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**ID132**

# A supply chain analysis and design method based on the value of information

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## ***Background***

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- Increasing severe competition in the global market.
- Increasing interests in making the competitive supply chain (SC) .
- Increasing recognition that information is a key to design and operate SC effectively in Supply Chain Management (SCM) .

## ***Objectives***

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- Develop a method of analysis and design of SC by focusing on the value and accuracy of information of each entity in SC.

## ***Assumption***

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- The entity ranked a higher value of information has stronger inference to the SC operation.
- The ranks of the value of information and the value added in each entity should be matched in SC.

# Calculating value of information

Eigen vector of SC network  $R$  is used as the value of information of each entity in SC. → Similar idea of Ranking Web Page

$R$ : Eigenvector of the matrix representing the value of information.

Element  $r_i$  ( $i=1$  to  $n$ ) of  $R$  is the rank of value of information of entity  $i$ .

$n$  is the total number of CS element.

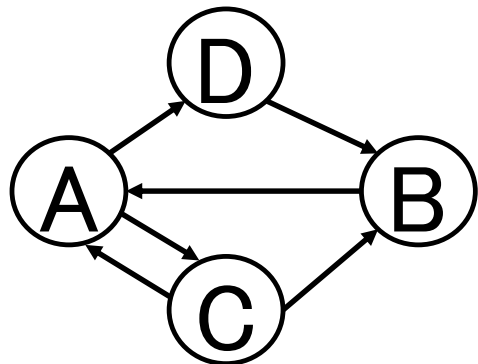
$R = c A R$   $A$ : A square matrix representing the structure of information links.

$a_{v,u}$  ( $=W_{v,u}/N_u$ ): Elements of  $A$ .

$N_u$  is the total number of links from the entity  $u$  to other entities  $v$ .  $W_{v,u}$  is a real number from 0 to  $N_u$  indicating relative importance of the links from entity  $u$  to  $v$ ,

and  $\sum_{v=1,n} W_{v,u} = N_u$  ( $u=1$  to  $n$ ). If there is no link,  $W_{v,u}=0.0$ .

## Example calculation



A supply chain with four elements

$$R = c \begin{pmatrix} A & B & C & D \\ 0 & 1 & 1/2 & 0 \\ 0 & 0 & 1/2 & 1 \\ 1/2 & 0 & 0 & 0 \\ 1/2 & 0 & 0 & 0 \end{pmatrix} R$$

A matrix representing the structure of information links

$$R = \begin{pmatrix} 0.3636 \\ 0.2727 \\ 0.1818 \\ 0.1818 \end{pmatrix} \begin{matrix} A \\ B \\ C \\ D \end{matrix}$$

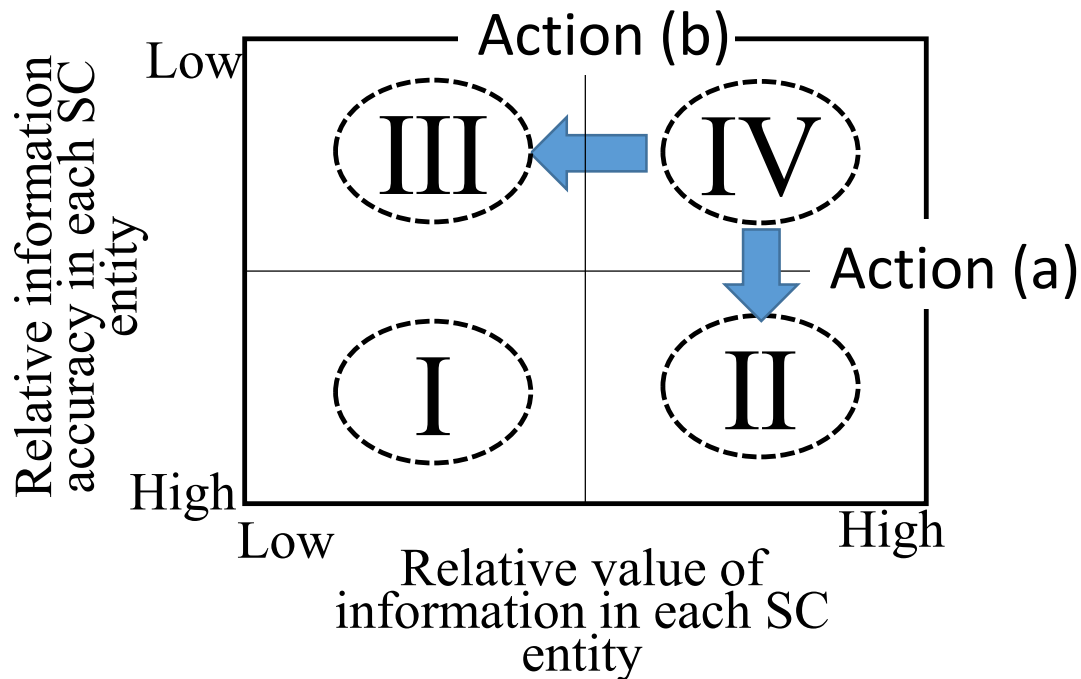
Eigenvector of the matrix representing the value of information

# Evaluation index of the entire SC (SCV)

$$SCV = |R - VA| = \sqrt{\sum_{i=1 \sim n} (r_i - va_i)^2}$$

- **VA** : Vector of the relative value added by each entity  $i$  in SC
- $va_i$  : Element of **VA**,  $va_i \geq 0.0$ ,  $\sum_{i=1, n} va_i = 1.0$ .
- $r_i$  : Rank of value of information of entity  $i$

# Value map of supply chain entity




- Position of each entity, i.e., Area I, II, III, and IV, is determined based on the relative information accuracy & value of information.
- The relative value of the information is obtained by  $r_i / n - 1$ .  
 $n$  : Total number of entities in SC.

# Method



## 1st stage

### Design of initial information network based on **SCV** index



**Step 1.1:** Calculate the *SCV* from the eigenvector ***R*** calculated and the vector ***VA*** showing the relative value added in each entity *i* in SC.

**Step 1.2:** Attempt to minimize the *SCV* by the following evolution rules R1 and/or R2.

R1: For the element *k* with the largest difference between ***R*** and ***VA***, review the value of  $a_{k,u}$  ( $u=1$  to  $n$ ) to reduce the difference between the value of information and relative value added to *k*.

R2: For the element *k* with the largest difference between ***R*** and ***VA***, where  $r_k < va_k$ , makes new links from elements not currently connected to *k*.

## 2nd stage

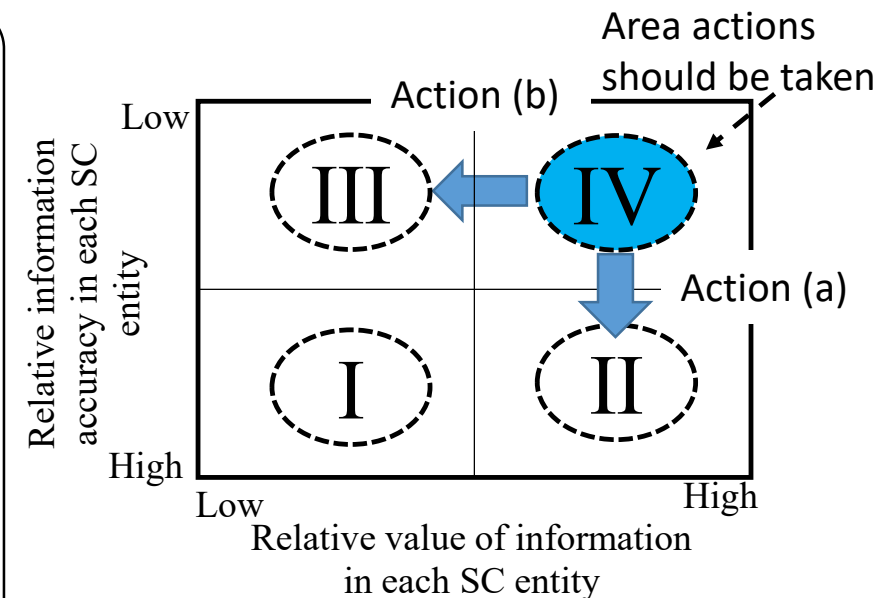
### Modify the information network based on accuracy of information

**Step 2.1:** From the relative value of information in each entity and its relative accuracy, the position of each entity, i.e., Area I, II, III, and IV in the value map, is determined.

**Step 2.2:** The following actions are taken to the entity in Area IV.

Action (a): Improve management level of the entity in order to move the entity in the direction of Area II.

Action (b): Establish a new entity, or construct a new information link in SC in order to move the entity in the direction of Area III.



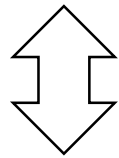
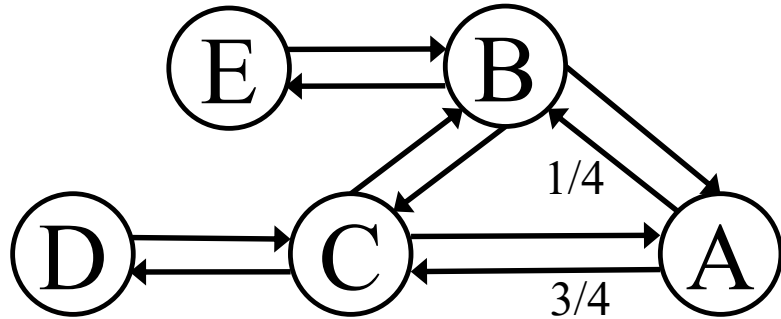
*Value map of supply chain entity*

**Step 2.3:** If there is an entity in Area IV, repeat Steps 2.1 and 2.2. Otherwise, terminate all the Steps.

# Numerical examples

## Case 0

(Initial information links)



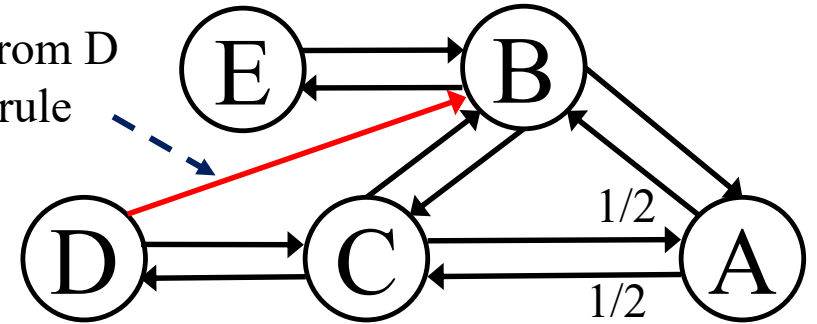
Initial matrix of information links

	A	B	C	D	E
A	0	1/4	2/3	0	0
B	1/4	0	1/6	0	1
C	3/4	1/2	0	1	0
D	0	0	1/6	0	0
E	0	1/4	0	0	0

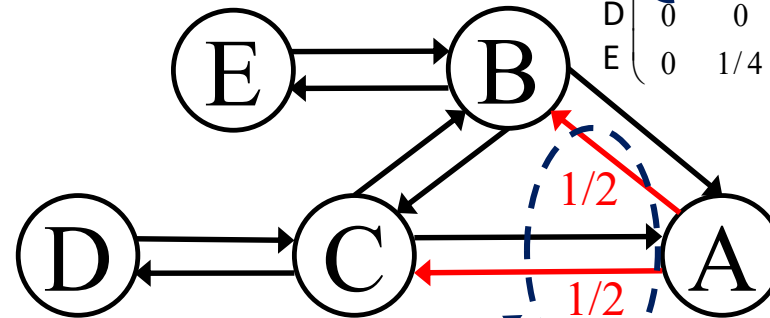
A new link of information from D to B is applied in Case 2 by rule R2 in Step 1.2.

	A	B	C	D	E
A	0	1/4	2/3	0	0
B	1/2	0	1/6	1/2	1
C	1/2	1/2	0	1/2	0
D	0	0	1/6	0	0
E	0	1/4	0	0	0

## Case 2



## Case 1

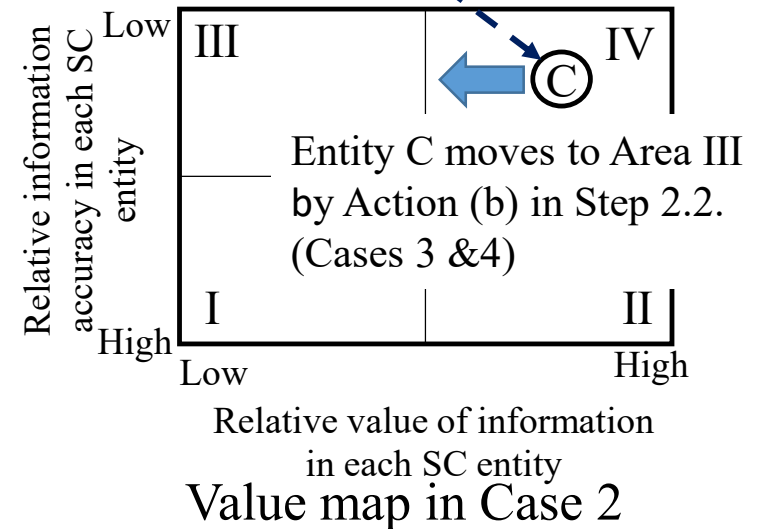


Importance of the information link from entity A to B is increased from 1/4 to 1/2 by rule R1 in Step 1.2.

	A	B	C	D	E
A	0	1/4	2/3	0	0
B	1/2	0	1/6	0	1
C	1/2	1/2	0	1	0
D	0	0	1/6	0	0
E	0	1/4	0	0	0

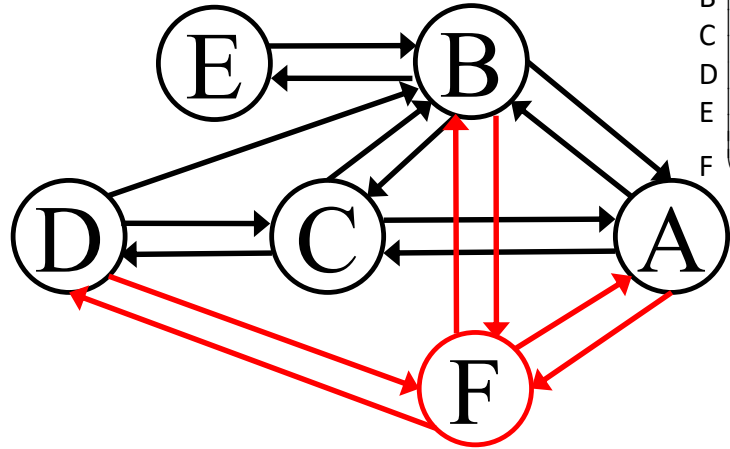
Relative values of information of entities in Case 2.

	A	B	C	D	E
	0.392	0.443	0.546	-0.742	-0.639



### Case 3

	A	B	C	D	E	F
A	0	1/6	2/3	0	0	2/3
B	1/3	0	1/6	1/3	1	1/6
C	1/3	1/3	0	1/3	0	0
D	0	0	1/6	0	0	1/6
E	0	1/6	0	0	0	0
F	1/3	1/3	0	1/3	0	0



- ✓ Setting up entity F as an entity having the same function as C by Action (b) in Step 2.2.
- ✓ Entity C moves from Area IV to the Area III

### Relative value added by each entity (VA)

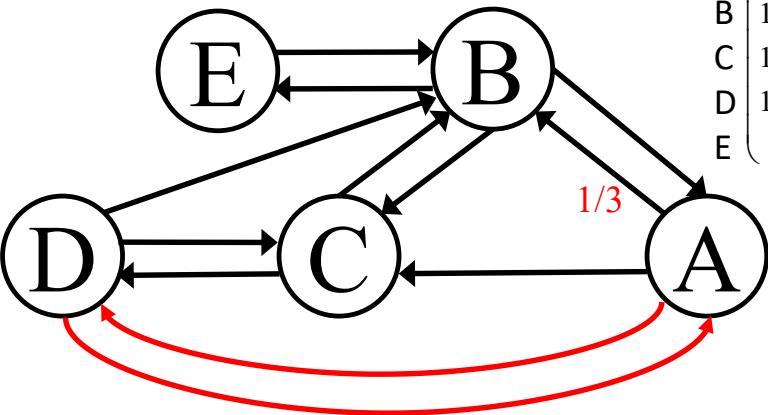
	A	B	C	D	E	F
<b>Case 0,1,2,4</b>	0.25	0.35	0.2	0.1	0.1	---
<b>Case 3</b>	0.25	0.35	0.1	0.1	0.1	0.1

### Value of information in each entity (R)

	A	B	C	D	E	F
<b>Case 0</b>	0.308	0.189	0.396	0.0651	0.437	---
<b>Case 1</b>	0.286	0.264	0.330	0.0549	0.0659	---
<b>Case 2</b>	0.278	0.289	0.309	0.0515	0.0722	---
<b>Case 3</b>	0.294	0.220	0.193	0.0642	0.0367	0.193
<b>Case 4</b>	0.285	0.248	0.266	0.139	0.0619	---

### Case 4

	A	B	C	D	E
A	0	1/4	2/3	1/3	0
B	1/3	0	1/6	1/3	1
C	1/3	1/2	0	1/3	0
D	1/3	0	1/6	0	0
E	0	1/4	0	0	0



- ✓ New information links between entities D and A by Action (b) in Step 2.2.
- ✓ Ranking of entity C has decreased from Case 2.
- ✓ Entity C moves from Area IV to the Area III

### Evaluation index of the entire SC (SCV)

Case 0	Case 1	Case 2	Case 3	Case 4
0.264	0.169	0.140	0.203	0.138

## Conclusions

- A method of analysis and design of SC based on the value and accuracy of information is developed.
  - The effectiveness is demonstrated via numerical experiments using a simple SC model.
- <Further investigations>**
- Method to determine the importance of each link within the information network should be investigated.
  - The method that integrates diverse factors, such as cost, risk, technical feasibility, and so on should be developed.