

Entropy Evaluation of Uncertainty in M&A Transaction System

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Abstract: Because of the indeterminations in Merger and Acquisition (M&A) trading, the participants are not always able to achieve the objective. This paper conducts a study on the comprehensive evaluation of M&A uncertainty from the angle of complexity science. In the process of study, beginning with the discussion of uncertainties in M&A transaction and trading environment, a structure diagram of the system uncertainty is created, and then the system is evaluated based on the entropy information theory. It is concluded that a low information entropy would be helpful to reduce the system uncertainty and facilitate the development of M&A transaction towards an orderly, steady and efficient direction.

Keyword: Complexity; M&A; Entropy; Evaluate; Uncertainty.

1. Introduction

There exists the mutual penetration and interaction between the M&A transaction and the environment, from which the exchange of material, energy and information speeds up the development of M&A transactions. As the impact of environment on M&A transactions increases, the environmental subsystems might be converted into M&A transaction's subsystems. For example, with the involvement of potential third-party competitor for M&A transaction, the intervention of arbitrageurs, and the public voices in the market have a direct impact on the M&A transactions. It is known that the border of the open M&A transaction system is vague and is equipped with access way which can be in and out. To some extent, the key to the M&A transaction success depends on whether the involvers can adapt to a changing environment or not. The M&A system consists of the enterprise entities, intermediary organizations, and environments. A simple M&A transactions is constructed as shown in Table 1.

Table 1: The complex M&A transaction system framework indicated

M & A Enterprises/ Target Enterprise	board of shareholders	The personnel actually involved in the M&A transaction
	Board of Directors	
	Executives	
	label union	
Intermediary organizations	Investment Bank	M&A Team
	public accounting firm	Accountants
	law issue office	Lawyers
	other	...
M & A environment	microenvironment	legal agent
		public relation staffs
		analysts
		public opinion
	the overall environment	local government
		economic environment
		social environment
		market environment
others	...	political setting
		entironment

Although the rules of M&A transaction system are exactly the same for all participants, it is difficult to make two M&A transactions identical. The M&A market provides a trade-off for all parties involved in the transactions, however, because of the existence of uncertainty, the participants are not always able to achieve the desired goals. During the M&A transaction process, the involvers will face with a lot of uncertainty such as the uncertainty of negotiations, the uncertainty of payment, the uncertainty of decision-making, the uncertainty of social environment and so on.

Uncertainty can be measured by assessing the probability of all possible occurrence, the associated risks, as well as gains (or "effect"), that is, link the uncertainty with the probability of event, using the variance of random variable to describe the size of its uncertainty. The decision making is often based on the assessment of the risk and return which are associated with the probability. For instance, in the famous Arrow - Debreu model, uncertainty is assumed to be: (i) Each of the uncertainty factors is identifiable in advance; (ii) Each of the uncertainty factors is tradable, and the transaction is in balance, which means each of the consequence of uncertainties is specific, or can be offset through the transaction. In the presence of uncertainty, the rational knowledge could be expressed as the capacity to judge and analyze the likely outcome of various behaviors, including the possible results and the possibility of results. The uncertainty problem is expected to be an outcome with deterministic probability distribution. As a consequence, it can be translated into a calculation problem. In this paper, the theory of information entropy is introduced to evaluate the uncertainty of M&A system.

2. Information power and entropy measure

As a measure of information content, entropy can be used to study the changes and uncertainties of the system's internal and external environment. The concept of entropy which comes from the thermodynamics was brought forward by Germany Clausius in 1865, it reflects the degree of confusion in the micro system. From then on, the models of entropy has been well developed and widely used.

For a set $A = \{x_1, x_2, \dots\}$ and a set $B = \{y_1, y_2, \dots\}$, where X and Y are random variables, A and B have intersection with some constraints between the two sets. The information contained in the set A and B can be measured through the probability distribution function $P(X)$ and $P(Y)$, and the conditional probability distribution function can be expressed as $P(Y|X)$. The entropy for X is:

$$H(X) = -\sum_i P(x_i) \log P(x_i) \quad (1)$$

The conditional entropy of the average amount of information about X provided by Y can be expressed as:

$$H(X; Y) = -\sum_j \sum_i P(x_i, y_j) \log \frac{P(x_i | y_j)}{P(x_i)} \quad (2)$$

For any k , if an estimated value Q has $Q_k(X|Y_k) = P(X|Z_k)$, then it indicates that the prediction is in line with truth. When all $Q_k(x_i | y_k) \in (0, 1)$, it indicates that this prediction is a determined case. Generalized information measure can be measured and expressed as:

$$I(x_i; y_k) = \log \frac{Q(x_i | y_k)}{Q(x_i)} \quad (3)$$

When $Q(X)$ is determined, the predictive value of $Q(X|y_k)$ is more closer to the truth, and the greater the amount of information would be. After averaging $I(X; y_k)$, we can obtain mutual probability prediction information:

$$I(X; Y) = \sum_k \sum_i P(x_i, y_k) \log \frac{Q(x_i | y_k)}{Q(x_i)} \quad (4)$$

Generally, $P(x_i)$ and $P(x_i | y_j)$ are unknown. What we can do is to judge if $Q(x_i)$ and $Q(x_i | y_j)$ are truth based on the experience and semantics. Therefore, we have to use the probability logic in lieu of the probability. If and only if the truth of x_i occurs, expression (4) can be extended:

$$I(x_i; y_j) = \log \frac{Q(x_i | y_j \text{ is true})}{Q(x_i)} = \log \frac{Q(x_i | A_j)}{Q(x_i)} = \log \frac{Q(A_j | x_i)}{Q(A_j)} \quad (5)$$

Expression (5) shows that: The smaller the transcendental logic probability $Q(A_j)$ and the greater the posterior logic probability $Q(A_j | x_i)$, the greater the amount of information. In the contrary, the amount of information is smaller, or even negative, and the statement is more vague.

3. The entropy evaluation of the M&A transaction system's uncertainty

System uncertainty can be evaluated from the following aspects: (i) the uncertainty of time. To predict the future event, the historical records should not be ignored. (ii) the uncertainty of the semantics itself. The understanding of the concept and rules might result in different uncertainty. (ii) The uncertainty resulted by the nonlinear interaction between the elements both in inner system and the environment.

From the analysis of M&A market, there are a lot of uncertainties in M&A transactions system. For a simple case study, some factors are selected and formed a tree like diagram as shown in the Figure 1 and Table 2. In order to facilitate the calculation, we have directly given the probability which uncertainty variable may happen (information content) listed in Table 3:

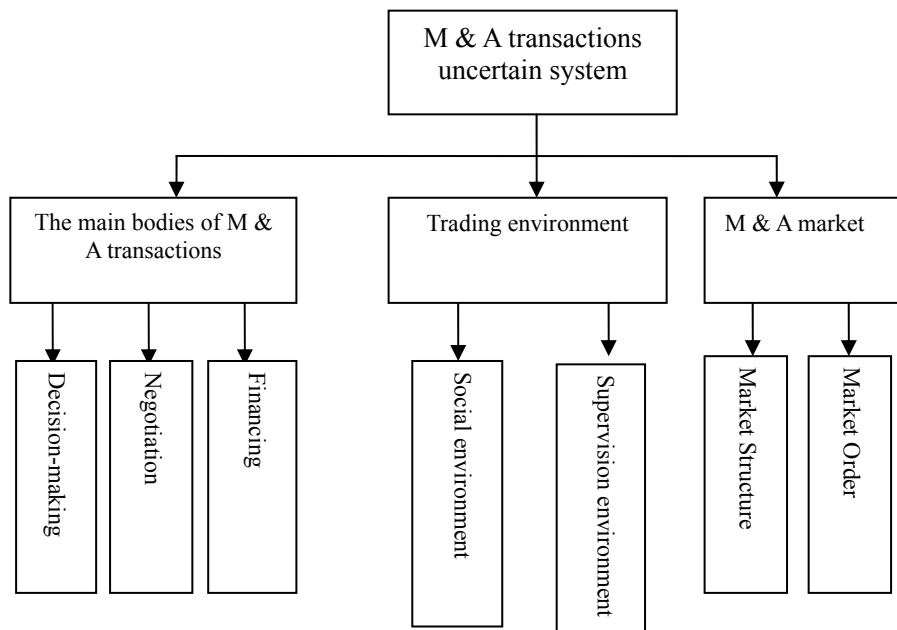


Figure 1: The schematic diagram of M&A transaction uncertain system

Table 2: The factors hierarchy of M & A transaction uncertainty

The M&A transaction systems uncertainty	The main bodies of transaction (X)	Decision-making (X _x)	Board of Directors, Shareholders, Trade unions, Individual	P1, P2, P3, P4
		Negotiation (X _y)	The structure style, Price, Ownership, Location	P5, P6, P7, P8
		Financing to pay (X _z)	Cash, Debt financing, Securities, Other ways	P9, P10, P11, P12
	Trading environment (Y)	Social environment (Y _x)	Local governments, Institutions, Public opinion	P13, P14, P15
		Supervision environment (Y _y)	Antitrust, Trade regulation, Judicial decision	P16, P17, P18
	M & A market (Z)	Market Structure (Z _x)	Intermediaries, Investment banks, Consultants, Competitors	P19, P20, P21, P22
		Market Order (Z _y)	Purpose, Disclosure of information, Synergies	P23, P24, P25

Table 3: The uncertainty probability of M & A transaction system

P1	25%	P6	50%	P11	20%	P16	10%	P21	15%
P2	20%	P7	40%	P12	15%	P17	20%	P22	30%
P3	10%	P8	10%	P13	20%	P18	30%	P23	5%
P4	5%	P9	20%	P14	25%	P19	30%	P24	30%
P5	30%	P10	10%	P15	25%	P20	5%	P25	30%

4. The comprehensive evaluation of M & A system’s uncertainty

Suppose management activities: $T_1, T_2, \dots, T_b, \dots, T_n$. Subsystems or departments constitute a concerted activity set: $[S_1, S_2, \dots, S_b, \dots, S_m]$, so the department coordination matrix as follows:

$$[A_{ij}] = [T_i, S_j] = \begin{bmatrix} A_{11} & A_{12} & \dots & \dots & A_{1m} \\ A_{21} & A_{22} & \dots & \dots & A_{2m} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ A_{n1} & A_{n2} & \dots & \dots & A_{nm} \end{bmatrix} \quad (6)$$

After evaluate information entropy of the various events, in order to assess the uncertainty of the whole system and further assess the ordering of various subsystems, we introduce the evaluation value of the orderliness unification.

Assuming entropy function H has a vector with variable X, Y and Z . Elements of E are defined as the complexity three-dimensional vector: $e_i=(x_i, y_i, z_i)$, or two-dimensional vector: $e_i=(x_i, y_i)$, or one-dimensional vector: $e_i=(x_i)$.

If $\|e_i\| : E \rightarrow H$ is expressed as information entropy of the complexity of vector e_i , then $\|e_i - e_{i+1}\|$ is called the E value, and the distance is^[3]:

$$d(e_i, e_{i+1}) = \sqrt{(x_i - x_{i+1})^2 + (y_i - y_{i+1})^2 + (z_i - z_{i+1})^2} \quad (7)$$

Corresponding to the M&A system tree structure, B_{i+j} produces the amount of entropy information after a structure B_i . The interaction of the various synergies exists in the organizational system. The definition of entropy vector can be obtained from the synergistic information force field and its components:

$$\|w\|_X = \sum_{i=1}^m Z_{xi} \sqrt{\|e_{xi}\|^2 - z_{xi}^2} \quad (8)$$

Table 4, Table 5 and Table 6 list the evaluation of the M&A subsystem transactions’ uncertainty, as well as the calculations of each component’s information entropy.

Table 4: The the uncertainty scale calculation of the M & A transactions’ main bodies

	Decision-making		Negotiation		Financing to pay		e(Xxi)	e(Yxi)	e(Zxi)	e(x)	W(x)
	(Xx)		(Xy)		(Xz)		H(Xx)	H(Yx)	H(Zx)		
The main bodies of transaction	Board of Directors	0.25	Structure style	0.30	Cash	0.20	0.1584	0.147	0.1575	0.2674	0.03403
	Shareholders	0.20	Price	0.50	Debt financing	0.10	0.159	0.1596	0.12506	0.2577	0.02818
	Trade unions	0.10	Ownership	0.40	Securities	0.20	0.1297	0.1575	0.1575	0.2577	0.03213
	Individual	0.05	Location	0.10	Others	0.15	0.0899	0.0857	0.14696	0.1924	0.01825
Subt ot al		0.60		1.30		0.65	0.5371	0.5498	0.58703	0.9753	0.1126

Table 4: The the uncertainty scale calculation of the M&A environment

Tradi ng envi ronment	Social environment		Supervision environment		e(Xyi)	e(Yyi)	e(Zyi)	e(y)	W(y)
	(Yx)	(Yy)	(Yz)	(Yw)	H(Xy)	H(Yy)	H(Zy)		
Local government	0.20	Antitrust	0.10		0.15544801	0.1297		0.2024	0.02016
Institution	0.25	Trade regulation	0.20		0.1596993	0.159		0.2254	0.0254
Public opinion	0.25	Judicial decision	0.30		0.1596993	0.1505		0.2195	0.02404
Subt ot al	0.70		0.60		0.47484661	0.4392	0	0.6473	0.0696

Table 5: The the uncertainty scale calculation of the M&A market

M & A mar ket	Market Structure(Market Order		e(Xzi)	e(Yzi)	e(Zzi)	e(z)	W(z)
	(Zx)	(Zy)	(Zz)	(Zw)	H(Xz)	H(Yz)	H(Zz)		
Intermediaries	0.30	Purpose	0.05		0.15973827	0.0857		0.1813	0.01369
Investment banks	0.05	Disclosure of information	0.30		0.0752575	0.155		0.1723	0.01166
Consultants	0.15	Synergies	0.30		0.13631226	0.155		0.2064	0.02113
Competitors	0.30				0.15973827			0.1597	0
Subt ot al	0.80		0.65		0.53104631	0.3956	0	0.7197	0.04648

5. Conclusion

The nonlinear interaction between the system and the elements as well as interaction between the element subsystems and environments are keeping change. On the one hand, participants constantly sum up experience in order to reduce or even eliminate uncertainty in the process of M&A transactions; On the other hand, with the creation of new rules, the system would result new uncertainties. It is this kind of interaction between the orderliness and uncertainties that makes the M&A transactions complex and diverse. From the viewpoint of the entropy information theory, the contribution of information entropy reduction to the system would give rise to a decrease of the uncertainty, the greater the value of information entropy is, the more undetermined the system would be. Therefore, it is important to reduce the uncertainty for the M&A transaction system to develop towards an orderly, steady and efficient direction.

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