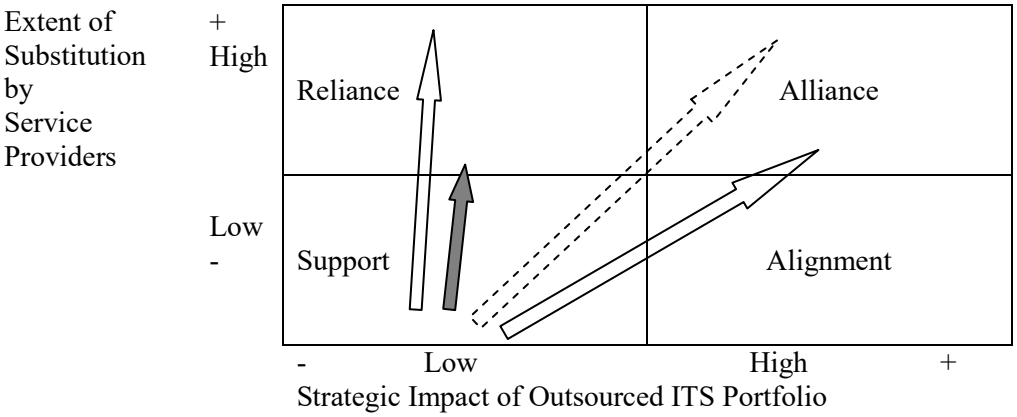


Figure 1 - Generic client – provider outsourcing relationships types by Kishore et al. (2003)



Legend

Supportive movement
Substitutional movement
Strategic movement

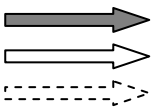
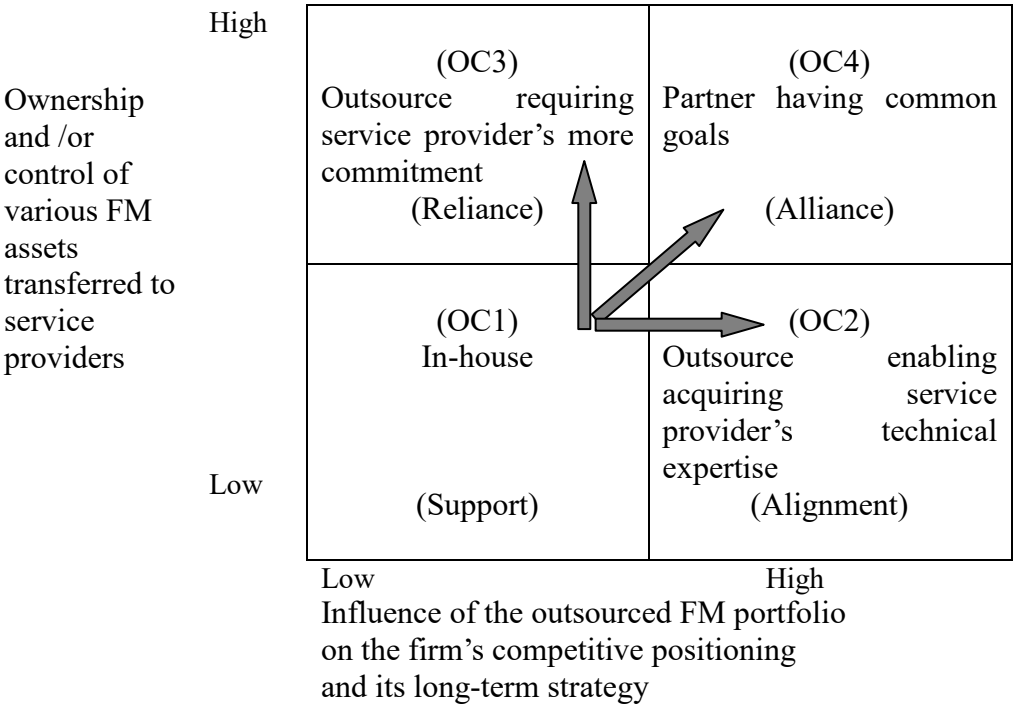


Figure 2 – The evolution of outsourcing relationships – An illustration of four client firms' outsourcing relationships over time by Kishore et al. (2003)



Remarks:
(IT dimension): e.g. (Support)
FM dimension: e.g. In-house

Figure 3 - The FORT Framework converted for the FM industry (The CORE model)

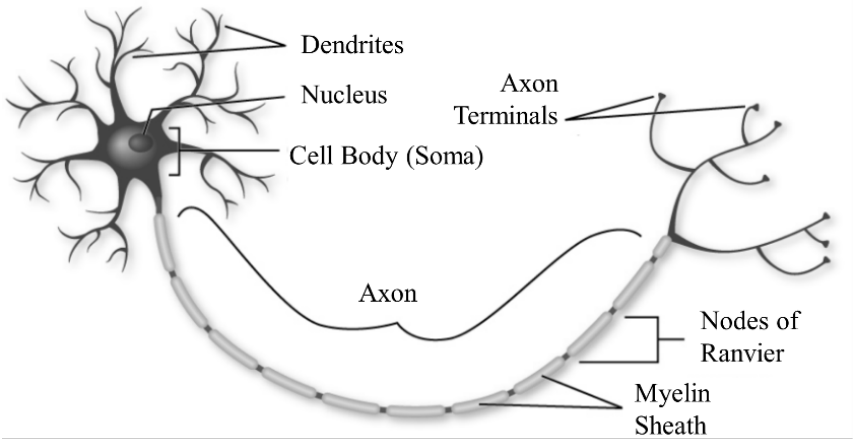


Figure 4 - The structure of a typical Neuro

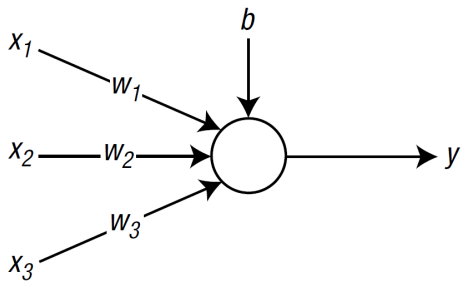


Figure 5 - A node in an ANN with three inputs and one output

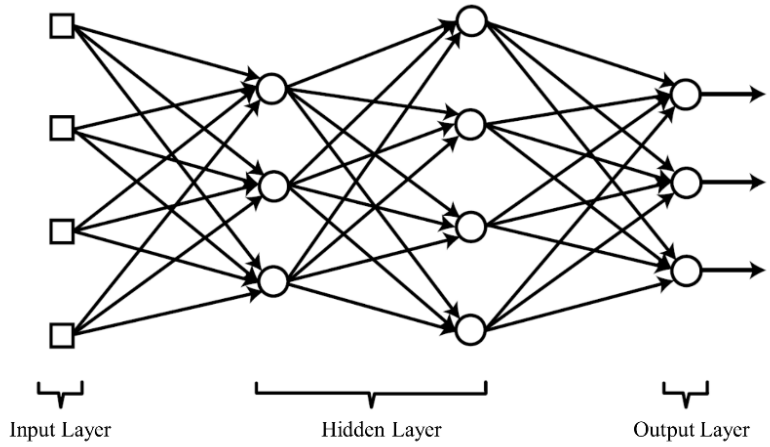


Figure 6 - Layered Structure of a typical ANN

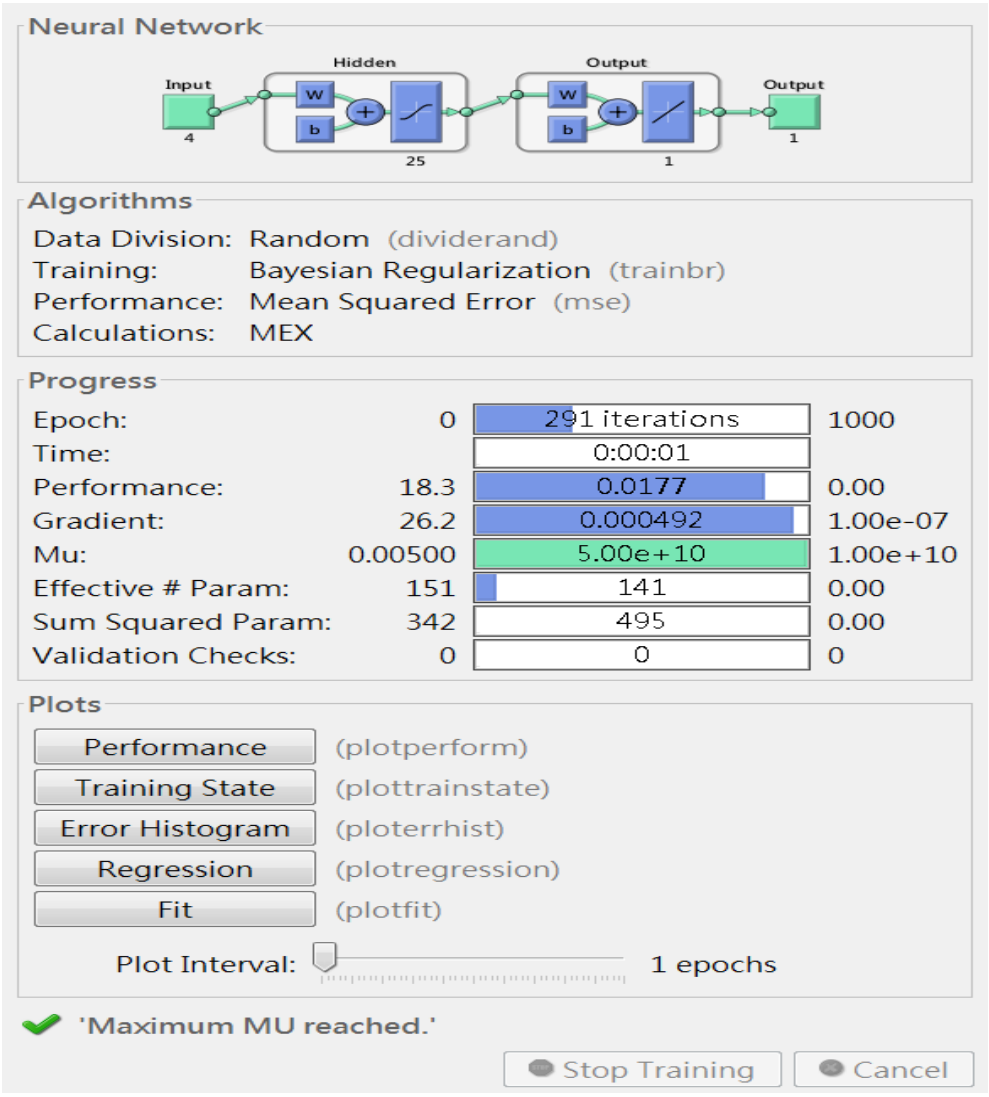


Figure 7 - Display of MatlabTM Neural Network Toolbox

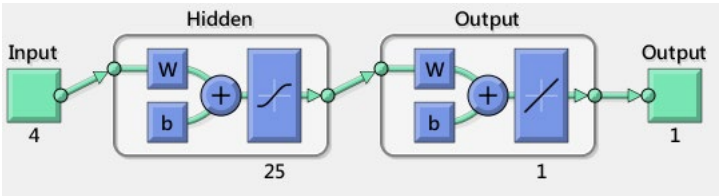


Figure 8 - Zoomed ANN Structure

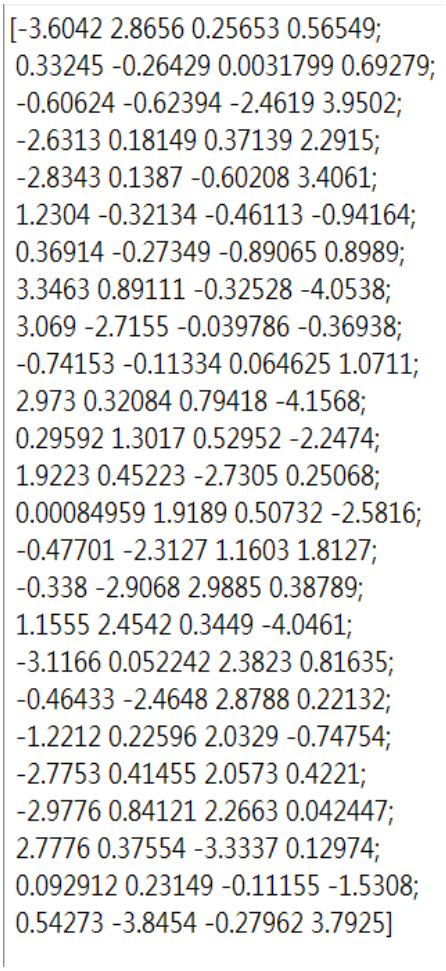


Figure 9(a)

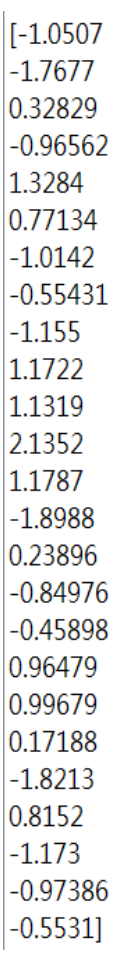


Figure 9(b)

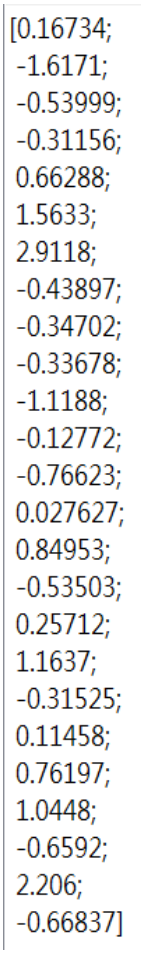


Figure 9(c)

Figure 9(d)

Input 1 = OC1	Input 2 = OC2	Input 3 = OC3	Input 4 = OC4	Known Output	ANN Real Output	ANN Rounded Output	By Curve Fitting	By Curve Fitting Rounded
3	1	1	1	1	1.03	1	1.97	2
3	1	1	2	1	1.03	1	2.29	2
3	1	2	1	1	1.07	1	2.00	2
3	1	2	2	1	0.95	1	2.32	2
3	2	1	1	1	0.98	1	1.97	2
3	2	1	2	1	1.07	1	2.29	2
3	2	2	1	1	1.14	1	2.00	2
3	2	2	2	1	1.20	1	2.32	2
4	1	1	1	1	1.06	1	1.97	2
4	1	1	2	1	1.18	1	2.29	2
4	1	1	3	1	0.99	1	2.72	3
4	1	2	1	1	1.11	1	2.00	2
2	4	1	1	2	2.09	2	1.97	2
2	4	1	2	2	2.02	2	2.29	2
2	4	1	3	2	2.00	2	2.72	3
2	4	2	1	2	2.03	2	2.00	2
2	4	2	2	2	1.86	2	2.32	2
2	4	2	3	2	2.06	2	2.76	3
2	4	3	1	2	2.16	2	2.06	2
2	4	3	2	2	2.11	2	2.38	2
2	4	3	3	2	2.08	2	2.81	3
3	4	1	3	2	2.06	2	2.72	3
3	4	2	1	2	1.95	2	2.00	2
3	4	2	2	2	1.88	2	2.32	2
3	4	2	3	2	2.19	2	2.76	3
3	4	3	1	2	2.09	2	2.06	2
3	4	3	2	2	2.19	2	2.38	2
3	4	3	3	2	2.12	2	2.81	3
3	5	1	1	2	1.92	2	1.97	2
4	5	3	2	2	1.93	2	2.38	2
4	5	3	3	2	1.91	2	2.81	3
4	5	3	4	2	2.25	2	3.35	3
4	5	4	1	2	2.06	2	2.14	2
4	5	4	2	2	2.05	2	2.46	2
4	5	4	3	2	2.18	2	2.90	3
4	5	4	4	2	2.13	2	3.43	3
5	5	1	1	2	1.85	2	1.97	2
5	5	1	2	2	2.02	2	2.29	2
5	5	1	3	2	2.45	2	2.72	3
5	5	1	4	2	1.89	2	3.26	3
5	5	2	1	2	1.89	2	2.00	2
5	5	2	2	2	1.97	2	2.32	2

Figure 10(a) Results of Curve Fitting

a	1.737683956
b	0
c	0
d	0
e	0.162439977
f	0
g	0
h	0.011622756
i	0.053820453

Figure 10(b) Tuned Parameters by Curve Fitting

List of Tables

Year	Model	Type	Field	Innovator
2003	Contingency	Four Outsourcing Relationship Types Framework	IT	Kishore et al., 2003
Theory applied	The four resulting types of outsourcing relationships: **Support (OC1)*** : Low extent of substitution & Low strategic impact Substitutional movement –a movement into the alignment (OC2), reliance (OC3) or alliance cells (OC4). Movement from the **support (OC1) cell to alignment (OC2) cell or reliance (OC3) cell is less risky** because of not involving large investments. However, from this cell into **alliance (OC4) cell may be a risky proposition** because of general lack of prior knowledge and experiences **Alignment (OC2)**: Low extent of substitution & High strategic impact Movement –**may decide to move to reliance or alliance cells progressively increasing their commitment**. move into an alliance relationship with their service providers usually find it helpful **Reliance (OC3)**: High extent of substitution & Low strategic impact Movement – move into the alliance cell. usually **difficult to return to the support or alignments cells due to locked-in relationships with current service providers** **Alliance (OC4)**: High extent of substitution & High strategic impact Strategic movement – Movement from this cell into other cells is the most arduous and calls for extremely well and **carries the highest set-up and switching costs.** Movements into alliance cells require **progressively more commitment** to the relationship from client firms. **The degree of locked-in relationships is the highest in the alliance cell.** Therefore, outsourcing decisions become **more irreversible**.			
Concepts	1) evolution of IT outsourcing relationships of the companies. 2) two dimensions most germane to outsourcing relationships. One is to deal with the extent of ownership substitution by outsourcing service providers, i.e. degree to which ownership and/or control of various ITS assets to service providers. 3) The other is to deal with the strategic impact of outsourced ITS portfolio, i.e. a firm's competitive positioning and its long-term strategy.			

Table 1 - The Four Outsourcing Relationship Types model

Outsourcing Category	Relationship Dimension	Degree	Meaning in Outsourcing	Description
1 - In-house	Substitution of Ownership	Low Low	Use of FM assets	To transfer the use of various FM assets wholly to service providers, e.g. routine day-to-day operations, hardware (Hard FM - The challenge of flexible facilities), software (Soft FM - The challenge of flexible relationships in service provision) and physical infrastructure.
2 – Technical expertise	Substitution of Control	High High	Management of FM assets	To transfer the management of various FM assets to service providers, e.g. managerial control and decision making over operations, planning, development and implementation of facilities and personnel replacement in-house FM personnel
3 - Commitment	Strategic impact on Competitive position	Low High	Business process improvement	To influence the outsourced FM portfolio (Managing multiple sites in various regions) on the market, e.g. competitive advantage, value points for leveraging FM portfolio and business process improvement.
4 – Common goals	Strategic impact on Long term plan	Low High	Long term strategic importance	To influence the outsourced FM portfolio of the firm, e.g. long term competitiveness, a close partnership, strategic inter-organizational relationship and new revenue.

Table 2 - Four outsourcing categories in dimensions of relationships in FM outsourcing

Information Technology	**Facility Management**	**Four Dimensions Relationships**	
Four Relationship types (FORT) model	**Contingency Outsourcing Relationship (CORE) model**		
Four Relationship types	Four Relationship types	Degree on vertical axis	Degree on horizontal axis
(1) Support	(1) In-house	low	low
(2) Alignment	(2) Service provider's technical expertise		High
(3) Reliance	(3) Service provider's more commitment	high	low
(4) Alliance	(4) Partner having common goals		high

Remarks:
Vertical axis: i) degree of ownership substitution and /or ii) control of various FM assets transferred to service providers
Horizontal axis: Strategic importance of the outsourced services and influence of the outsourced FM portfolio on the firm's iii) competitive positioning and iv) its long-term strategy

Table 3 - Framework of the four outsourcing relationships between service providers and clients in IT and FM industries

Advantages of the CORE model in relation to outsourcing relationships in an FM contract
Clear explanation
Efficient differentiation of contracts
Easy to handle
Effective
Versatile
User-friendly
Flexible
Most reliable

Table 4 - Advantages of the CORE Framework

Service Provider Number	Officer Number	OC1	OC2	OC3	OC4
1	1	3	4	5	2
	2	4	5	5	3
	3	3	4	4	1
Average of Inputs		3.33	4.33	4.67	2.00
2	1	5	3	2	2
	2	4	4	3	2
	3	4	5	3	3
Average of Inputs		4.33	4.00	2.67	2.33
3	1	4	5	4	3
	2	5	5	3	2
	3	5	4	3	4
Average of Inputs		4.67	4.67	3.33	3.00
4	1	3	4	3	1
	2	3	5	4	1
	3	4	4	4	2
	4	5	5	4	2
Average of Inputs		3.75	4.50	3.75	1.50
5	1	3	3	2	3
	2	3	2	1	5
	3	5	4	2	5
	4	3	4	1	4
Average of Inputs		3.50	3.25	1.50	4.25
6	1	2	2	2	4
	2	3	4	3	5
	3	3	3	3	4
	4	4	5	4	4
Average of Inputs		3.00	3.50	3.00	4.25

Table 5: Raw Data from Surveys from six Service Providers

Service Provider Number	Officer Number	OC1	OC2	OC3	OC4		Immediate Results from well-trained ANN	Rounded Results from well-trained ANN
1	1	3	4	5	2		2.88	3
	2	4	5	5	3		2.89	3
	3	3	4	4	1		2.77	3
Average of Inputs		3.33	4.33	4.67	2.00		3.01	3
2	1	5	3	2	2		0.88	1
	2	4	4	3	2		1.96	2
	3	4	5	3	3		1.91	2
Average of Inputs		4.33	4.00	2.67	2.33		1.56	2
3	1	4	5	4	3		2.18	2
	2	5	5	3	2		2.03	2
	3	5	4	3	4		1.22	1
Average of Inputs		4.67	4.67	3.33	3.00		1.92	2
4	1	3	4	3	1		2.09	2
	2	3	5	4	1		2.12	2
	3	4	4	4	2		3.07	3
	4	5	5	4	2		1.94	2
Average of Inputs		3.75	4.50	3.75	1.50		2.29	2
5	1	3	3	2	3		3.81	4
	2	3	2	1	5		4.24	4
	3	5	4	2	5		3.91	4
	4	3	4	1	4		3.81	4
Average of Inputs		3.50	3.25	1.50	4.25		4.34	4
6	1	2	2	2	4		3.98	4
	2	3	4	3	5		3.88	4
	3	3	3	3	4		4.18	4
	4	4	5	4	4		2.13	2
Average of Inputs		3.00	3.50	3.00	4.25		3.99	4

Table 6: Rounded results from the ANN