MODELLING TRUST IN CUSTOMER AND SUPPLIER INTERACTION – A SIMULATION OF DYNAMIC PERFORMANCES

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ABSTRACT

This paper writes about a theoretical model developed to understand trust in customer and supplier relationship. The model developed considers seven variables in an interaction between a customer and a supplier. These influencing factors suggest here affect customer's trust towards their suppliers. These factors are (1) Control, (2) Feedback, (3) Delay, (4) Disturbance, (5) Co-operation, (6) Supplier's Commitment and (7) Distance. The model proposes that a supplier's performance in a high volume with repeated transactions environment is dynamic. It is written here that making decision (investment) based on past supplier's repeated performances are possible links to trust. Simulation of supplier dynamic performance proofs the links possible, making prediction possible of what is known.

1.0 INTRODUCTION

Trust is an important factor in customer and supplier relationship and is by far the most important factor characterizing a good relationship as stated by Ford (1980). Trust cannot be measured. However, supplier's performance can be measured. In this paper, the influences of trust developed are represented in a model. The model is based on Wolstenholme (1992) influence diagram. This leads to two simple arithmetic equations which equates supplier's performance with factors influencing trust. The two equations relate supplier's performance with trust, a factor that customer has towards their supplier.

Modelling is completed by using system dynamics approach where trust is influenced by several factors. This is based on the Industrial Marketing and Purchasing IMP Model in Europe and other literature search. The factors formulate that the influences of trust are affected by (1) Control, (2) Feedback Rate, (3) Delay and (4) Disturbance. At later stage, the model is extended to include (5) Co-operation, (6) Supplier's Commitment and (7) Distance.

The above factors are broadly classified into four (4) main categories. These categories are *Authority, Information, Uncertainty* and *Attitude*. The Control factor is a representation of *Authority*. Feedback Rate and Delay is classified as *Information*. External Disturbances and the Distance between a customer and their suppliers cause *Uncertainty* in a relationship. Co-operation and Supplier Commitment indicates supplier's *Attitude* in a relationship.

The model is based on the Industrial Marketing and Purchasing IMP Model published, Hakansson (1982), by the group and also other literature search. The model represents industrial buying and selling in customer and supplier relationship. It simplifies customer and

supplier relationship to Interaction Processes (the processes in a relationship), Interaction Parties in a relationship (supplier and customer) and Environment in which an Atmosphere emerges as a customer interacts with a supplier forming a relationship. The interactions are assumed to be long term.

The model developed is to increase a low trust supplier to a higher trust supplier, to assist in decision as to whether it is important to invest further in the relationship based on quantifiable mathematical equations. It is also important not to neglect the qualitative part of making a decision, the consideration of the human factor in a decision. The model considers the qualitative part by considering or looking into the soft factors, identifying and defining the root cause of the problem, similarly to increase low trust supplier to higher trust supplier by improving the variable that influences trust. It is not possible to capture every factor that influences trust in a relationship. Here it is intended and limited to a few factors as stated in later sections.

2.0 SOME BACKGROUND ON CUSTOMER AND SUPPLIER RELATIONSHIP BASED ON LITERATURES SEARCH

The initial perception before getting into a relationship is interesting. Initially, both customers and suppliers are unaware of opposing abilities. It is only by perception, as the origin of trust in a customer and supplier relationship investigated by Smeltzer (1997) considers the origin by three factors - corporate identity, image and reputation. It is explained that customers perceived their suppliers by the above three (3) factors. On the other hand, suppliers perceive their customers by the same factors. This means that both customers and suppliers trust each other in a relationship by perception. In other words, the customer and the supplier perceive trust by their (1) corporate identity, (2) image portrayed and (3) established reputation of the interacting company or organization.

Examination of the nature of buyer-seller relationship in industrial market was done by Ford (1980) considering the development of their relationship through time, by analysing the process of establishment and development of a relationship over a five stages evolution. From this study, customer and supplier relationship builds up as it progresses. It is not an instantaneous situation that both parties know each other from the day a customer or a supplier meets. A relationship requires time to establish to a stage where more commitment will be exemplified.

However, if the customers are not benefiting from the suppliers, meaning not meeting the initial requirements, it is very likely that the customer will find another supplier. The customer will not commit further and just find another supplier that is able to offer the product or the service that is required. In this case, it is not in view of the long-term approach but it is only to seek another supplier which is able to offer the required product or service.

The terms of partnership, it is only form when both parties realize that there are shared benefits, especially the customer. One point to share is the utilization of resources that are available from the supplier to achieve the objectives. Another point is to spread financial prudency to the supplier. Both the customer and the supplier see the worth of getting into a partnership agreement and a closer relationship is formed. The resources and costs are spread between the two parties, and development time reduced, to mention a few benefits.

In partnership there are success and failures. Partnership pitfalls or success is written in an article by Lisa (1995). In the article, the reasons why buyer and supplier enter into a partnership are ranked. The key factors that contributed to a partnership failure are also tabulated. The main reason buyers enter into a partnership is due to price or total cost of delivered item or of product class. The main reason suppliers enter into a partnership is to secure reliable market for this item or of product class. It is also believed that the most important factor to the success of a purchasing partnership is due to two-way information sharing (by buyers) and top management support (by suppliers). The article found that the main reason of a failure in partnership is due to poor communication.

In addition to this, instead of just development of a relationship though time and to see whether it is worth continuing, Wilson and Mummalaneni (1986) put it such that two parties are brought together due to the "complementarity of their needs", "ties or bonds" establishes between the two parties. The "investment and level of satisfaction" of the customer determine "the degree of commitment" in the relationship.

In every relationship, there bound to have uncertainties in a relationship realized before both parties get into a relationship. Hakansson, Johanson and Wootz (1976) explained the term *uncertainties* in three headings. These *uncertainties*, as explained are: (1) need uncertainty, (2) market uncertainty and (3) transaction uncertainty. As defined need uncertainty as being whether the customer can really know the exact product or service that is required from the supplier. Market uncertainty is to know whether knowledge in the market area is known and that the change involved offered by suppliers. Transaction uncertainty is being defined as the ability to purchase the product or service. This means that these uncertainties are realized throughout the purchase of product or service as defined. Uncertainties are in opposed to strengthening of a relationship. The uncertainties need to be reduced to ascertain the customer of its abilities.

In addition, Touboulic and Walker (2015) manage to investigate and map from a theoretical perspective, sustainable supply chain conceptualisation - for future field of works and development. It is also suggesting here that an impact on sustainable supplier selection, sustainable supplier performance (monitoring) and collaborative supplier development program will ensure or ascertain the relationship, as highlighted Yang and Zhang (2017), empirical study finding from a buyer perspective shows positive influences on buyer-seller relationship.

Recently in 2015, 193 countries for instance, adopted the Sustainable Development Goals SDGs which provides a viable model for long term growth, a framework that sets clear vision to address the global challenges we encounter today. This drive, in sustainable model, specifies the need for supply chain practitioners in the industry to overcome the situation with the goals to achieve, which is dynamic in the real world; dynamic models can characterize the real world to a certain extent.

3.0 THE DYNAMIC BEHAVIOUR – IN CUSTOMER AND SUPPLIER INTERACTION

The behaviour of suppliers in customer and supplier performance is dynamic. Occasionally, suppliers perform in a relationship. Inversely, the reverse occurs. The dynamic performance of the supplier is dependent on influencing factors that affects the interaction. For example,

trust is affected if the suppliers perform badly, trust being an important factor in customer and supplier interaction as informed by Han, Wilson and Dant (1993). The factors affecting an interaction must be identified. It will ultimately maintain the trust in subsequent interactions. It will gradually improve by lifting the lowest scored influence to an acceptable level, ensuring that the lowest value is within the required mean performance. It is agreed that it requires time to establish trust. In modelling customer and supplier relationship, the dynamic behaviour is dependent on factors effecting the interaction. It shows an approach of defined variables to simplify a complex problem situation. Modelling customer and supplier relationship is to represent the factors that will possibly affect the interaction between a customer and his or her supplier. The model identifies important influences of a complete picture in a relationship.

In view of a long-term relationship, it is not to dissolve a relationship but rather to increase the trust level from low to a higher level, if possible. Else, the mean performance of a relationship, which shows the dynamic behaviour throughout the interaction process should lies within the required level, based on trust, or around a value if the performance is calculated. The trust level is required to be established to a comfortable level. The performance level, quantitatively calculated, is an *indication* of a trusting relationship. It can be used as an indication of a rough prediction used as a measurement of a next value.

4.0 THE TRUST MODEL

The factors that influence the relationship in the trust model are shown in figure 1. It consists of seven variables; (1) Control, (2) Feedback Rate, (3) Delay and (4) Disturbance, (5) Co-operation, (6) Supplier's Commitment and (7) Distance. These variables can be extended or added. In addition, it can also be removed if it is not applicable. In this paper, seven variables affecting a relationship are explained. These variables are developed through the IMP Model and literature search.

Fig. 1 System Dynamic Representation – The Influencing Factors of Trust

Control and Feedback Rate increases the trust level whereas Disturbance and Delay reduces the trust level. The word *Control* is defined here. Incoming data that can be recorded, counted for the number of rejects in each dispatch quantity, etc., is a control factor on the assembly parts. The word Feedback Rate is the responses from the supplier when a customer requires information of a change in design requirements. In other words, it is how the rate of response or the response to the change is relayed back to the customer. If there is a delay in the respond to a change, the trust level will be affected because the supplier might not be interested. The attitude of the supplier plays an important role towards the success of a relationship. Disturbance is due to uncertainties beyond the known boundaries, for example, a change in market trend in foreign place, a change in end customers' perception, etc.

If the interface variable such as the number of rejects is measured, the number of known failures causing the reject can be controlled. A change in end customer requirements on the market is informed to the supplier to accommodate for the change. The feedback rate can be measured to show the keenness of the supplier. A delay in response to the change will affect the performance slightly. Disturbance due to uncertainties will affect the relationship slightly.

It is later added that distance of the customer cause uncertainty in a relationship. Co-operation and Supplier Commitment are indications of supplier's attitude in a relationship. This model is superimposed on the IMP Model and is shown in figure 2.
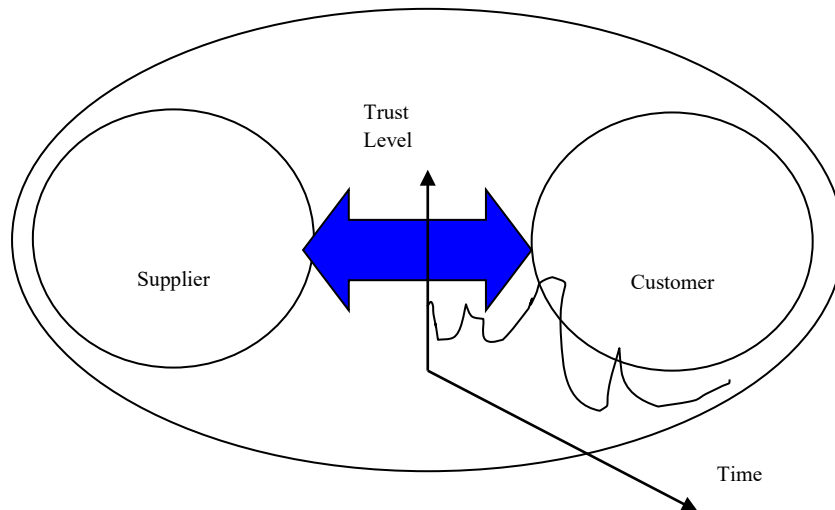

Fig. 2 Time Scale and Trust Measurement Between Customer and Supplier

It is to measure trust in an interface between the customer and supplier interaction. It is time scaled as shown to monitor and to see the possible trend developing, whether it is up, down or horizontal straight.

To be able to monitor this interface will benefit the interaction parties as improvement in the relationship is possible due to defined components of trust. The model reckons that a "low trust" supplier can be increase to a "higher trust" supplier, if the components of trust are defined to improve on the low scored components.

It is time scaled; hence, a trend is possible to be established to track past interactions. With the trend developed, the direction of the interaction can be determined. The trend will be able to identify and assist decision whether future investment into a relationship is foreseeable.

5.0 THE EQUATION OF TRUST MEASUREMENT MODEL

Trust is regarded and based on the past performances of suppliers. Supplier performance is determined by the arithmetic summation or subtraction of components in a relationship that are measurable between the interfaces.

Trust consists of performance of the suppliers which is quantifiable by specific key components, measurable to equate and to indicate it as a number, by a fraction total to one (1). A high number near to 1 shows high trust and a low number near to 0 shows low trust. The model relates trust to supplier's performance. Supplier's performance is an indication of trust towards the supplier.

Trust develops through time. It consists of the past performances in a customer and supplier relationship. The equation below shows the relation.

Performance, $P = f(C, F, D1, D2)$ (1)

where C = Control; F = Feedback Rate; $D1$ = Delay; $D2$ = Disturbance

Performance, $P = f1 * C + f2 * F + f3 * D1 + f4 * D2$ (2)

where $f1$, $f2$, $f3$ and $f4$ are weighted factors, sum to 1.

As trust consists of past experiences, it is represented as follows.

Trust, $T_{t=1} = (P_{t0} + P_{t-1} + \ldots P_{t-n}) / n+1$ (3)

where $n+1$ is how many numbers of past experiences that sum up to a trust level (Moving Average Method).

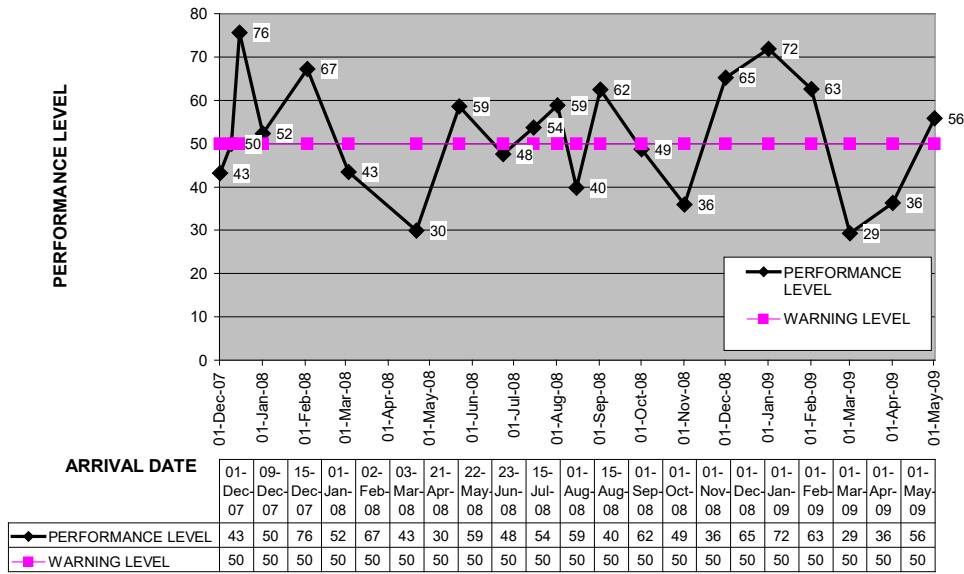Based on the above equation (3), the average of actual past experiences determines the trust level.

Trust, $T_{t=1} = \alpha * P_{t0} + (1-\alpha) * T_{t0}$ (4)

where α is a constant to weight more emphasis on the actual performance or initial trust level (Exponential Smoothing Method).

In equation (4), trust is part of the equation. The first trust level T_{t0}, is a number, and it is the initial trust the customer has towards a supplier in the beginning of a relationship. The actual performance P_t is calculated based on equation 2. With this equation, subsequent trust level is calculated with a past performance and a past trust level.

A few simulations were calculated based on the above two equations (3 & 4). An equal weighted factor (f1, f2, f3 & f4 = 0.25) is assumed. Initial trust of 0.5 (or 50 percent) is assumed. Moving average is based on past two experiences. The smoothing factor is 0.8 for the exponential smoothing method, more emphasis on the performance. Below are the results.

GRAPH 1 : SUPPLIER'S PERFORMANCE LEVEL

ARRIVAL DATE	01-Dec-07	09-Dec-07	15-Dec-07	01-Jan-08	02-Feb-08	03-Mar-08	21-Apr-08	22-May-08	23-Jun-08	15-Jul-08	01-Aug-08	15-Aug-08	01-Sep-08	01-Oct-08	01-Nov-08	01-Dec-08	01-Jan-09	01-Feb-09	01-Mar-09	01-Apr-09	01-May-09
PERFORMANCE LEVEL	43	50	76	52	67	43	30	59	48	54	59	40	62	49	36	65	72	63	29	36	56
WARNING LEVEL	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50

GRAPH 2 : SUPPLIER'S TRUST LEVEL

ARRIVAL DATE	01-Dec-07	09-Dec-07	15-Dec-07	01-Jan-08	02-Feb-08	03-Mar-08	21-Apr-08	22-May-08	23-Jun-08	15-Jul-08	01-Aug-08	15-Aug-08	01-Sep-08	01-Oct-08	01-Nov-08	01-Dec-08	01-Jan-09	01-Feb-09	01-Mar-09	01-Apr-09	01-May-09
MOVING AVERAGE	0	0.0	46.6	62.8	64.0	59.8	55.4	36.7	44.3	53.1	50.6	56.2	49.3	51.1	55.6	42.3	50.6	68.6	67.2	45.9	32.7
EXPONENTIAL SMOOTHING	50.0	44.6	48.8	70.3	55.9	65.0	47.8	33.5	53.6	48.7	52.7	57.6	43.3	58.6	50.7	38.9	60.0	69.5	63.9	36.2	36.2

(Note: The above graphs do not depict a real relationship. It does not have real data to substantiate. The equations are to introduce measuring trust in customer and supplier interaction)
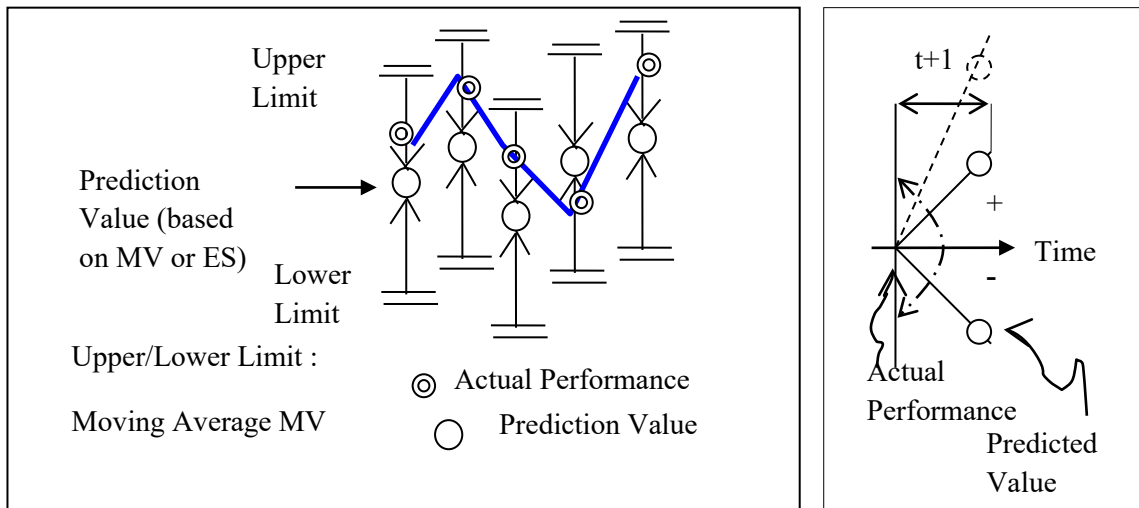
Fig. 3 Limits of Prediction (Representation)

Figure 3 shows that the prediction value based on moving average technique or exponential smoothing technique is within an error limit. As the next estimate is predicted, the value can either be an incline positive or negative slope from the performances.

The errors of prediction from the actual value are more than or less than the actual value. Summing the errors equates to an error which determines what lies within the upper and lower limit. The sum of errors equals to the sum of predicted performances minus the sum of actual performance.

$$\text{Error, } T\underline{e} = |\ \Sigma\ T\underline{p}\ -\ \Sigma\ T\underline{a}\ | \tag{5}$$

where $\underline{e}$ is the error, '$\underline{p}$' the predicted value and '$\underline{a}$' the actual value.

6.0 AN ESTIMATED PREDICTION OF TRUST MODEL

In many instances, the next value in performance needs to be known to know the next decision. A subsequent commitment in a relationship in terms of money or time requires something to be based on before a decision is made. By looking into past performances, it can be a gauge that would assist in concluding a decision. Two predictive techniques – simple moving average or exponential smoothing, are measurement techniques that can calculate an estimate in a relationship quantitatively.

Although quantitative in nature, the fact that human emotion cannot possibly be gauge and is only amazing to know that people react towards the result because of the reward. Anyway, a predictive technique to measure past performance is applied in this case to track the past performance and linking it to trust. With these techniques, trust being an emotion of believing that suppliers meet the requirements, can be determined quantitatively. An estimate value of the two techniques with known error can be determined by the equations.

7.0 DISCUSSION ON THE TRUST EQUATIONS

The equations are a guide to assist in deciding whether it is worth committing further in a customer and supplier relationship where there are measurable interface components. The components are grouped into four main components. The components are Control, Feedback Rate, Delay and Disturbance. The interface components that are scored in the equation to know the performance and trust level towards the suppliers. It is later extended to include three more components. These are Co-operation, Supplier's Commitment and Distance. For example, some measurable items are the number of rejects, the number of later deliveries, the number of quantities received (whether correctly received), etc. The above items can be calculated.

The components of trust must be carefully selected. Deciding the components is important to monitor the interface that is required to be maintained or improved in a relationship. The equation is rigid which consist of only addition of the components. The components are scored high if it is good, and scored low if there are many rejects, for instance. Changing the components would mean starting the tracking process all over again.

The trust level is possible using moving average or exponential smoothing method, as defined. Based on random number generated from computer (= RAND()), it is found that the error is almost the same for the above two methods. Moving average technique sum the average of past trust level whereas exponential smoothing technique emphasis on whether to weight more on current performance or past trust level by the smoothing constant.

The components of trust need to be well defined to inform supplier of the requirements in the market condition where the product or service is sold. Secondly, the aspects of the market condition that can be listed down and informed to the suppliers on the requirements that the supplier need to play a part will be part of the equation. Change in the requirements need to be informed to the supplier and feedback actions need to be known to meet the change. The equation forms a trend which will show whether it is trending upwards, downwards, or just maintaining at that level. Based on this trend, further commitment into a relationship can be determined.

8.0 A RIGID EQUATION - A TECHNIQUE TO KNOW THE NEXT VALUE

Moving average is a mathematical equation that utilizes the past values to calculate the next value. It is the average of past performances and making it a next prediction value. The prediction value is then equated to "trust". Trust is known to be unquantifiable. Hence, the trust level as shown mathematically here is only an *indication* of past performances, which only link past performances to trust in a quantifiable manner. In real, it is impossible to link supplier's performance mathematically to a word "trust". It is the intention of this paper to show prediction of supplier performance mathematically - summation of past performances linking to trust; making it only as an *indication* quantitatively. A person after reading the trust level should not interpret it as a value but an *indication*. The value is intended as a tool in deciding future interactions with the suppliers in a high volume, repeated sales environment. Huge amount of money exchanges over a period. The predicted value is the summation of the latest two past performance $\{ T = ((P-1) + (P-2))/2 \}$. As another interaction takes place, the previous performance is removed from the equation.

With the above techniques, it is possible to calculate a prediction value. However, it is only an estimate due to errors in prediction. Each time a next value is prediction, error exist, as

mentioned in the above section, within the upper and the lower limit. As the number adds, the lower and upper limit varies depending on the new actual value. The calculated predicted value falls within the variable limits.

The similarities of the above two techniques are that the mathematics equate performance to trust, defining trust as the average of past performances (for moving average technique) or a fraction of past and a guess value or subsequent trust value (for exponential smoothing technique). Trust is a belief or feeling whereas performance is a rating system based on soft factors, sometimes with quantifiable factors. Applying the result, it is found that the calculated value is an *indication* of the next trust level as defined within the factors that influences trust between a customer and a supplier.

9.0 AT THE DECISION POINT

To decide on further interaction is difficult especially when there are external factors which are not controllable. To make an overnight decision is ridiculous. At the point of decision making, past data need to be investigated. If the relationship can be improved, it is advisable to. If it turns out to be a bad relationship, then dissolving the relationship will be the resort.

The IMP Model, which analysed 1300 relationship in Europe is a good guide in understanding industrial relationship between customer and supplier. It describes the factors that are influencing customer and supplier relationship. Trust is one of the factors, grouped in the Interaction Process that will emerge when customer and supplier interacts.

The approach measures the components that make up trust, to avoid a "break up" in a relationship. This is because experience is gain from the interactions and a lot of money, time and effort involved. However, if this is not possible to work out a remedy, then it is better to just conclude the relationship. "Alternative" source is then required; however, it is in view of a long-term relationship.

The approach enables the relationship to be improved based on the defined components. With the components defined, the matter can be discussed and decisions can be made.

10.0   CONCLUSION

A model-to-model trust based on the Industrial Marketing and Purchasing IMP Model by the group and other literature search is modelled. It is a theoretical model with two equations that relates supplier's performance to trust, trust being influence by four (4) broad factors; *Authority, Information, Uncertainty* and *Attitude*. More Control and Feedback from supplier improves the trust level the customer has towards the supplier. Delay and Disturbance will reduce the trust level. Co-operation, Supplier's Commitment improves the trust while Distance reduces trust. It is an initial model developed to monitor, maintain, or improve customer supplier relationship in an environment with repeated interactions with long term intention. The intention of the model is to increase a low trust supplier to a higher trust supplier, to decide whether further commitment in the relationship is foreseeable for a longer-term relationship.

The dynamic behaviours of moving average and exponential smoothing techniques predicts the next trust level in customer and supplier interaction. Modelling trust in customer and

supplier interaction is to find out the factors that would affect a trusting relationship. The predictive equations calculate the next trust level utilizes past performances in moving average technique and an initial trust value or subsequent trust in exponential smoothing technique. The predicted value has error. It is within an error limit which varies as the next trust level is calculated. The calculated trust level is an *indication* of supplier performance, making trust predictable but only an *indication*.

Unfortunately, real data is required to show that the proposed trust model is true. Actual data to show the link between a customer trust towards their supplier and supplier's performance are required to be collected further to this. Without these data, the link is not possible. It is only at this point that there might a possible link between customer's trust and supplier's performances.

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