

Boolean Analysis of Vocational Indecision-Making

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1. Introduction

Vocational decision making is one of the most important developmental tasks in adolescence or early adulthood. According to Holland, Gottfredson, and Power (1980), vocational identity means the possession of a clear and stable picture of one's goals, interests, and talents, and these characteristics lead to relatively untroubled decision making and confidence in one's ability to make good decisions in the face of some inevitable environmental ambiguities.

However, there have been growing numbers of so-called "freeters" who continue to work at non-regular jobs, and of so-called "NEETs" who are not in employment, education, or training after graduation from school (Japan Institute for Labour Policy and Training, 2006). Therefore, it has become much more important to develop effective career guidance and counseling for the students who cannot make their vocational decision.

As a measure of career indecision, Shimoyama (1986) developed the Vocational Indecision Scale, which was based on A Scale of Vocational Indecision (SVI) (Osipow, Carney, & Barak, 1976) and the Vocational Decision-Making Difficulty Scale (VDMD) (Holland & Holland, 1977). The Vocational Indecision Scale consists of five subscales: "immaturity," which

contains items expressing an immature sense of occupation, lack of plan for the future, and being not able to start choosing an occupation; "confusion," representing a confusion of mind when thinking about an occupational choice; "moratorium," representing a desire to put off making a occupational decision for the time being; "exploration," representing active exploration for choosing an occupation; "easiness," representing a desire to make a decision quickly regardless of interest and to get it over with.

These subscales of vocational indecision were extracted and constructed by factor analyses. Therefore, the Vocational Indecision Scale measures what factors and how strong "undecided" students have. However, in order to understand how these factors are combined and what causal combinations cause students' vocational indecision, another analysis will be needed.

As a useful mathematical technique for identifying the relations between the combinations of causal conditions and the outcomes, Ragin (1987, 1995, 2000) developed Boolean approach, or Qualitative Comparative Analysis. As a case-oriented comparative method, Boolean analysis has been used for various topics in the field of social sciences such as sociology, politics, economics, management, and anthropology (e. g., Degenne & Lebeaux, 1996; Yamashita, Kono, & Shimada, 2001; Ya-

mashita & Kono, 2002 ; Yamashita, 2004), and Boolean analysis is very useful for seeking and formulizing patterns of unanticipated as well as expected causal relationships.

Yamashita, Kono, and Kuzuhara (2003) tried to apply Boolean analysis to analyzing college students' vocational indecision. However, they used only the subscale values of the Vocational Indecision Scale (Shimoyama, 1986) as their logical variables and they did not examine the other possible variables. Therefore, in order to understand students' vocational indecision more deeply, the present study extends Yamashita et al. (2003) by adding both motives for going to college and vocational motives as logical variables.

2 . Vocational indecision

In this chapter, we will exemplify Boolean analysis procedure, especially Quine-McCluskey minimization technique by analyses of vocational indecision of undergraduates (Yamashita et al., 2003). Yamashita et al. (2003) administered the Vocational Indecision Scale to 102 undergraduates (91 males and 11 females). The students rated each item of the scale on a 5-point scale anchored by 1, do not think so at all, and 5, think so absolutely, with 3 being neutral.

2.1. Truth table

Boolean analysis requires binary variables. For a case or an individual, each variable takes the values 0 or 1, that is, each case or individual is conceived as a configuration of conditions. Data have the form of a truth table in which the columns represent causal variables (that is, logical variables) and the rows represent indi-

viduals. For an individual, each causal variable may take the values 0 or 1. In the column of the causal variable *immaturity*, 1 is equivalent to *immaturity* and 0 to its negation \sim *immaturity*.

Table 1 is a truth table which has five causal variables, *immaturity*, *confusion*, *moratorium*, *exploration*, and *easiness*, indicating five subscales of the Vocational Indecision Scale. We assumed that the truth value was 1 when the rated value of each subscale for each student was larger than or equal to the average rated value across all the students and that the truth value was 0 when the rated value of each subscale for each student was less than the average rated value across all the students.

Each logical combination of values on the causal variables or the independent variables is represented as one row of the truth table. Truth tables have as many rows as there are logically possible combinations of values on the causal variables. With five causal variables, the maximum number of different rows in the truth table is $2^5 = 32$, but Table 1 has only 25 rows because the other configurations did not come up in the results.

2.2. Disjunctive canonical form

A monomial form, in which all logical variables are present and combined with the operation "and," is called a minimal term or a minterm. For example, \sim *immaturity* \cdot \sim *confusion* \cdot \sim *moratorium* \cdot \sim *exploration* \cdot \sim *easiness* in the first row is a minterm. "Cases" in Table 1 indicates the number of the students who have the minterm in each row. "Instances" indicates the number of the students who have made their occupational decision. We assumed that the output variable was 1 when the proportion of the instances was larger than or equal to 75

Table 1 Truth table showing five causes for vocational indecision

Causal variables					Outcome	Cases	Instances (ratio)
<i>immaturity</i>	<i>confusion</i>	<i>moratorium</i>	<i>exploration</i>	<i>easiness</i>			
0	0	0	0	0	1	10	9(0.90)
0	0	0	0	1	1	4	3(0.75)
0	0	0	1	0	0	10	7(0.70)
0	0	1	0	0	0	4	1(0.25)
0	0	1	1	0	0	3	0(0.00)
0	0	1	1	1	0	1	0(0.00)
0	1	0	0	0	1	5	4(0.80)
0	1	0	0	1	0	3	0(0.00)
0	1	0	1	0	1	2	2(1.00)
0	1	0	1	1	0	5	0(0.00)
0	1	1	0	0	0	2	1(0.50)
0	1	1	1	0	0	3	1(0.33)
0	1	1	1	1	0	3	2(0.67)
1	0	0	0	1	0	3	0(0.00)
1	0	0	1	0	0	3	2(0.67)
1	0	1	0	0	0	3	0(0.00)
1	0	1	1	0	0	4	0(0.00)
1	0	1	1	1	0	1	0(0.00)
1	1	0	0	0	0	1	0(0.00)
1	1	0	0	1	0	4	2(0.50)
1	1	0	1	0	0	3	2(0.67)
1	1	1	0	0	0	4	2(0.50)
1	1	1	0	1	0	11	2(0.18)
1	1	1	1	0	0	3	2(0.67)
1	1	1	1	1	0	7	1(0.14)

%,

A logical function, in which all the minterms are combined with the operation “or,” is called a disjunctive canonical form. In Boolean analysis by Ragin (1987), the operation “or” is denoted by plus. We get the disjunctive canonical form as follows :

$$\begin{aligned}
 & \text{vocational decision} \\
 = & \sim\text{immaturity} \cdot \sim\text{confusion} \cdot \sim\text{moratorium}
 \end{aligned}$$

$$\begin{aligned}
 & \cdot \sim\text{exploration} \cdot \sim\text{easiness} \\
 + & \sim\text{immaturity} \cdot \sim\text{confusion} \cdot \sim\text{moratorium} \\
 & \cdot \sim\text{exploration} \cdot \text{easiness} \\
 + & \sim\text{immaturity} \cdot \text{confusion} \cdot \sim\text{moratorium} \\
 & \cdot \sim\text{exploration} \cdot \sim\text{easiness} \\
 + & \sim\text{immaturity} \cdot \text{confusion} \cdot \sim\text{moratorium} \\
 & \cdot \text{exploration} \cdot \sim\text{easiness}.
 \end{aligned}$$

2.3. Prime implicants

The goal of Boolean analysis is to specify the different configurations of the causal variables that produce the outcome variable. And the goal of the logical minimization is to represent in a logically shorthand manner the information in the truth table. The minimization process follows the complementary law :

$$a + \sim a = 1.$$

This simple law can combine rows that differ on only one causal condition. For example, the first two rows in Table 1 (that is, $\sim immaturity \cdot \sim confusion \cdot \sim moratorium \cdot \sim exploration \cdot \sim easiness$ and $\sim immaturity \cdot \sim confusion \cdot \sim moratorium \cdot \sim exploration \cdot easiness$) differ on only the fifth causal condition, and both produce the same outcome. Thus, the value of *easiness* is irrelevant to *vocational decision*, so the two minterms can be combined to produce a single, simpler expression, $\sim immaturity \cdot \sim confusion \cdot \sim moratorium \cdot \sim exploration$, which is called a prime implicant. Table 2, the form of which was designed by Kanomata (1998), summarizes this process of logical minimization. The reduced Boolean equation is as follows :

vocational decision

$$\begin{aligned}
 = & \sim immaturity \cdot \sim confusion \cdot \sim moratorium \\
 & \cdot \sim exploration \\
 + & \sim immaturity \cdot \sim moratorium \cdot \sim exploration \\
 & \cdot \sim easiness \\
 + & \sim immaturity \cdot confusion \cdot \sim moratorium \\
 & \cdot \sim easiness.
 \end{aligned}$$

2.4. Minimized algebraic equation

If there are more prime implicants than are needed to cover all the original causal conditions for an outcome, the prime implicants are selected to produce a final minimized algebraic equation. For example, prime implicant $\sim immaturity \cdot \sim confusion \cdot \sim moratorium \cdot \sim exploration$ covers, that is, implies two minterms $\sim immaturity \cdot \sim confusion \cdot \sim moratorium \cdot \sim exploration \cdot \sim easiness$ and $\sim immaturity \cdot \sim confusion \cdot \sim moratorium \cdot \sim exploration \cdot easiness$.

Prime implicant $\sim immaturity \cdot \sim moratorium \cdot \sim exploration \cdot \sim easiness$ implies minterm $\sim immaturity \cdot confusion \cdot \sim moratorium \cdot \sim exploration \cdot \sim easiness$, but this minterm is also covered by $\sim immaturity \cdot confusion \cdot \sim moratorium \cdot \sim easiness$. Thus, $\sim immaturity \cdot \sim moratorium \cdot \sim exploration \cdot \sim easiness$ may be redundant from a purely logical point of view. Table 3

Table 2 Computation of prime implicants

Minterms	$\sim a \cdot \sim b \cdot \sim c \cdot \sim d \cdot \sim e$	$\sim a \cdot \sim b \cdot \sim c \cdot d \cdot e$	$\sim a \cdot b \cdot \sim c \cdot d \cdot \sim e$
Reduced terms	$\sim a \cdot \sim b \cdot \sim c \cdot \sim d$	$\sim a \cdot b \cdot \sim c \cdot d$	$\sim a \cdot b \cdot \sim c \cdot \sim e$

- a* = immaturity
- b* = confusion
- c* = moratorium
- d* = exploration
- e* = easiness

Table 3 Prime implicant chart showing coverage of minterms by prime implicants

Prime implicants	Minterms			
	$\sim a \cdot \sim b \cdot \sim c \cdot \sim d \cdot \sim e$	$\sim a \cdot \sim b \cdot \sim c \cdot \sim d \cdot e$	$\sim a \cdot b \cdot \sim c \cdot \sim d \cdot \sim e$	$\sim a \cdot b \cdot \sim c \cdot d \cdot \sim e$
$\sim a \cdot \sim b \cdot \sim c \cdot \sim d$	◎	◎		
$\sim a \cdot \sim c \cdot \sim d \cdot \sim e$			○	
$\sim a \cdot b \cdot \sim c \cdot \sim e$			○	◎

a = immaturity
b = confusion
c = moratorium
d = exploration
e = easiness

shows a prime implicant chart which can be used to select the essential prime implicants. From the analysis of the prime implicant chart, we get the final reduced Boolean expression containing only the logically essential prime implicants :

$$\begin{aligned}
 & \text{vocational decision} \\
 = & \sim \text{immaturity} \cdot \sim \text{confusion} \cdot \sim \text{moratorium} \\
 & \cdot \sim \text{exploration} \\
 + & \sim \text{immaturity} \cdot \text{confusion} \cdot \sim \text{moratorium} \\
 & \cdot \sim \text{easiness}
 \end{aligned}$$

This equation states that “the students whose sense of occupation is not immature, and whose mind is not confused when thinking about an occupational choice, and who do not desire to put off making an occupational decision for the time being, and who are not exploring and gathering information for choosing an occupation,” or “the students whose sense of occupation is not immature, and whose mind is confused when thinking about an occupational choice, and who do not desire to put off making an occupational decision for the time being, and who do not desire to make an occupational decision quickly regardless of interest and get it

over with,” are going about implementing their occupational choice.

From the same analyses of the students who have not made their occupational decision, we get the minimized algebraic equation :

$$\begin{aligned}
 & \text{vocational indecision} \\
 = & \text{immaturity} \cdot \sim \text{confusion} \cdot \sim \text{moratorium} \\
 & \cdot \sim \text{exploration} \cdot \text{easiness} \\
 + & \sim \text{immaturity} \cdot \text{confusion} \cdot \sim \text{moratorium} \\
 & \cdot \text{exploration} \cdot \text{easiness}.
 \end{aligned}$$

This equation suggests that the combination of *immaturity* and *easiness*, or the combination of *confusion*, *exploration*, and *easiness* should be associated with students’ vocational indecision problems.

3 . Questionnaire survey

In order to understand more deeply how students’ vocational indecision problems are caused, we tried to apply Boolean analysis to students’ motives for going on to college and vocational motives.

Table 4 Participants

School year	Men	Females	Total
Freshmen	170	36	206
Sophomore	69	14	83
Junior	58	70	128
Senior	7	5	12
Total	304	125	429

3.1. Method

3.1.1. Participants

A total of 304 men and 125 females from four different universities participated in the questionnaire survey. The details of sample sizes by education are summarized in Table 4.

3.1.2. Questionnaire

The participants were asked to rate the 11 vocational motives on a 5-point scale anchored by 1, absolutely not important, and 5, very important, with 3 being neutral. The vocational motives were as follows :

1. short working hours per day
2. worth doing
3. many paid vacation
4. highly appreciated
5. very well paid
6. feels less stress and fatigue
7. leads a well-regulated life
8. can demonstrate one's full ability
9. secures a sure means of living
10. not far from the place where now living
11. less possibility of transfer to another locality.

These motives were based on Yamashita (1996a, 1996b), and Yamashita, Youn, and Matsumoto (1999).

The participants were also asked to rate 26 motives for going to college on the same 5-point

scale. The 26 motives, which are shown in Table 7, were based on Yamashita (1997) and Yamashita, Furusawa, and Yamashita (1993).

Furthermore, the participants rated the following questions on a 5-point scale anchored by 1, do not think so at all, 5, think so absolutely, with 3 being neutral.

1. I have decided my future profession.
2. I have decided what kinds of companies I would apply to.

We regarded the participants whose average rated value of the two questions was less than 3, as vocational undecided students.

3.2. Results and discussion

3.2.1. Vocational motives

(1) Factor analysis

A factor analysis was done for the 11 items. Four factors with eigenvalues over 1.0 were identified. A varimax rotation was performed for the four factors. The results are shown in Table 5.

The first factor included three items of "3. many paid vacation," "1. short working hours per day," and "6. feels less stress and fatigue," so we named it "less workload." Since the second factor included three items of "5. very well paid," "9. secures a sure means of living," and "4. highly appreciated," we named it "prestige and income." The third factor was highly weighted with three items of "10. not far from the place where now living," "11. less possibility of transfer to another locality," and "7. leads a well-regulated life," so we named it "well-regulated life." The fourth factor consisted of only two items "2. worth doing," and "8. can demonstrate one's full ability," we named it "demonstration of one's full ability."

Table 5 Factor loadings for vocational motives

Item	Factor 1 : Less workload	Factor 2 : Prestige and income	Factor 3 : Well-regulated life	Factor 4 : Demonstration of one's full ability
3 . many paid vacation	0.82	0.13	0.14	-0.04
1 . short working hours per day	0.75	0.03	0.21	-0.20
6 . feels less stress and fatigue	0.73	0.16	0.21	0.09
5 . very well paid	0.10	0.78	0.01	0.02
9 . secures a sure means of living	0.25	0.74	0.17	-0.01
4 . highly appreciated	-0.02	0.73	0.11	0.21
10 . not far from the place where now living	0.15	0.02	0.87	-0.09
11 . less possibility of transfer to another locality	0.18	0.14	0.86	-0.07
7 . leads a well-regulated life	0.33	0.40	0.43	0.11
2 . worth doing	-0.05	-0.01	-0.12	0.83
8 . can demonstrate one's full ability	-0.05	0.16	-0.04	0.80
Eigenvalue	2.00	1.93	1.84	1.45
Contribution ratio (%)	18.15	17.54	16.72	13.20
Cumulative contribution ratio (%)	18.15	35.69	52.40	65.60

(2) Boolean analysis

Table 6 shows the truth table which was constructed from the four logical variables which were extracted from the factor analysis. We assumed that the truth value was 1 when the average rated value for each student across the items included in each factor was larger than 3 and that the truth value was 0 when the average rated value was less than or equal to 3. We also assumed that the output variable was 1 when the ratio of the instances was larger than or equal to 75% of the cases.

By applying Quine-McCluskey minimization technique to the truth table, we get the following minimized algebraic equation :

$$\begin{aligned} & \text{vocational indecision} \\ = & \text{prestige and income} \cdot \text{well-regulated life} \\ & \cdot \sim \text{demonstration of one's full ability} \end{aligned}$$

$$\begin{aligned} & + \text{less workload} \cdot \sim \text{prestige and income} \\ & \cdot \sim \text{well-regulated life} \\ & \cdot \text{demonstration of one's full ability} \\ + & \sim \text{less workload} \cdot \sim \text{prestige and income} \\ & \cdot \text{well-regulated life} \\ & \cdot \text{demonstration of one's full ability.} \end{aligned}$$

For example, if one wants to get high *prestige and income*, he/she will have to work hard at the cost of *well-regulated life*. However, the above equation suggests that the students who have difficulty in vocational decision making tend to attain contradictory goals such as *prestige and income* and *well-regulated life*, *less workload* and *demonstration of one's full ability*, and *well-regulated life* and *demonstration of one's full ability*.

Table 6 Truth table for vocational motives

Causal variables				Outcomes		
<i>less workload</i>	<i>prestige and income</i>	<i>well-regulated life</i>	<i>demonstration of one's full ability</i>	<i>vocational indecision</i>	Cases	Instances (ratios)
1	1	1	1	0	173	106(0.61)
0	1	0	1	0	82	42(0.51)
1	1	0	1	0	72	46(0.64)
0	1	1	1	0	49	25(0.51)
0	0	0	1	0	17	9(0.53)
1	0	0	1	1	9	8(0.89)
1	1	1	0	1	8	7(0.88)
1	0	1	1	0	7	3(0.43)
0	0	1	1	1	4	3(0.75)
1	1	0	0	0	3	2(0.67)
0	0	0	0	0	2	0(0.00)
1	0	1	0	0	2	1(0.5)
0	1	1	0	1	1	1(1.00)

3.2.2. Motives for going to college

(1) Factor analysis

A factor analysis was done for the 26 items. Six factors with eigenvalues over 1.0 were identified. A varimax rotation was performed for the six factors, the results of which are shown in Table 7. The items with an absolute factor loading greater than 0.48 are combined and framed.

In consideration of items for each factors, we named six factors "motive to enjoy life," "motive to study and to acquire expert knowledge, techniques, and qualifications," "moratorium motive," "motive to use academic background for future career," "recommendation by parents or teachers, and consideration to family," and "motive to be free and independent," respectively.

(2) Boolean analysis

We regard the obtained six factors as six logical variables, *enjoy life*, *study*, *moratorium*, *for future career*, *for family and teachers*, *free and independent*, and we get the following minimized algebraic equation :

$$\begin{aligned}
 & \text{vocational indecision} \\
 = & \sim \text{for family and teachers} \\
 & \cdot \sim \text{free and independent} \\
 + & \sim \text{moratorium} \cdot \sim \text{free and independent} \\
 + & \sim \text{study} \cdot \sim \text{for future career} \\
 & \cdot \sim \text{free and independent} \\
 + & \text{enjoy life} \cdot \text{study} \cdot \text{for future career} \\
 + & \text{enjoy life} \cdot \text{for future career} \\
 & \cdot \text{for family and teachers} \\
 + & \text{enjoy life} \cdot \text{moratorium} \\
 & \cdot \sim \text{for future career} \\
 & \cdot \sim \text{for family and teachers} \\
 + & \text{enjoy life} \cdot \text{study} \cdot \text{moratorium}
 \end{aligned}$$

Table 7 Factor loadings

Item	Factor 1 : Motive to enjoy life	Factor 2 : Motive to study and to acquire expert knowledge, techniques, and qualifi- cations	Factor 3 : Moratorium motive	Factor 4 : Motive to use aca- demic background for future career	Factor 5 : Recommen- dation by parents or teachers, and consid- eration to family	Factor 6 : Motive to be free and independ- ent
16. Wants to enjoy life	0.77	0.09	0.13	0.14	-0.09	0.13
13. Yearns for college life	0.76	0.17	0.13	0.09	0.19	0.00
14. Wants free time	0.74	0.02	0.21	0.04	0.02	0.14
12. Wants to be able to associate with many people	0.71	0.26	0.00	0.10	0.22	-0.02
17. Wants to play around	0.64	-0.22	0.40	0.13	0.05	0.19
21. Wants to feel free	0.62	-0.05	0.36	-0.05	0.07	0.26
10. Wants to continue to study	-0.05	0.77	-0.15	-0.01	0.00	-0.10
11. Wants to fulfill possibilites	0.29	0.69	-0.06	0.03	0.08	-0.07
18. Wants to acquire expert knowledge and techniques	-0.14	0.68	-0.05	0.17	-0.22	0.04
22. Wants to enhance the level of general culture	0.29	0.67	0.01	0.08	-0.07	0.00
24. Wants to enhance the characteristics and qualities of self	0.12	0.64	-0.06	0.12	0.00	0.31
25. Wants to obtain qualifications and liscenses	0.06	0.48	0.11	0.21	0.01	0.31
3. Does not want to go out into the world	0.14	-0.04	0.86	0.01	0.10	0.03
19. Does not want to work yet	0.28	0.02	0.81	0.06	0.08	0.00
4. Current fashion	0.09	-0.19	0.63	0.26	0.19	0.12
20. Friends and acquaintances will go on to colleges	0.26	-0.19	0.51	0.21	0.36	-0.04
5. Is advantageous for future career	0.12	0.14	0.20	0.77	0.05	0.02
2. Wants to get a job in a first-rate company	0.07	0.03	0.02	0.72	0.22	0.12
26. Need for future career	0.01	0.37	-0.06	0.63	-0.06	-0.08
15. Wants to live well in the future	0.18	-0.02	0.11	0.63	0.01	0.46
7. Because it is recommended by teachers	0.02	-0.05	0.12	-0.06	0.77	0.22
1. Because it is recommended by parents	0.05	-0.08	0.18	0.16	0.71	-0.04
23. To set parents' heart to rest	0.28	0.11	0.17	0.23	0.53	0.10
6. Wants to be respected	0.34	-0.09	0.20	0.43	0.49	-0.03
9. Wants to become independent	0.12	0.09	-0.04	0.05	0.00	0.77
8. Wants to make money and to spend it freely	0.17	-0.06	0.13	0.10	0.21	0.74
Eigenvalue	3.71	3.06	2.65	2.45	2.05	1.80
Contribution ratio (%)	14.26	11.77	10.18	9.42	7.90	6.92
Cumulative contribution ratio (%)	14.26	26.03	36.21	45.62	53.53	60.45

· for family and teacher.

This equation suggests that when \sim free and independent is combined with other causal conditions, or when enjoy life is combined with other causal conditions, students' vocational indecision problems should be caused

4 . Conclusion

Different causal conditions often combine in specific configurations to produce particular qualitative outcome in human behavior. Therefore, in order to identify the relations between the causal variables and the outcome variables, Ragin (1987) formulated Boolean analysis as Qualitative Comparative Analysis in social sciences.

We tried to apply Boolean analysis to vocational indecision problems in college students. Vocational indecision has been studied and discussed by developing and using various vocational indecision scales. However, the present Boolean analyses revealed that vocational indecision in college students could be also associated with their motives for entering a college and vocational motives. On the basis of the findings, we will develop effective career guidance and counseling for college students who have difficulty in career decision making.

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