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TRUST IN E-PROCUREMENT

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Abstract: The efficiency of e-Procurement is based on the imperatives, trust and perceived risk. Trust is established as a major factor moderating transaction processes on the internet. It has implicit relational properties and therefore needs the context of a relationship to develop. Previous works have suggested that lack of trust is a major impediment to e-Procurement. Trust and perceived risk exhibits inverse relationships and, paradoxically have causative effect on e-Procurement. E-Procurement organisations are in continuous search on how their consumer's trust can be evaluated. In this study, based on a synthesis of literature, we offer an integrative model of consumer trust in e-Procurement. It is a mathematical model that not only maps trust behaviour, but also sensitive and accommodative of an acceptable risk threshold in electronic transaction environments. It also proffers solution to the exploration of consumer's trust evaluation.

1. Introduction

Trust plays an important role in electronic transactions and the lack of it could constitute a major barrier to e-Procurement's usage. Customers who expressed concerns with trust in electronic transactions concomitantly reduced their overall use of the internet. Recent surveys (Princeton Survey Research Associates, 2002) showed customers concerns on trust and thus reduced usage. Trust issues has so many facets and, therefore, multi-dimensional. Trust is a major factor in establishing and sustaining trade relationships (Okah et al 2007a). Jones and Morris (1999) defined trust as "the property of a business relationship, such that reliance can be placed on the business partners and the business transactions developed with them". This view of trust is from a business management perspective and offers an interesting analysis of what must be done to embed trust in e-Procurement. Grandison (2001) defines trust as the firm belief in the competence of an entity to act dependably, securely and reliably within a specified context.

The e-Procurement environment is obviously an environment characterised with risk, for a variety of reasons. Firstly, procurement in general, by its very nature, involves risk. Many of the risks can be explained by looking at the information available to the parties in a transaction, which includes personal details, such like bank account details, billing name and address and so on. Secondly, the medium of procurement is electronic which is global in terms of scope and reach therefore; implications arise from divergent legal systems across different global arena, among other constraining factors. For example, in some countries, the electronic version of a paper-based contract may not have the same legal status as the paper version. Hence, when an organisation or person negotiates a contract electronically with a party in another country, the contractual obligation may not necessarily bind either party.

Certainly, people have to take a certain amount of risk when they engage in e-Procurement transactions but usually some risks are not transparent. By instincts, the

riskier a transaction becomes the lower the propensity to trust. There are some relationships between trust and risk on the one hand and trust and experience on the other. These relationships may not be straight forward and therefore problematic. Consequently, the questions to ask are: 'What is the exact nature of these relationships?' 'Does the level of risk increase in the same proportion (or disproportionately) with the level of trust?' 'Are there some linear or polynomial relationships between these concepts?' 'Is it even possible to express these relationships?'

In this paper, we combined some cognitive perspectives of trust and perceived risk to develop an integrative mathematical model of trust in e-Procurement.

2. Related Work

The restrictive definitions of trust are from Game Theory (Bacharach and Gambetta 2001). Their view gives an artificial limitation and quite pessimistic view of social interaction. Trust is a cosmic topic that incorporates trust establishment, trust management and risk concerns. Grandison (2001) survey of trust on internet protocol portrayed trust as an important aspect of decision making for internet applications which particularly influences the specification of security and risk policies. The survey provides a working definition of trust for Internet applications and it also explains the properties of trust relationships. Tan and Theon (2002) investigated the determinants of trust in e-Commerce (eC), and present different methods to increase the level of this trust in a transaction. Their model shows that an individual would only engage in a transaction if trust exceeds its personal threshold. And the threshold

depends on the type of transactions and other parties involved in the transaction. The outcome of a trust decision is based on the propensity to trust the perceived benefits, customers' beliefs, past experiences relating to the organisation and perceived risk. Mayer (1990) ascertains that the level of trust is often associated with a relationship (the deeper the level of relationship the higher the level of trust?). Some entities may be trusted more than others. It is not clear whether trust should be discrete or continuous. If discrete, the qualitative label of high, medium or low may be sufficient. Some models support arithmetic operations on trust recommendations so numeric quantification is more appropriate. It is also possible to provide a mapping from qualitative to numeric labels.

The associations between trust in e-Procurement and their impact on perceived benefits have been studied by earlier researchers. For example, Kini and Choobineh (1998) examine trust from the perspectives of personality theorists, sociologists, economists and social psychologists. They highlighted the implications of these eclectic perspectives and combined their results with the social psychological perspective of trust to create their definition of trust as "a belief that is influenced by the individual's opinion about certain critical system features". Their discussion is based on general concept eC, but did not address trust between the entities involved in e-Procurement transactions.

3. Trust Management and Trust Relationships in e-Procurement

Trust is a vast topic, with huge exploratory capacity, that incorporates trust management and trust relationship.

3.1 Trust Management:

Trust management is thus concerned with collecting the information required to make a trust relationship decision, evaluating the criteria related to the trust relationship as well as monitoring and re-evaluating existing trust relationships. Blaze et. al. (1996) defined trust management as “a unified approach to specifying and interpreting security policies, credentials, relationships which allow direct authorisation of security-critical actions”. They have implemented several automated trust management solutions but the flaw with their implementation is that they identified a static form of trust, usually at the discretion of the application coder (that is, the programmer inserts code to evaluate trust, often at the start of a session).

3.2 Trust Relationships:

Trust relationships are based on the competence, reliability or integrity of the trustee. In e-Procurement, the customer trusts the vendor to support mechanisms that will ensure that passwords are not divulged and to prevent transactions from being monitored. The vendor is also trusted to maintain the privacy of any information such as name, address and credit card details, which s/he holds about the customer. Where there is an occurrence of high-profile incidents, for example, exposure of customer personal details due to human errors from procedural slips or equipment misconfiguration, trust is broken. Trust is never certain. Some uncertainty (ignorance) is always present and some probability of failure must be taken into account. (Ang et al.2001). A trustor must accept this and run such a risk. Thus a fundamental component of X's decision to trust Y is acceptance of a

certain risk and the feeling of being exposed to it. The act of trusting is a real gamble, a risky activity: it presumes logically some uncertainty, but it also requires some predictability of Y, and usually some degree of trust in Y.

4. Conceptual Framework

To establish a conceptual premise, we argue that a customer arrives at a decision to make an online transaction by the following expression:

$$PB_c \geq PR_c \Rightarrow e-T$$

Where PB_c denotes the benefit of e-Procurement perceived by the customer (the “customer” denoted by the subscript (c) from transacting electronically, PR_c is Perceived Risk and $e-T$ is electronic transaction.

If equation (1) holds, an individual will only engage in an electronic transaction if s/he perceived the benefits of e-Procurement to be equal to or greater than the risk perceived. This, in turn, depends on the type of transaction and other parties involved in the transaction and the organisation from which transaction is made.

4.1 Perceived Benefits:

These are the benefits perceived by e-Procurement usage:

- electronic enabled relationship with suppliers speeds procurement cycle times and facilitates supplier performance improvements
- greater data accuracy minimises ordering inaccuracies and provides the essential

foundation for better management through measurement and analysis.

4.2 Perceived Risks:

These are the risk perceived by e-Procurement usage, For example:

- legal environment has new and conflicting laws
- fear of payment information being unsecured.
- privacy issues
- people's resistance to change

Source: Developed from Okah et al, (2007b)

Following Wang and Singh (2007), we understand trust to be based on evidence. Evidence in terms of experiences is conceptual in regard of positive and negative outcomes. The positive outcomes are the perceived benefits being greater than the perceived risk in a transaction experience. The negative outcomes are the perceived risks being greater than the perceived benefits in a transaction experience or the occurrence of an incidence. It is commonly accepted that one of the main sources of trust is direct experience in positive outcomes. Generally, in this framework to each success of a positive transaction, the trustee correspond an increment in the amount of the trustor's trust. Similarly, to every trustee's failure corresponds a reduction of the trustor's trust towards the trustee.

5. Methodology

After initial qualitative studies, using a cognitive approach, we proposed an integrative model that is represented mathematically and diagrammatically. A

cognitive approach is a reasoning and problem solving method from relevant fields that includes physiology, psychology, neuron science, computer science, and physics. According to Thagard (2005) it deals with understanding the logical connection between concepts.

The idea that trust is scalable is usual. However, since no real definition and a cognitive characterisation of trust is given, the quantification of trust is quite arbitrary and the introduction of this notion or predicate is semantically empty. On the contrary we claim that there is a strong coherence between the cognitive definition of trust, its value, and its relationship. Here we will ground the degree of trust of X in Y , on the cognitive components of X as the trustor and Y as the trustee. More precisely we claim that the degree of trust (τ) is a function of the subjective certainty of the pertinent beliefs.

Let's call the degree of trust of X in Y about

$$\tau: e-PT_{XY} (0 \leq e-PT_{XY} \tau \leq 1). \quad (2)$$

We postulate the degree of trust (τ) as a function of the "strength" of the trusting beliefs. The trusting belief is based on of the competence or reliability or integrity of the trustee. In other words, it is based on the constituents of a trust relationship. It expresses both the subjective probability of the perceived benefits (facts) and the belief in the constituents of the trust relationship despite the risks: the greater X 's belief in Y 's competence and reliability or integrity the greater X 's trust in Y .

The proposed approach in expression (2) is based on the fundamental intuition that a trustee can model the behaviour of the trustor. The probability must lie in the real interval $(0, 1)$. The trustor's trust corresponds to how strongly the agent

believes that this probability is a specific value.

$$\mathbf{e-PT}_{X,Y} = \mathbf{CX}[(\mathbf{PB}>\mathbf{PR})\mathbf{Y}] \ \& \ \mathbf{CX}[\mathbf{e-PT}_{XY\tau}] \ \& \ \mathbf{CX}[\mathbf{e-P} \ \mathbf{Exp}] \quad (3)$$

where:

- $\mathbf{e-PT}_{X,Y}$ - is an integrative trust relationship.
- $\mathbf{CX}[(\mathbf{PB}>\mathbf{PR})\mathbf{Y}]$, is the degree of credibility of X's beliefs about the perceived benefits being greater than the perceived risks, hence transaction.

- $\mathbf{CX}[\mathbf{e-PT}_{XY\tau}]$, the degree of credibility of X's beliefs about the Y's competence to perform, its reliability or integrity, hence transaction
- $\mathbf{CX}[\mathbf{e-P} \ \mathbf{Exp}]$, the degree of credibility of X's beliefs about the Y's actual performance based on experiences, hence transaction

We assume that the various credibility degrees are independent from each other. This framework denotation is a diagrammatical representation of the above expression.

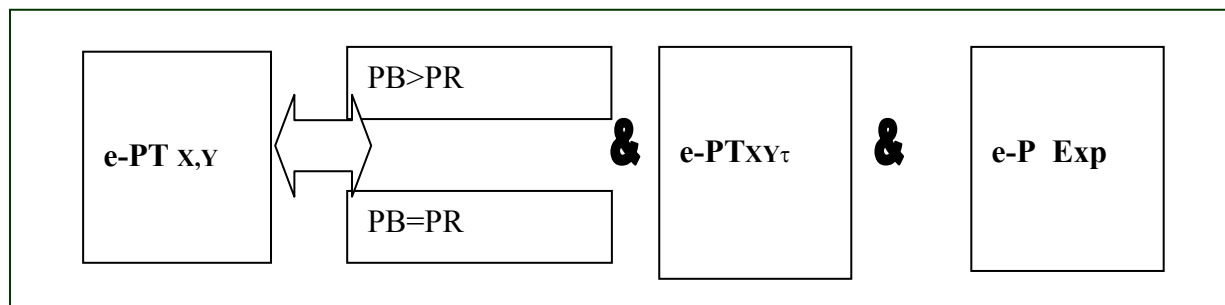


Figure 1. An Integrative Model of Consumer's Trust in e-Procurement

Based on the certainty that a business transaction would be positive, we adapted Wang and Singh (2007), representing the probability of a positive experience by using the Probability Certainty Density Function (PDCF) whereby the strength of belief is captured in probability terms.

From expression (2), because the cumulative probability of a probability lying within [0, 1] must equal 1, all PCDFs must have the mean density of 1 over [0, 1], and 0 elsewhere. All PCDF would be a uniform distribution over [0, 1]. However, the PCDF could deviate from the uniform distribution. For example, knowing that the probability of good experience that increases trust is at

least 0.5, we would obtain a distribution, that is 0 over [0, 0.5) and 2 over [0.5, 1].

In formal terms let $p \in [0, 1]$ represent the probability of a positive experience. Let the distribution of p be given as a function $f: [0, 1] \mapsto [0, \infty)$ such that $\int_0^1 f(p)dp = 1$

The probability that a positive experience lies within (t1, t2) could be calculated as $\int_{t1}^{t2} f(t) dt = 1$

The mean value could be calculated as

$$f = \int_0^1 \frac{f(p)dp}{1-0} = 1$$

When we don't know what the value of the probability is, f is a uniform distribution over probabilities p . That is, $f(p)=1$ for $p \in [0, 1]$ and 0 elsewhere. This reveals the Bayesian intuition of assuming an equiprobable prior. The uniform distribution reflected has a positive experience certainty of 0. As more knowledge is acquired, the probability mass shifts so that $f(p)$ is above 1 for some values of p and below 1 for other values of p . Our key intuition is that the trustor's trust corresponds to increasing deviation from the uniform distribution. Two of the most established measures for deviation are standard deviation and mean absolute deviation (MAD). MAD is more robust, because it does not involve squaring (which can increase standard deviation because of outliers or "heavy tail" distributions such as the Cauchy distribution). Absolute values can sometimes complicate the mathematics. But, in the present setting, MAD turns out to yield straightforward mathematics. In a discrete setting involving data points x_1, x_2, \dots, x_n with mean as μ , MAD is given by $\frac{1}{n} \sum_{i=1}^n |x_i - \mu|$. Because a PDCF has

a discrete value of 1, reduction in some parts must increase elsewhere. Both increase and reduction from 1 would be counted by $|f(p)-1|$. Expression (4) scales the MAD for f by $\frac{1}{2}$.

The certainty (c) that the transaction could be a positive experience (yielding trust) is

$$cf = \frac{1}{2} \int_0^1 |f(p)-1| dp \tag{4}$$

For example, consider randomly picking a ball from a bag that contains N balls

coloured blue (t) or red (q). Suppose p is the probability that the ball randomly picked is blue. If we have no knowledge about how many red balls there are in the bin, we cannot estimate p with any confidence. That is, the certainty is = 0. If we know that exactly t balls are blue and know the total numbers of balls in the bag, then we have a perfect knowledge about the distribution.

We could then estimate that $p = \frac{t}{N}$, with $c=1$.

However, if all we know is that at least t balls are blue and at least q balls are red (thus $t+q \leq N$), then we have partial knowledge. Then $\frac{t+q}{N}$. The probability of

drawing a blue ball ranges from $\frac{t}{N}$ to $1 - \frac{q}{N}$

. We then have

$$f(p) = \begin{cases} 0 & p \in \left[0, \frac{t}{N}\right) \\ \frac{N}{N-t-q} & p \in \left[\frac{t}{N}, 1 - \frac{q}{N}\right] \\ 1 & p \in \left(1 - \frac{q}{N}, 1\right] \end{cases}$$

Using equation 4 we could confirm that c

$$\begin{aligned} cf &= \frac{1}{2} \int_0^1 |f(p)-1| dp \\ &= \frac{1}{2} \int_0^{\frac{t}{N}} 1 dp + \int_{\frac{t}{N}}^{1-\frac{q}{N}} \left(\frac{N}{N-t-q} - 1 \right) dp + \int_{1-\frac{q}{N}}^1 1 dp \\ &= \frac{1}{2} \left(\frac{t}{N} + \frac{N-t-q}{N} \left(\frac{N}{N-t-q} \right) + \frac{q}{N} \right) \\ &= \frac{t+q}{N} \end{aligned}$$

6. Discussion

Expression (1) reflects a consumer (trustor) willing to take part in a transaction when he perceives that the benefits are greater than or equal to the perceived risks.

Expression (2) shows that the degree of trust lies in the strength of trusting belief. The strength of the trusting belief is drawn from the competence, reliability or integrity of the organisation (trustee).

Expression (3) shows that for a trustor X to Trust in the trustee Y, integrally, there should a combination of X perceiving the benefits greater or equal to the risks, competence, reliability and integrity; and some certainty based on positive transaction experiences.

Expression (4) shows that with calculation of the probability, a transaction outcome would be certainly positive if the trustor has prior knowledge of all information towards that transaction. Having a knowledge about all that entails in an e-Procurement transaction is an integration of a consumer perceiving the benefits, perceiving the risks and having a credible knowledge that the transacting organisation is reliable and competent. If there is no knowledge about transaction information, then the possibility of a positive transaction is 0. If there is a partial knowledge of transaction information, then the certainty of a positive experience is $\frac{1}{2}$ and if a perfect knowledge is derived then credibility of a positive transaction is 1.

7. Conclusions

Our mathematical model shows trust could be derived in an e- Procurement system from a consumer to business transaction. It could be derived when the consumer's knowledge of perceive benefits is greater or

equal to perceived risks. Inclusively, knowledge of the competence and reliability of the organisation and knowledge of its experience of positive transactions could develop a trusting relationship. Our model shows that the perception of risk increase could reduce trust and vice-versa.

The model is robust in the rationality that it was from different perspectives and contexts.

The limitation of this model is that values need to be resolved by an organisation (trustee) that wants to evaluate the degree of trust (τ) of the consumer (trustor), as a function of the strength of the trusting beliefs. The model can be further integrated in standardisation efforts, for trust evaluation. For future work, we would develop a trust assessment matrix, which in turn would be subjected to empirical substantiation.

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