Determining the Net Financial Risk for Decision Making in Business Interactions

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***Abstract*—In a business interaction, transactional risk highlights the uncertainty associated in not achieving the desired outcomes. The assessment of transactional risk gives the interacting user the different levels of failure in achieving its desired outcomes and the consequences that it can experience. In a business interaction, the consequences that can be experienced pertain to the financial resources invested to achieve the desired outcomes. The level of financial loss that could be experienced plays a very important role in the interacting user's decision to form a business interaction. The level of financial loss is dependent on the different types of uncertain events associated with the business interaction. In this paper, we will propose a methodology by which the interacting user in an e-business interaction can capture the different types of uncertainties and ascertain the financial risk that could be experienced from it.**

Keywords-risk assessing agent; risk assessed agent; dependable events; non-dependable events; financial risk.

I. INTRODUCTION

The growth of e-business activities is quite evident when considering the statistics of its adoption and utilization by users in the recent past [1-4]. One of the primary reasons behind this is their capability of providing the users with enhanced functionality by which they can complete their tasks in much less time and with greater ease as compared to the previous interaction infrastructures. These functionalities continue to increase with the constant development and advancement of e-business interaction infrastructures, thereby increasing the advantages to the users. But apart from all the advantages that this interaction infrastructure provides, interacting users have to constantly look out for those factors that will produce a 'negative' outcome as a result of their interaction. A negative outcome signifies the non-achievement of desired outcomes by the interacting user and hence the experience of losses. So the users, before carrying out any business activities over this interaction medium, have to make 'informed decisions' by which they minimize or alleviate any possible losses while at the same time maximizing their benefits. In order to achieve this, the analysis of Risk plays an important part. Risk is a determinal term that expresses the 'negative' concepts that could be possible in an interaction [5, 6]. A user, by analyzing the level of risk, can determine the possible failure and consequences that it could experience as a result of forming an interaction. We consider that business interactions have different levels of financial resources invested in them by the interacting user, and subsequently the consequences that it could experience are related to those financial resources that it has at stake. The levels of consequences that could be experienced in a business activity are ascertained by analyzing the level and magnitude of risk in it, and thus risk analysis commands a central role in any discussion related to decision-making. Such an analysis from risk is important in influencing the behavior of the user in forming a business interaction, as the decision to buy is related to the cost-benefit analysis [7]. Hence, in order for a user to achieve its aims, the manifestation of the level of risk in such interactions is very important.

A business activity may be a combination of one or more desired events, each of which should be achieved as desired for its successful completion. Failure to achieve even one desired outcome in any way other than what was expected may result in the interacting user experiencing failure and financial loss in its business activity. So, in order for the interaction initiating user to determine the possible financial losses in its business interaction, it should first determine the level of non-occurrence of its desired outcomes. Based on this analysis, it can determine the total financial loss that it could possibly experience in its business interaction. In this paper, we will propose a methodology by which the interacting user can determine the total financial loss that it can experience in its business activity due to the non-occurrence of its desired outcomes. In the next section, we will define the problem that we intend to address in this paper.

II. PROBLEM DEFINATION

Transactional Risk Assessment for decision-making in business interactions should be done according to those sub-categories which identify, assess and represent the level of occurrence of the negative outcomes and their impact which shows the resultant consequences [8]. In our previous work, we proposed that transactional risk in e-business activities should be analyzed and assessed according to the subcategories of *performance risk* [9] and *financial risk* [10]. Performance risk represents the level of failure in an interaction due to the non-occurrence of desired outcomes; whereas, financial risk represents the financial consequences that could be experienced as a result of the failure of the interaction. We term each of the desired outcomes that the

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interaction initiating user wants to achieve as a result of its interaction as the 'assessment criteria', and the collection of all the assessment criteria as the 'expectations' of the business activity. We consider that the expectations of an interaction are formed after a series of negotiations between the interacting users. Furthermore, the two interacting users of the business activity are termed the 'risk assessing agent' and the 'risk assessed agent'. The risk assessing agent is the initiator of the business activity who wants to achieve certain desired outcomes; whereas, the risk assessed agent is that agent who has the capability to give the risk assessing agent its desired outcomes in return for its financial resources. For a particular business activity, there can be more than one risk assessed agent and the risk assessing agent, when making a decision, has to choose and decide carefully on an agent with which to interact.

The financial risk to the risk assessing agent is dependent on the level to which it does not achieve each of its desired outcomes in the business activity. So, before determining the financial risk, the risk assessing agent has to determine the performance risk of the risk assessed agent in each assessment criterion of its expectations. But not all assessment criteria from the expectations of the business interaction are dependent on the risk assessed agent to be completed as desired. There might be some assessment criteria that may be outside the scope of dependence on the risk assessed agent, but still they need to be achieved as desired while forming the expectations, in order for the business activity to be successfully completed. To explain with an example, let us consider that risk assessing agent 'A' wants to interact with a logistics company for transporting its goods from Europe to Australia and forms the expectations of its interaction as:

- The logistics company should pack the goods properly at the pick-up address (C1).
- The goods should reach the destination within 5 days (C2).
- The goods should reach the destination undamaged (C3).
- The logistics company should provide with a track and trace facility (C4).
- The total cost for transferring the goods is 3000 Euros. Agent 'A' should pay half of the amount when the goods are picked up (C5).
- Once the goods are delivered, agent 'A' should make the remaining payment of 1500 Euros in Australian Dollars to the logistics company's branch office in Perth (C6).

The assessment criteria from the expectations of the interaction can broadly be divided into two categories, each of which has uncertainty associated with it. They are *Dependable Criteria* and *Non-Dependable Criteria* [11]. Dependable criteria are those assessment criteria from the expectations that are dependent on the performance of the risk assessed agent in the interaction (C1-C4). These criteria are the desirable events, and the uncertainty associated with these types of events is that the risk assessing agent is unsure whether the other agent will act and behave as promised, based on which it will achieve its desired outcomes. Failure to achieve these outcomes or assessment criteria might result in agent 'A' experiencing failure in its interaction along with financial consequences. Risk assessing agent 'A' can alleviate the uncertainty associated with these assessment criteria by determining the performance risk of the risk assessed agent that shows its inability to commit to the expectations in the time period of its interaction. Non-dependable criteria relate to those assessment criteria of the expectations which are outside the scope of dependence on the risk assessed agent, but that will have a direct or indirect impact on the successful completion of the business activity (C5-C6). Failure to achieve these assessment criteria as desired in the expectations might result in risk assessing agent 'A' experiencing financial consequences or losses in its interaction. The uncertainty associated with these types of outcomes is that the risk assessing agent is unsure whether these events will occur as desired in the expectations.

To clarify our understanding with an example, let us consider that at the time of agent 'A' forming the expectations, 1 Euro (EUR) convert to 2.008 Australian Dollar (AUD). Then, according to assessment criterion C6, agent 'A' has to pay 3012 in Australian dollars to the logistics company's branch office at Perth. But it may be possible that by the time the logistics company delivers agent 'A' its goods, the exchange rate between the Euro and Australian dollar changes as compared to what it was while initiating the interaction. As a result, the amount which agent 'A' has to pay to the logistics company while taking delivery of its goods might be more or less than initially anticipated when forming the expectations. If the risk assessing agent has to make extra investments as opposed to what was decided initially in order to complete its expectations, then it can be considered as s 'financial loss' to it in the business activity. The financial loss experienced from such non-dependable criteria is different from what could be experienced from the dependable criteria (C1-C4), and subsequently these too should be taken into consideration when determining the financial risk in the business activity. So, the total financial risk to the risk assessing agent in its business activity is a combination of the financial loss that it may experience from both the dependable and non-dependable events. Approaches have been proposed in the literature which consider the financial resources in the business activity [12-16], but these approaches consider only the dependable events of the activity. They do not take into consideration the existence of non-dependable criteria and, subsequently, the financial loss determined by those approaches does not express the total financial loss that the risk assessing agent could experience in its business activity. Furthermore, none of these approaches takes into consideration the dynamic and context-specific nature of risk while determining the financial loss in the business interaction.

In this paper, we will propose a methodology by which the risk assessing agent can determine the total financial loss that it could experience in forming an interaction with the risk assessed agent. The proposed approach will take into consideration the financial loss that could be experienced from both dependable and non-dependable criteria. In order to achieve this, we will utilize our previous work where we proposed approaches by which the risk assessing agent can determine the financial loss that it could experience from each type of criteria. We will give a brief overview of these approaches in the next sections and then propose a methodology by which the financial loss from each type of criteria are combined to ascertain the total financial loss in the business activity.

III. Determining the Financial Loss from Dependable Criteria in Business Interactions

As mentioned earlier, the risk assessing agent, in order to determine the financial loss that it can experience due to the dependable criteria, should determine the level of failure of the risk assessed agent in committing to these according to the expectations. This is determined by ascertaining the performance risk of the risk assessed agent in the business activity. We proposed in Hussain et al. [9] the methodology by which the risk assessing agent can determine the different levels of failure of the risk assessed agent in not providing it with its desired outcomes in the dependable assessment criteria of its interaction. The proposed methodology takes into consideration each dependable assessment criteria and determines the inability of the risk assessed agent in committing to these according to the expectations. Based on the analysis, it plots the 'FailureLevel Curve' (FLC) of the business interaction, which represents the performance risk of the risk assessed agent. In order for the risk assessing agent to determine the financial loss as the result of failure of the dependable criteria, we proposed in Hussain et al. [17] that the risk assessing agent first ascertain its accurate investments in each time slot of its interaction with the risk assessed agent and plot the 'Amount Invested Curve' (AIC). The AIC represents the accurate level of the resources that the risk assessing agent will invest and will have at stake in the business interaction, as decided in the expectations. To determine the financial loss, we propose that the risk assessing agent determine the impact of the performance risk (FLC) of the risk assessed agent on the AIC of the interaction, in order to determine the 'Factual Amount Invested Curve' (FAIC) of the interaction. The FAIC as shown in Figure 1 represents the required level of the resources that the risk assessing agent should invest and need to keep at stake in the interaction, due to the performance risk of the risk assessed agent. Interested readers are encouraged to look at Hussain et al. [17] where we explain in detail how the risk assessing agent determines the AIC and FAIC in forming an interaction with the risk assessed agent. Due to space limitations, we will not discuss the methodology in this paper.

But the FAIC of the interaction represents the financial resources which the risk assessing agent needs to keep at stake by considering only the dependable assessment criteria of the interaction. This does not take into consideration the non-dependable assessment criteria of the interaction. But as discussed earlier, the risk assessing agent, in order to determine the total financial risk in its business activity, should also consider the non-dependable assessment criteria, apart from just considering the dependable criteria, as they too may contribute towards the financial loss that it can

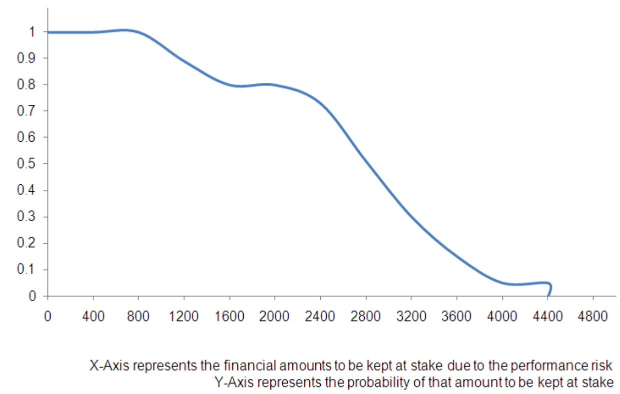

Figure 1. The Factual Amount Invested Curve of the Interaction

experience in the interaction. Speaking in terms of the current example being discussed, during risk analysis, it is important that agent 'A' ascertain the financial loss that it may experience due to assessment criterion C6, apart from just considering the assessment criteria C1-C4 to determine the total financial loss. In the next section, we will give a brief overview of our previous work by which the risk assessing agent can determine the financial loss to it due to the non-dependable events in the business interaction.

IV. Determining the Financial Loss from Non-Dependable Criteria in Business Interaction

It is important to note that non-dependable criteria are:

a) specific to the business interaction in which they have to be determined; and

b) vary according to the different outcomes that the risk assessing agent wants to achieve as a result of its interaction.

Subsequently, in order for the risk assessing agent to determine the impact of such criteria on the successful completion of its interaction, it should first identity them according to the specific characteristics of its interaction in question. Once the non-dependable criteria in an interaction have been identified, then the risk assessing agent should ascertain the financial loss that could possibly be experienced from them. The financial loss that could be experienced is due to the occurrence of the non-dependable criteria in a way that is different from what was expected initially by the risk assessing agent in the expectations. But the variation in the occurrence of these criteria may be spontaneous or volatile, as a result of which it may be extremely difficult for the risk assessing agent to have a distribution of any sort which models the trend of variation in their occurrence during the interaction time period. But on the other hand, it is important for the risk assessing agent to account for the uncertainty of such assessment criteria, as they too may contribute to the total financial loss that could be experienced in the business interaction.

To achieve this, in our previous work [11] we proposed that the risk assessing agent utilize the Monte Carlo simulation to model the uncertainty associated with the type of non-dependable criteria that are being considered in the current example. The Monte Carlo technique is not a model which gives a deterministic output at each simulation, but is a method for iteratively evaluating a deterministic model using sets of random variables as inputs for the defined problem. In the current example scenario, we considered that the risk assessing agent 'A', by considering the market volatility and the past conversion trends, determines that the exchange rate of AUD to EUR may be a value within the range of {1.95-2.50}. We proposed that on this range the risk assessing agent runs Monte Carlo simulation for n=5000 iterations with 99% confidence level to determine the resultant amount that it might have to pay to the risk assessed agent.

In order to determine the financial loss that could be experienced from the non-dependable assessment criteria, we proposed in Hussain et al. [11] that the risk assessing agent from the simulation results plot the Factual Cost Curve (FCC) of the interaction and plot its *maximum investment capacity* (MIC) on it. Factual Cost Curve, as shown in Figure 2 represents the probability of an amount (in Euros) which the risk assessing agent might end up paying to the risk assessed agent due to the different values of occurrence of the non-dependable uncertain variable of its interaction. The maximum investment capacity of the risk assessing agent is the financial amount that the risk assessing agent had to pay, as decided in the expectations of its interaction. So any levels of investments that the risk assessing agent has to make after its MIC, represents the possible loss that it could experience in the interaction due to variation in the occurrence of non-dependable criteria. These levels of required investments are represented by the part of the FCC after the risk assessing agent's MIC. Interested readers are encouraged to look at Hussain et al. [6] where we explain in detail how the risk assessing agent determines the FCC from the simulation results. Due to space limitations, we will not discuss the methodology in this paper.

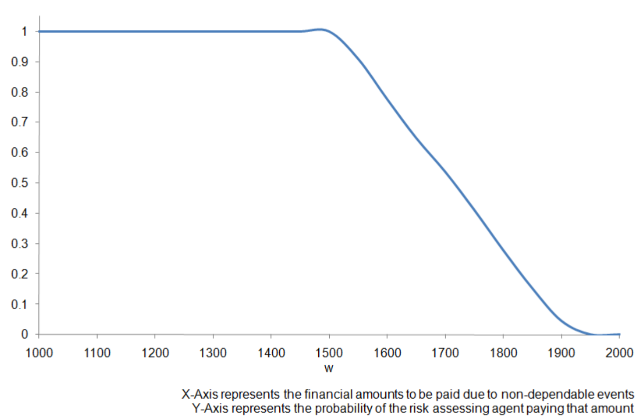

Figure 2. The Factual Cost Curve (FFC) of the Interaction

To determine the total financial loss, the risk assessing agent should combine the part of the FCC after its MIC with the FAIC to determine accurately the net financial resources that it needs to keep at stake in its business activity. In the next section, we will propose the methodology by which the risk assessing agent 'A' can combine the part of the FCC curve after its MIC with the FAIC of the interaction.

V. DETERMINING THE TOTAL FINANCIAL RESOURCES TO BE KEPT AT STAKE

In order for the risk assessing agent to determine the total level of financial resources to be kept at stake in its business activity, we propose that:

- it should determine the probability mass function (PMF) of the FCC in interacting with the risk assessed agent.
- The PMF of the FCC shows the probability of each amount that the risk assessing agent might have to pay to the risk assessed agent due to the variation in occurrence of the non-dependable criteria from the expectations.
- It should then determine the point on the PMF of the FCC which represents its MIC. This is termed 'x'.
- From point 'x', the risk assessing agent should determine the levels of extra financial resources or the levels of un-served investments in the interaction.
- It should then normalize the part of the FCC after the MIC so that the probability of occurrence of the different levels of amount after the MIC satisfies the equation:

$$\sum_{i=1}^{n} p(i) = 1$$

where: 'n' represents the number of financial levels after the MIC.

We term the normalized part of the FCC after the risk assessing agent's MIC as the Extra Investment Curve (EIC). The EIC as shown in Figure 3 represents the extra levels of financial resources with their probability that the risk assessing agent might have to pay to the risk assessed agent, due to the variation in the occurrence of the non-dependable criteria. Subsequently, the risk assessing agent in order to determine the total financial resources that it needs to keep at stake in its business interaction, should combine the EIC with the FAIC of the interaction.

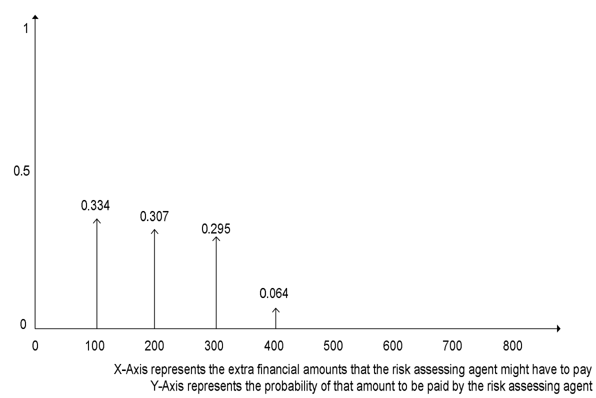

Figure 3. The probability and the extra level of resources from FCC after the MIC

We utilize the mathematical operator 'convolution' in order to combine the Extra Investment Curve (EIC) and the Factual Amount Invested Curve (FAIC). Convolution is a mathematical integral operator which expresses the amount of overlap and impact of one function as it shifts over the other. We term the combination of the EIC and FAIC the 'Total Factual Amount Invested Curve' (TFAIC) of the interaction. In this paper, we will plot the Total Factual Amount Invested Curve (TFAIC) of the interaction by utilizing two methods of convolution:

1. Conventional method
2. Cumulants method

A. Conventional Method to ascertain the Total Factual Amount Invested Curve

Mathematically, the Total Factual Amount Invested Curve (TFAIC) can be determined by the conventional process of convolution by the random variables of both the EIC and FAIC by:

$$TFAIC = EIC \oplus FAIC$$

where: FAIC = Factual Amount Invested Curve,
EIC = Extra Investment Curve,
TFAIC= Total Factual Amount Invested Curve.

Two scenarios arise while determining the Factual Amount Invested Curve (FAIC) in interacting with a risk assessed agent.

Scenario 1: There is only one level of extra investment to be made by the risk assessing agent due to the non-dependable criteria:

If there is only one level of investment to be made by the risk assessing agent due to the non-dependable criteria, then the convolution of the EIC and FAIC is done by the recursive formulae:

$$TFAIC(x) = p_i * FAIC(x - l_i) \quad \text{for } (x - l_i) \geq 0$$

or,

$$TFAIC(x) = p_i \quad \text{for } (x - l_i) < 0 \qquad \textbf{Equation 1}$$

where: x = the point of financial amount at which the TFAIC is to be ascertained,

l_i = level of extra financial resource from the EIC,

p_i = probability of that extra level of financial resource which the risk assessing agent might have to pay,

FAIC $(x - l_i)$ = Factual Amount Invested Curve value at point $(x - l_i)$.

Scenario 2: There is more than one level of extra investment to be made by the risk assessing agent due to the non-dependable criteria:

If there is more than one level of investment to be made by the risk assessing agent due to the non-dependable criteria, then the convolution of the EIC and FAIC is done by the recursive formulae:

$$TFAIC(x) = \sum_{i=1}^{n} p_i * FAIC(x - l_i) \quad \text{for } (x - l_i) \geq 0$$

or,

$$TFAIC(x) = \sum_{i=1}^{n} p_i \quad \text{for } (x - l_i) < 0 \qquad \textbf{Equation 2}$$

where: n = the number of extra financial resources to be invested by the risk assessing agent,

x = the point of financial amount at which the TFAIC is to be ascertained,

l_i = level of extra financial resource from the EIC,

p_i = probability of that extra level of financial resource which the risk assessing agent might have to pay,

FAIC $(x - l_i)$ = Factual Amount Invested Curve value at point $(x - l_i)$.

B. Cumulant Method for ascertaining the Total Factual Amount Invested Curve

The Total Factual Amount Invested Curve (TFAIC) of the interaction, by using the cumulants method of convolution, is determined by the properties known as the moments and cumulants of the distribution function of the Extra Invested Curve (AIC) and the Factual Amount Invested Curve (FAIC). Moments of a distribution function are termed as the expectations of different powers of the random variable. Alternately, they are a set of descriptive constants which are useful for measuring the properties and in certain circumstances for specifying the distribution function [18]. But they are not the best set or the only set of constants for representing the distribution function. Another series of the constants used to represent the distribution function are known as the cumulants (represented by κ). They have the properties which can describe better the underlying distribution function and which are more useful from the theoretical standpoint. The cumulants of a distribution function are determined by its statistical moments. The cumulant method for convolution provides an alternative way to obtain the Total Factual Amount Invested Curve (TFAIC) of the interaction rather than by using the recursive formulae as shown in equation 1 and equation 2. In the cumulant method, the convolution of the distribution functions is expressed as a sum of the individual cumulants of the random variables representing the distribution functions. So, by utilizing the cumulants method, the convolution of the EIC with the FAIC of the interaction is obtained by adding their corresponding individual cumulants. Based on the knowledge of the resulting obtained cumulants, the distribution function of the output function, the Total Factual Amount Invested Curve (TFAIC) is approximated by using the probabilistic functions.

Of the available probabilistic functions, the one which best approximates the output distribution function from the knowledge of its cumulants is the Gram-Charlier Series Expansion. The Gram-Charlier series expansion approximates the cumulative distribution function of the Total Factual Amount Invested Curve (TFAIC) from the knowledge of its cumulants obtained as a result of convolution between the Factual Amount Invested Curve (FAIC) and the Extra Investment Curve (EIC) of the interaction. A brief description of the series and how it is utilized to represent the TFAIC of the interaction is discussed in the next sub-section.

1) Gram-Charlier Series Expansion

Gram-Charlier series expansion is a probabilistic series expansion function from the knowledge of its cumulants. The Gram-Charlier series has the Normal distribution as its leading term, followed by terms containing the successive derivatives of the normal from order 3 onwards. The motivation for this series comes from the central limit theorem. This theorem basically states that a sum of any 'n' independent random variables (satisfying certain conditions) is approximately normal distributed for sufficiently large n [19]. In Gram-Charlier expansion, certain coefficients are added to the normal to improve the approximation given by the normal distribution. The importance of these terms in the series decreases as the number of random variables involved in the sum increases. The standardized third cumulant of the series is proportional to the skewness of the resulting density function series with respect to the standard normal; whereas, the standardized fourth cumulant is proportional to the kurtosis of the resulting density function series. The skewness of the density function shows the direction of its inclination; whereas, the kurtosis shows the breadth of the resulting density function. The Gram-Charlier series expansion of the resultant distribution function is represented by:

$$\text{TFAIC}(z) = 1 - \int_{-\infty}^{z} N(z)dz + \sum_{k=3}^{5} \frac{G_k}{k!} N^{(k-1)}(z) \quad \textbf{Equation 3}$$

where: z = standardized variable,
G_k = standard cumulant of order 'k',
N (z) dz = standard normal,
$N^{(k-1)}(z) = (k-1)^{th}$ derivative of the standard normal.

The standard cumulant of order 'k' which is represented by G_k are the cumulants of the Total Factual Amount Invested Curve (TFAIC) of the interaction obtained as the sum of the resulting cumulants of Factual Amount Invested Curve (FAIC) with the Extra Investment Curve (EIC). The standardized variable is given by the expression:

$$z = \frac{x-\mu}{\sigma} \quad \textbf{Equation 4}$$

where: x = investment level for which the corresponding value on the TFAIC has to be determined,
μ = mean of the resulting random variable,
σ = standard deviation of the resulting random variable.

C. Determining the Total Factual Amount Invested Curve (TFAIC) of the Interaction

Continuing the above example, risk assessing agent 'A' in order to determine the total financial resources that it has to keep at stake in interacting with the logistics company, should convolve the EIC of Figure 3 with the FAIC of Figure 1. Utilizing equation 2 and convolving the EIC with the FAIC by the conventional method, we obtain the TFAIC as shown in Figure 4:

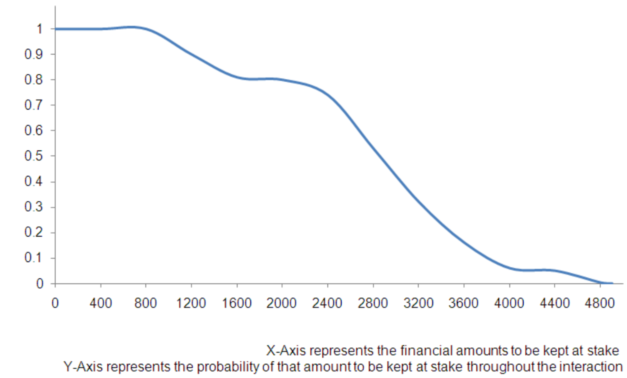

Figure 4. The Total Factual Amount Invested Curve of the Interaction

It can be seen that the TFAIC is inflated as compared to the FAIC of the interaction. This is because of the extra levels of resources that need to be kept at stake due to the non-dependable assessment criteria in the business interaction. The higher the levels and probabilities of the resources in the EIC, the greater the inflation in the TFAIC as compared to the FAIC. Once the TFAIC of the interaction has been determined, the risk assessing agent can then ascertain the total possible financial risk to it in forming a business interaction with a risk assessed agent.

VI. Determining the Financial Risk in the Business Interaction

We propose that the risk assessing agent, in order to determine the financial risk that it could experience in forming an interaction with the risk assessed agent, should determine:

- the probability at which it will not achieve the full benefit of the resources that it invests and has at stake while interacting with a risk assessed agent;
- the level/s of un-served investments or the degrees of the extra resources that it has to keep at stake in the interaction apart from what was decided in the expectations.

To ascertain these factors, the risk assessing agent has to first determine its *'maximum investment capacity'* in the interaction. As discussed earlier, the maximum investment capacity of the risk assessing agent represents the maximum extent to which it can invest its resources while interacting with the risk assessed agent. These resources are those which were decided between the interacting agents while forming the expectations of the interaction.

A. Determining the Loss of Investment Probability in an Interaction

The *'Loss of Investment Probability' (LOIP)* in the interaction gives the probability of the risk assessing agent not achieving the full benefit of its financial resources that it invests while interacting with a risk assessed agent. This arises due to:

- the risk assessed agent not completing the risk assessing agent's objectives to its maximum investment capacity due to its performance risk, as opposed to what was decided and promised to it earlier in the expectations, and
- the occurrence of non-dependable events in an interaction in a way different to what was initially expected.

So, the Loss of Investment Probability (LOIP) index to the risk assessing agent in the interaction can be determined by ascertaining the level to which the risk assessed agent needs extra financial resources to be at stake in the interaction, after the point of the maximum investment capacity of the risk assessing agent. The LOIP index of an interaction, as shown in Figure 5 is the ordinate of the TFAIC corresponding to the amount on the abscissa immediately after the risk assessing agent's maximum investment capacity in the interaction. By definition of TFAIC, this ordinate is the probability of the corresponding level of the amount needed to be at stake in the interaction due to the performance risk of the risk assessed agent and the other non-dependable criteria. However, this level and the levels of the amount after this point will not be kept at stake by the risk assessing agent as they are beyond its maximum investment capacity. So the Loss of Investment Probability (LOIP) to the risk assessing agent in the interaction is determined by:

$$\text{LOIP} = \text{TFAIC}(w) \qquad \textbf{Equation 5}$$

where: w = the point immediately after the maximum investment capacity of the risk assessing agent, and

TFAIC (w) = ordinate on the Total Factual Amount Invested Curve (TFAIC) after investing the total capacity of the risk assessing agent's resources in the interaction.

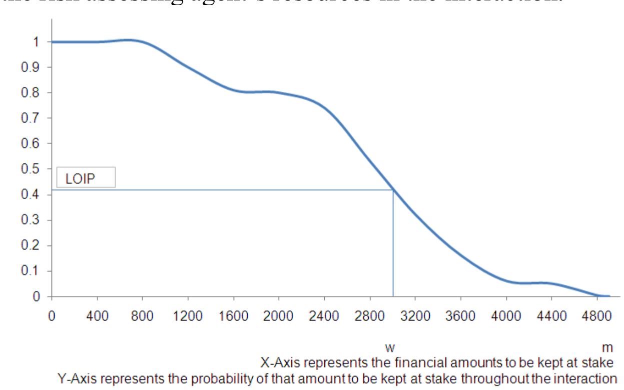

Figure 5. The Loss of Investment Probability (LOIP) in the interaction

B. Determining the Possible Financial Consequences of Failure in an Interaction

The *'Possible Consequences of Failure' (PCF)* in a business interaction are the level of un-served investment/s by the risk assessing agent, due to the performance risk of the risk assessed agent and the variation in the occurrence of non-dependable events of the interaction. It is possible that there might be more than one level of un-served investment in the interaction and subsequently while determining the financial risk, the risk assessing agent should capture all these levels. To achieve that, we propose that the risk assessing agent should take the part of the TFAIC after its MIC, and repeat the steps mentioned in Section 5 to normalize and determine the cumulative probability of the total un-served investments in the time period of the business activity. The resultant curve will represent the total loss which the risk assessing agent may experience in the time period of its interaction with the risk assessed agent. We term the cumulative probability of the un-served investments in the interaction as the *Loss Curve*. The Loss Curve represents the different level/s of financial loss and the probability of the risk assessing agent experiencing it while interacting with risk assessed agent, by taking into account the different types of uncertainties associated with its interaction. Continuing the above example, the MIC of the risk assessing agent is 3000. Based on that the Loss Curve of the risk assessing agent's 'A' interaction with the logistics company by considering the TFAIC of Figure 5 is shown in Figure 6.

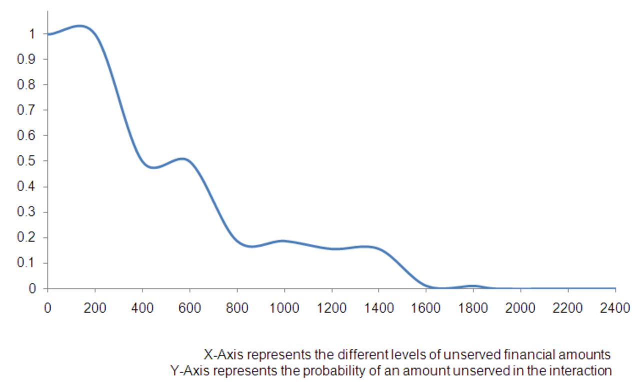

Figure 6. The Loss Curve in the interaction

By utilizing the proposed approach the risk assessing agent can determine the different levels of financial loss with their probabilities that it can experience in its business activity. Such an analysis of quantifying the level of financial loss in the interaction is novel and has not been discussed previously in the literature. Approaches have been proposed in the literature which determines the level of loss as a crisp financial amount that can be experienced in an e-business interaction. In finance, Value at Risk (VaR) is a widely used measure of risk that represents the total financial loss that can be experienced over a time horizon with a given probability [20]. But, as the business interaction is going to be carried out at a future point in time in which nothing is certain, it is quite difficult to determine beforehand and be certain of the crisp financial loss in exact amounts that a risk assessing agent can experience in its business interaction. Our proposed approach overcomes this and represents the different levels of financial loss along with the probability of experiencing these, by taking into consideration the different types of uncertainties in the business activity. The risk assessing agent can utilize the determined analysis of loss when making an informed decision of whether to form an interaction with the risk assessed agent or business in question, or choose another agent with which to interact. Based on that, it can carry out the steps of risk management to alleviate the identified risks in its business activity.

VII. CONCLUSION

In this paper, we proposed a methodology by which the risk assessing agent can determine the total financial loss that it can experience in forming a business interaction with a risk assessed agent. The proposed approach takes into consideration both the dependable and non-dependable events of the business interaction, and then determines the impact, on the invested financial resources, of not achieving them as desired. The output that is achieved is not a single crisp financial value showing the financial loss, but the different levels of financial amounts that the risk assessing agent might lose along with their probability, in forming an interaction with the risk assessed agent. The proposed approach can be applied to any business scenario, according to its specific characteristics that involves financial values, in order to determine the possible financial losses that it could experience. The level of risk determined by the analysis can then be utilized to carry out the steps of risk management, which minimizes or alleviates the identified risks. This is the focus of our future work.

VIII. REFERENCES

[1] Australian Bureau of Statistics, "Online Shopping Blooms," in *Use of the Internet by Householders, Australia, Nov*, 2000.

[2] Thuiswinkel Organisatie, "Internet shopping gaining popularity in the Netherlands," in *m&c*, 2007.

[3] Reineke Reitsma, "European Online Shopping Landscape 2007," in *Forrester Research*, 2007.

[4] Lori Enos, "E-tail Invades the Real World," in *E-Commerce Times*, 2001.

[5] Preston G. Smith and G. M. Merritt, *Proactive Risk Management*. USA: Productivity Press, 2002.

[6] Y. Y. Haimes, *Risk Modelling, Assessment, and Management*: John Wiley & Sons, INC., 1998.

[7] Sander Greenland, "Bounding Analysis as an Inadequately Specified Methodology," *Risk Analysis,* vol. 24, pp. 1071-1083, October 2004.

[8] James G. March and Zur Shapira, "Managerial perspective on risk and risk taking," *Management Science,* vol. 33, pp. 1404-1418, 1987.

[9] Omar Khadeer Hussain, Elizabeth Chang, Farookh Khadeer Hussain, and Tharam S. Dillon, "A methodology to quantify failure for risk-based decision support system in digital business ecosystems," *Data & Knowledge Engineering,* vol. 63, pp. 597-621, December 2007.

[10] Omar K. Hussain, Elizabeth Chang, Farookh K. Hussain, and Tharam S. Dillon, "Towards Quantifying the Possible Risk in e-commerce Interactions for RDSS," in *Proceedings of the IEEE International Conference on e-Business Engineering (ICEBE'07)*, IEEE, Ed. Hong Kong, China: IEEE, 2007, pp. 89-96.

[11] Omar Hussain and Tharam Dillon, "Ascertaining the Financial Loss from Non-dependable Events in Business Interactions by using the Monte Carlo method," Accepted for publication in *The Fourth International Conference on Availability, Reliability and Security (ARES'09)*, Fukuoka, Japan 2009.

[12] Yan Wang and F.-r. Lin, "Trust and Risk Evaluation of Transactions with Different Amounts in Peer-to-Peer E-commerce Environments," in *IEEE International Conference on e-Business Engineering (ICEBE'06)*, Shanghai, 2006, pp. 102-109.

[13] Yuk-Hei Lam, Zili Zhang, and K.-L. Ong, "Trading in Open Marketplace Using Trust and Risk," in *Proceedings of the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (WI-IAT'05)*, Compiegne, France, 2005, pp. 471-474.

[14] Cheng Su, Hong Zhang, and F.-m. Bi, "P2P-based Trust Model for E-Commerce," in *IEEE International Conference on e-Business Engineering (ICEBE'06)* Shanghai: IEEE Computer Society, 2006, pp. 118-122.

[15] Colin English, Sotirios Terzis, and W. Wagealla, "Engineering Trust Based Collaborations in a Global Computing Environment," in *Second International Conference on Trust Management (iTrust'04)*. vol. LNCS 2995 Oxford, UK: Springer, 2004, pp. 120-134.

[16] A. F. Salam, H. R. Rao, and C. C. Pegels, "Consumer-perceived risk in e-commerce transactions," *Communications of the ACM,* vol. 46, pp. 325-331, 2003.

[17] Omar Hussain, Elizabeth Chang, Farookh Hussain, and Tharam Dillon, "Towards Quantifying the Possible Risk in e-commerce Interactions for RDSS," in *Proceedings of the IEEE International Conference on e-Business Engineering (ICEBE'07)*, IEEE, Ed. Hong Kong, China: IEEE, 2007, pp. 89-96.

[18] Maurice G. Kendall and A. Stuart, *The Advanced Theory of Statistics*, 3 ed. vol. 1. London: Butler & Tanner Ltd., 1969.

[19] Boris V. Gnedenko, *Theory of Probability*, 3 ed. vol. 1. New York: Chelsea Publishing Company, 1966.

[20] Steven Allen, *Financial Risk Management, A Practitioner's Guide to Managing Market and Credit Risk*. New Jersey: John Wiley & Sons, Inc., 2003.