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# Toward a General Approach to International Comparison of Time Use Data: Canadian White-collar Workers and Japanese White-collar Workers*

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## 1. Introduction

Activity rates matrix of time use is comprised of data that describe how many percentages of persons are engaged in what kinds of activities at every time slot in a single day. These data have been relatively neglected in time use studies, although they contain much valuable information. One of the authors, Fujiwara, has been engaged in developing a series of analytical method to dig up their information as far as possible. He calls this approach 'activity rates approach.' On the other hand, he names the conventional approach 'average hours approach', because it has been examining the average duration of activities as units of analysis.

This paper aims at applying the activity rates approach to a pair of activity rates matrices of full-time Canadian and Japanese male white-collar workers, and obtaining fact findings from our approach to international time use data. This paper will also try to establish a general approach to international comparison of time use data, and aims at contributing to the growing concerns of comparative studies of time use across countries, as national time use surveys are increasing in their number these days.

For our international comparison, we arranged the shape of matrices of both countries, so that they can be compared. The shape of each activity rates matrix is $20 \times 48$. The row vector shows the rates of people's participation in a specific activity along 48 time slots of a day.

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The column vector represents the rate of people's participation in 20 kinds of activities.

## 2. Research Data for Analysis

We are using Canadian and Japanese data for our international comparison of time use data. Let us explain both surveys respectively. Then, we show the feature of our white-collar workers data.

(1) Outline of the 1992 Canadian survey

This research uses the data of the seventh cycle of the 1992 General Social Survey conducted by Statistics Canada. The outline of this survey is as follows.

[Survey sample]

National sample. The target population for this survey was all persons of 15 years and over in Canada. The survey employed Random Digit Dialling. A stratified sampling method was adopted. The sample consisted of 12,765 households. A response was obtained from 9,815 of the selected households, yielding a 77% response rate.

[Survey date]

From January through December 1992.

[Method of the survey]

Telephone survey.

[Classification of activities]

After-coded diary method was used. Three-digit daily activities code was used.

[Weighting]

Weighted data were used.

(2) Outline of the 1991 Japanese survey

This research uses the data of 1991 Survey on Time Use and Leisure Activities conducted by Statistics Bureau, Management and Coordination Agency Japan. The outline of this survey is as follows.

[Survey sample]

National sample. This survey investigated members of the households of 15 years and over. A stratified two-stage sampling method was adopted. About 250,000 persons in about 99,000 households were surveyed.

[Survey date]

Two straight days within the nine-day period from September 28 to October 6 were designated for each enumeration district.

[Method of the survey]

Preceding the survey date, the enumerator visited the selected households to distribute questionnaires. After the survey date, the enumerator visited the households again to collect the filled-in questionnaires.

[Classification of activities]

Pre-coded diary method was used. Daily activities were classified into the 20 categories, which are grouped into three broad groups, called primary activity (personal care), secondary

activity (work (both paid work and housework)) and tertiary activity (free time).

[Weighting]

Weighted data were used.

(3) The characteristics of data employed for our analysis

1) Attributes of white-collar workers to be analyzed

Married male full-time white-collar workers were selected from the total sample for the analysis. Data of workdays on weekdays, on which the amount of paid work was not zero, were analyzed. Table 1 shows the percentage distributions of occupation among selected white-collar workers in Canada 1992 and Japan 1991. There is a higher proportion of managers and officials in Canada and a higher proportion of clerical and related workers in Japan.

Table 1 Percentage distributions of occupation

| | Canada | Japan |
|---|---|---|
| Professional and technical workers | 31.7% | 28.6% |
| Managers and officials | 32.0 | 12.8 |
| Clerical and related workers | 18.2 | 36.7 |
| Sales workers | 18.1 | 21.9 |
| Total | 100.0 | 100.0 |
| N: weighted | 1338372 | 8659753 |
| N: unweighted | 471 | 13360 |

Canada: The General Social Survey-Cycle 7 Time Use (1992)
Japan: Survey on Time Use and Leisure Activities (1991)

2) Time slots

Activity rates of each activity were calculated for 48 time slots of a day at thirty-minute intervals.

3) Classification of activities

We adopt the existing 20 categories of Japanese time use survey for our comparative study. Therefore, we arrange the categories of Canadian time use survey so that comparison can be made with each other. Twenty categories and alphabetical letters, which are used in this paper for indicating each activity, are as follows.

1 S : Sleep
2 C : Personal care
3 E : Meals
4 M: Commuting to and from school or work
5 J : Work (paid work)
6 G : Schoolwork
7 H : Housekeeping
8 N : Nursing
9 I : Child care

10 B : Shopping
11 D : Moving (excluding commuting)
12 T : TV, radio, newspaper and magaziens
13 R : Rest and relaxation
14 O : Studies and researches (excluding schoolwork)
15 L : Hobbies and amusement
16 P : Sports
17 A : Social activities
18 K : Social life
19 X : Medical examination or treatment
20 Z : Other activities

These twenty categories are grouped into three broad groups.

Primary activity (personal care) 1-3
Secondary activity (work (both paid work and housework)) 4-10
Tertiary activity (free time) 11-20

(4) Time use of white-collar workers from the perspective of average hours approach

Though this research focuses on activity rates of white-collar workers in Canada and Japan, we would like to examine their time use from the point of view of average hours approach. Table 2 shows time use of white-collar workers on workdays on weekdays in 20 activities and three broad groups in Canada 1992 and Japan 1991.

Japanese white-collar workers spent time on primary activity about 20 minutes longer than Canadian counterparts. Almost the same time was spent on secondary activity in both countries. However, time spent on paid work and commuting was longer in Japan and time spent

Table 2 Time spent on 20 activities and three broad areas in Canada and Japan (white-collar workers on workdays on weekdays, in minutes)

| | Sleep | Personal care | Meals | Commuting to and from school or work | Work | Schoolwork | House-keeping | nursing |
|---|---|---|---|---|---|---|---|---|
| Canada | 428 | 42 | 81 | 52 | 524 | 1 | 43 | 1 |
| Japan | 435 | 52 | 86 | 85 | 562 | 0 | 3 | 0 |
| | Child care | Shopping | Moving (excluding commuting) | TV, radio newspaper, magazines | Rest and relaxation | Studies and researches (excluding schoolwork) | Hobbies and amusements | Sports |
| Canada | 22 | 9 | 29 | 100 | 22 | 2 | 27 | 15 |
| Japan | 2 | 2 | 15 | 90 | 51 | 7 | 13 | 4 |
| | Social activities | Social life | Medical examination or treatment | Other activities | Primary activity | Secondary activity | of which Housework | Tertiary activity |
| Canada | 13 | 28 | 1 | 0 | 551 | 652 | 75 | 238 |
| Japan | 3 | 26 | 2 | 3 | 573 | 654 | 7 | 213 |

Canada: The General Social Survey-Cycle 7 Time Use (1992)
Japan: Survey on Time Use and Leisure Activities (1991)

on housework was longer in Canada. They are offset by each other. The difference of each work between Canada and Japan was about seventy minutes. Canadian white-collar workers had 25 minutes longer free time (time spent on tertiary activity) than Japanese counterparts. Comparing the durations of each free time activity, Canadian white-collar workers spent more time on many free time activities. In both countries, white-collar workers spent the largest amount of time on TV, radio, newspaper and magazines.

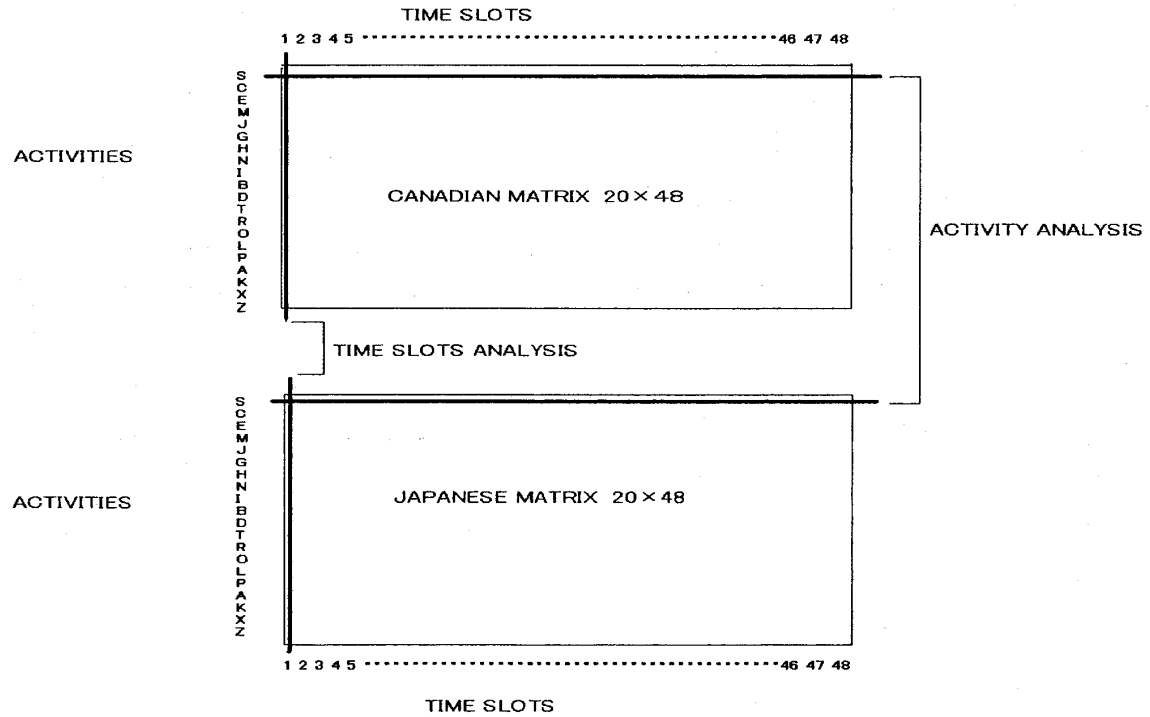
## 3. The Outline of General Approach

Figure 1 is drawn for showing the outline of our analysis. The target of our analysis is the comparison between Canadian white-collar workers with Japanese ones. The matrices of both countries are expressed respectively in a pair of rectangles. Referring to Figure 1, let us explain the outline of our general approach.

The activity rates analysis comprises of two sub-analyses. The first one is activity analysis, and the second one is time slot analysis. Through the activity analysis, we attempt to compair the difference between a pair of the same row vectors of two countries. The row vector represents the activity rates showing the sequence of a distinctive activity of a day. On the other hand, the time slot analysis is conducted for the comparison between a pair of the same column of both countries. The column vector shows respectively the activity rates of 20 activities at a distinctive time slot of a day.

The activity analysis is aiming at judging the extent of similarity of each activity of both countries. The activities comprise twenty categories of activities, ranging from sleep(S), personal care(C), meals(E), commuting(M), work(J) to the last 'residual activity'(Z). The concept

Figure 1 General analytical frame of activity rates analysis



of analysis is to judge whether the rhythm of a distinctive activity is similar or not. We could examine the similarity of sleep style, personal care style, meal style, commuting style, work style, and others one by one. The twenty life styles constitute the so-called 'life style' in our time use study.

The time slots analysis purports to test the similarity of activities of each time slot between both countries. The analytical concept is to judge how many percentages of persons do the same activities or do the different activities at the same time slot between two countries. We are making this analysis across 48 time slots one by one. Through these analyses, we can judge which time slots have similarity to each other between countries.

## 4. The Activity Analysis

In most time use studies, we draw a step chart to illustrate a series of activity rates data of a day. But, we use instead a line graph for the explanation, as is shown in Figure 2. We make use of the length of 48 activity rates data.

In the below, we try to examine the way of discerning the similarity or dissimilarity between a pair of line graphs that chart activity rates of every time slot of a day. Our activity analysis can be divided into 'shape of graph analysis' and 'height of graph analysis'. We explain them respectively.

(1) Shape of graph analysis and its use

A pair of line graphs is drawn for analyzing the similarity of work style of Canadian and Japanese white-collars.

When one of the slops of a line graph is ascending, we put a positive sign on it. On the contrary, if another slope is descending, a negative sign is put on it. And, in a case of a flat slope, a sign of 0 is given to it.

A basic idea of analysis is that, as long as a sign of the graph of Japan at a point shows the same as that of the graph of Canada, we regard it as a similar move or truth. On the other hand, when it has a different sign, we judge that it has a different move or false. Some logical rules of product between a sign of Canadian graph and that of Japanese one are shown in the note of the Figure 2.

Let us suppose three different extreme cases. If a pair of line graphs show completely the same sign at every slope, the total number of T (truth) is 47. On the other hand, if they show a different sign in every slope, the total number of F(false) shows 47. And, when they have no relation at all, on half of products is T, and another half of products is F.

Then, we propose the use of a Chi-square test to examine the relation of Japanese graph and Canadian graph. Here, we set the following null hypothesis.

Null hypothesis: the wave motion of Canadian graph and that of Japanese graph have no relation at all.

As is clear, the general formula for Chi-square is following.

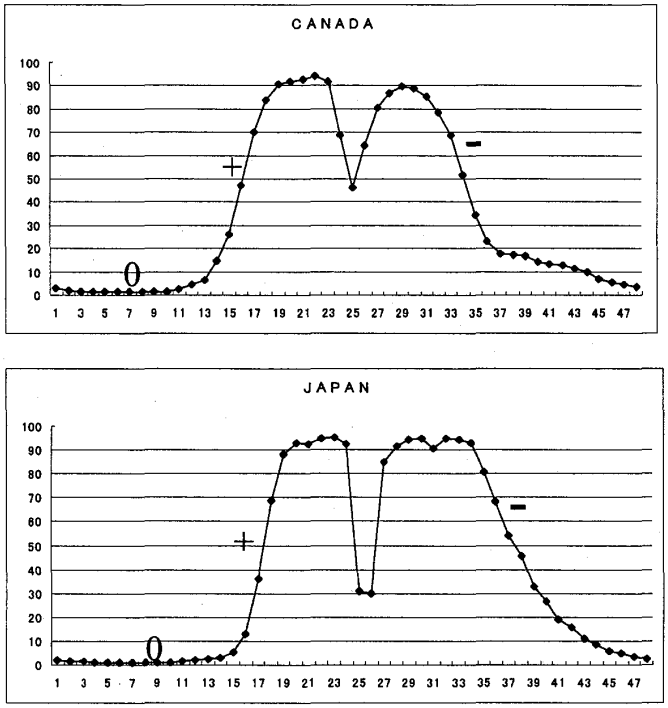
$$x^2 = \sum_{i=1}^{n} \frac{(O-E)^2}{E}$$

In the formula, n is the number of cells in the table, O is the observed frequency in each cell, and E is the expected frequency in each cell.

In our case, we have two cells, namely, a cell of T sign and a cell of F sign, shown in Table 2. The degree of freedom is 1.

$$x^2=\frac{(\text{frequency of T}-\text{E})^2}{\text{E}}+\frac{(\text{frequency of F}-\text{E})^2}{\text{E}}$$

Figure 2 The comparison of work style between Canadian white-collars and Japanese ones




| SLOPE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CANADA | - | - | + | - | - | 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | - | - | - |
| JAPAN | - | - | - | - | - | + | + | 0 | + | + | + | + | + | + | + | + | + | + | + | - | + | + | - | - |
| PRODUCT | T | T | F | T | T | F | T | F | T | T | T | T | T | T | T | T | T | T | T | F | T | F | T | T |
| SLOPE | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | |
| CANADA | + | + | + | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| JAPAN | - | + | + | + | + | - | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| PRODUCT | F | T | T | T | F | T | F | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | |

Notes: Products of this third raw are following the rule listed below.

1. If two signs are positive or negative at the same time slot, their product is T.
   (1) + and + --> T (2) - and - --> T
2. If one is positive and the other is negative, their product is F.
   + and - --> F
3. If two signs are zero, their product is T, because they can regarded as showing the same move.
   0 and 0 --> T
4. If one is zero and the other is positive or negative, their product is F, because they show a different move.
   (1) 0 and + --> F (2) 0 and - --> F

Following our null hypothesis, the frequency of T and that of F are expected to show the same frequency. The expected frequency is 23.5, because it is a half of the total frequency 47.

Table 3 Summary of products of Figure 2

| Category of sign | T(Truth) | F(Faulth) |
|---|---|---|
| Frequency | 39 | 8 |

As is shown in the Table 3, the frequency of T is 39, that of F is 8. Accordingly, the process and result of calculation is as follows.

$$x^2=\frac{(39-23.5)^2}{23.5}+\frac{(8-23.5)^2}{23.5}=20.45$$

$$\phi = 1$$

The critical value of 5% is 3.84 in case of one degree of freedom. If our Chi-square value is at or beyond 3.84, our null hypothesis can be rejected. Its value shows 20.45 and beyond 3.84. Therefore, we can conclude that our null hypothesis can not be supported, and that the shape of Canadian graph and that of the Japanese one show the similarity to each other. As far as shape of wave analysis is concerned, we can find that the work styles of Canadian and Japanese white-collar workers have similarity to each other.

(2) Height of graph analysis

1) Necessity of height of graph analysis

Look at another example. The Figure 3 shows another pair of graphs. Graph A is the same as the Graph of Canada. Graph B is charted by one half of the activity rates of Graph A. The wave motion of Graph A is the same as that of Graph B.

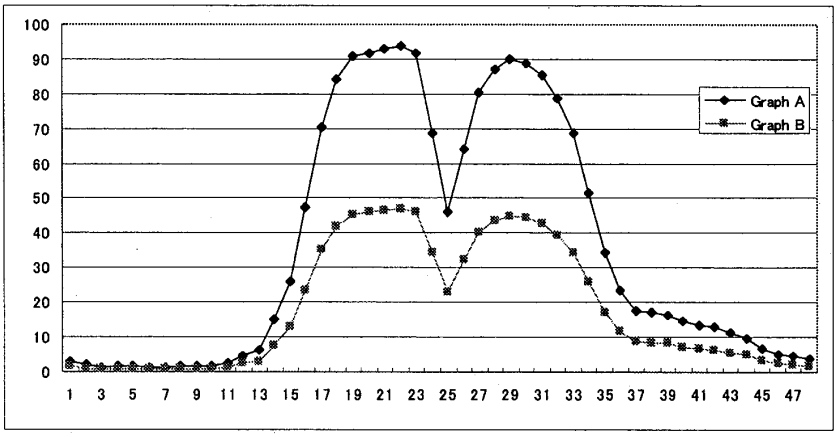
As is clear in Figure 3, a pair of signs at every slope can be judged to have the same sign at every slope (See the bottom of Figure 3). Accordingly, all of their product show T signs, and the total number of T signs are 47 (See Figure 3).

Chi-square value is calculated in the following formula.

$$x^2=\frac{(47-23.5)^2}{23.5}+\frac{(0-23.5)^2}{23.5}=47$$

$$\phi = 1$$

Figure 3 The height of graph analysis




| SLOPE | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Graph A | − | − | + | − | − | 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | − | − | − |
| Graph B | − | − | + | − | − | 0 | + | + | + | + | + | + | + | + | + | + | + | + | + | + | + | − | − | − |
| PRODUCT | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T |
| | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | |
| | + | + | + | + | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | |
| | + | + | + | + | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | − | |
| | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | T | |

In this case also, we the following null hypothesis as before.

Null hypothesis: the wave motion of Graph A and that of Graph B have no relation at all.

Chi-square value shows the maximum value of 47. This is far beyond 3.84 in case of critical value of 5 percent. We can conclude that our null hypothesis cannot be supported.

Let us think for a while. As for the shape of wave, Graph A and Graph B show the biggest similarity. But, when we turn to the height of wave, namely, the value of activity rates of Graph A and Graph B at every time slot, it is quite clear that there is a big difference between them. Through this case, it is apparent that we should also pay attention to the variance of activity rates for examining the similarity of a pair of line graphs.

Here, we introduce a F-test into height of graph analysis. We divide the bigger one of the two variance estimates by the other smaller one to obtain the F-value. Accordingly, we have only to look into the critical value of 2.5 percent under a two-tailed test. The length of vector of Graph A and Graph B is respectively 48. Accordingly, both have a degree of freedom of 47.

The critical value of 2.5 percent under the two-tailed test is 1.78, approximately 1.8.

$F_{47}\,47\ (0.025) = 1.78$

If the F-value surpasses the critical value(1.8) of in the F-table, we can conclude that their variance estimates differ significantly. On the contrary, we can suppose that the closer the F-value is to 1, the more similar a pair of graphs are.

The variance estimate of activity rates of Graph A($=V_1$) is 1282.96, while that of Graph B($=V_2$) is 320.74.

$$V_1=\frac{60299.10}{48-1}=1282.96$$

$$V_2=\frac{15074.77}{48-1}=320.74$$

Here, let us calculate the F-value(F-ratio) with $V_1$ as numerator, and $V_2$ as denominator. The length of vector data of Graph A and that of Graph B is respectively 48. Accordingly, both have respectively a degree of freedom of 47.

We set the following hypothesis.

Hypothesis: Sample $V_1$ and $V_2$ are extracted from the same population.

$$F=\frac{\frac{V_1}{\sigma_1}}{\frac{V_2}{\sigma_2}}$$

As we take as the hypothesis that the population of $V_1$ and that of population $V_2$ are the same, we can set as follows.

$$\sigma_1=\sigma_2$$

Therefore,

$$F=\frac{V_1}{V_2}=\frac{1282.96}{320.74}=4$$

Our F-value is 4, and it is beyond the critical value 1.8. Therefore, we can judge that our hypothesis can not be verified. This is why the similarity of Graph A and Graph B can not be verified.

As for the relation between Graph A and Graph B, through Chi-square test, we could deny our null hypothesis, and through F-test, we concluded that our samples are not excluded from the same population. In sum, although Chi-square test verifies the similarity of wave motion of two graphs, F-test denies their similarity. Therefore, we may conclude that there exists no similarity between them.

From the explanation so far, it becomes clear why we need not only the shape of wave analysis but also the height of wave analysis in making activity analysis.

2) Applying the height of graph analysis to the examination of work styles of Canadian and Japanese white-collar workers

Let us calculate the F-value of between Canadian and Japanese white-collar workers. The variance estimates of activity rates of $V_1$ (Japan) and $V_2$ (Canada) are as follows.

$$V_1=\frac{73297.35}{48-1}=1559.52$$

$$V_2=\frac{60299.10}{48-1}=1282.6$$

The F-value of between Canadian and Japanese white-collar workers is as follows.

$$F=\frac{V_1}{V_2}=\frac{1559.52}{1282.6}=1.22$$

Let us compare the F-value with the concerning critical value.

$F_{47}47\ (0.025)\ =1.78$

It is clear that the F-value(1.22) is under the critical value 1.78. Accordingly, through our height of wave analysis, we can find that a pair of Canadian and Japanese graphs have verified similarity.

In short, not only the shape of wave analysis, but also the height of wave analysis respectively verified the similarities between the work style of Canadian white-collar workers and that of Japanese ones. Accordingly, we may conclude that there exists a similarity of work style between Canadian white-collar workers and Japanese ones.

(3) Applying activity approach to Canadian and Japanese data and its findings

So far we have outlined the analytical logic of activity analysis. We have explained the way how the shape of wave analysis and the height of wave analysis should be made. Through our discussions, we could conclude the similarity between a pair of graphs showing a particular kind of activity exists, on condition that both the shape of wave analysis and the height of analysis provide could verify the similarity between them.

1) Examination of results of activity approach

With these conditions in analysis, we tried to verify the similarity of various activities one by one. Figure 4 is the results of our similarity test across various activities between the Canadian white-collar workers and the Japanese ones.

As is explained, two conditions must be satisfied to ascertain the similarity of a pair of activity rates graphs. Concretely, as long as the Chi-square value is beyond the critical point 3.84, and the F-value is within the range from 1 to 1.78, we can regard them similar to each other.

Looking at the Figure 4 closely, we can find J (paid work), T (TV, Radio, Newspaper, and Magazines), S (Sleep), E (Meals), and C (Personal care) within the range, and judge that each activity has similarity between Canada and Japan.

Outside these specific activities, the broad categories like 1 (primary activity), 2 (secondary activity), and 3 (tertiary activity) are also within the verified range similarity. This shows that once grouped into the biggest categories, all of them come to have similarity between countries. Above all, the primary activity shows the highest similarity of all broad categories and activities, because all its sub-activities like S, E, and C are within the verified range of similarity.

Table 4 is shown for explaining the fact-findings obtained through Figure 4. You can instantly grasp the logical structure of verification of similarity through it. Then, you can understand why some activities are adopted as ones having similarity, and others are discarded.

2) The findings obtained through activity analysis

Through Figure 4 and Table 4, we can obtain the following fact-findings about the time

Figure 4 The results of shape of graph analysis and height of graph analysis

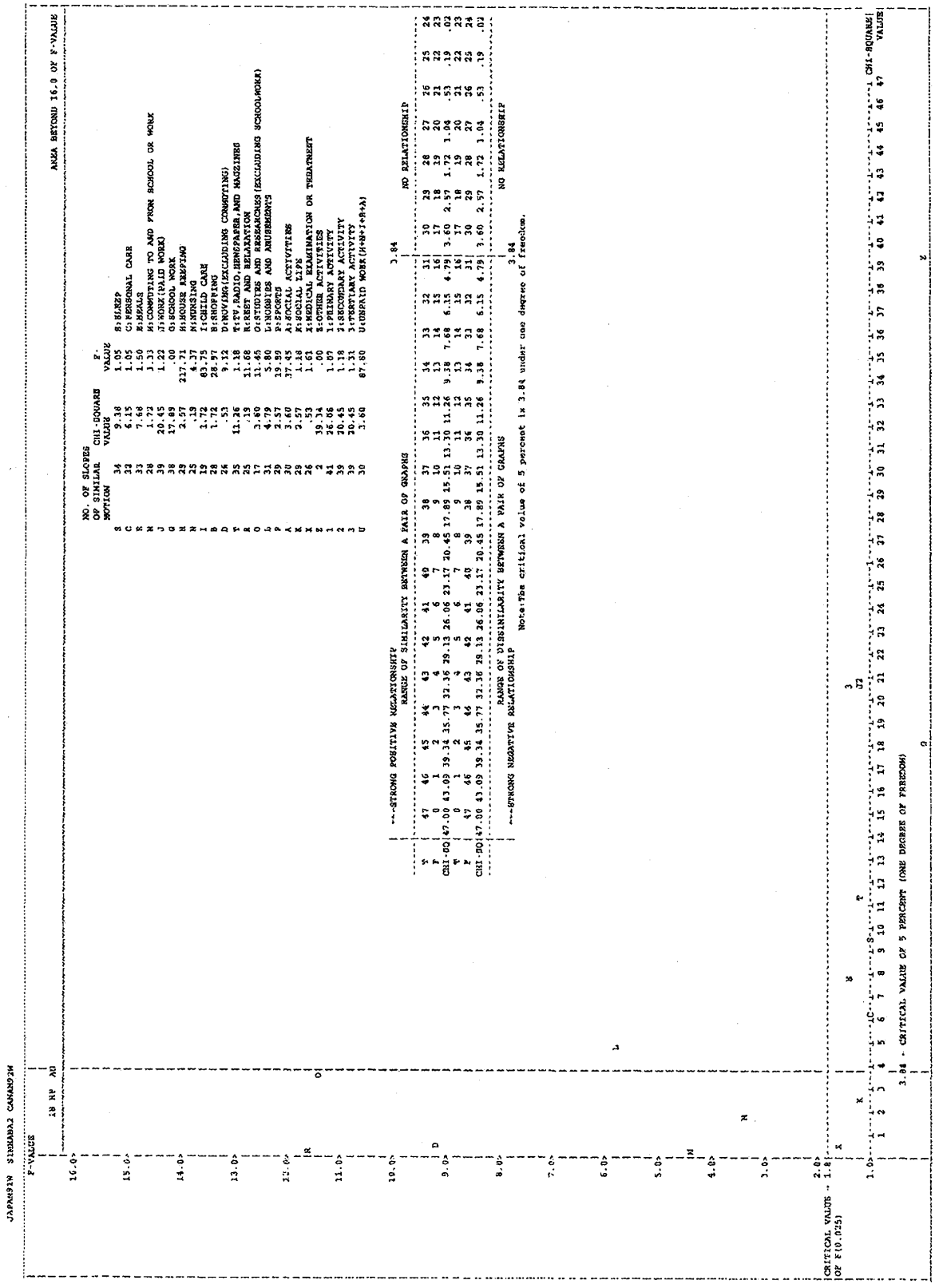


Table 4 The results of shape of wave analysis and height of wave analysis

| | | | Shape of graph Analysis Chi-square Test | |
|---|---|---|---|---|
| | | | Hypothesis The wave motion of Graph J and that of Graph C have no relation at all. | |
| | | | Yes (Chi-square value<3.84) | No (3.84≦Chi-square value≦47) |
| Height of graph Analysis F-test | Sample $V_1$ and $V_2$ are extracted from the same population | No (F-value≧1.78) | Dissimilarity O,M,N,O,D,R,A,U,P,H,B,I | Dissimilarity L |
| | | Yes (1≦F-value<1.78) | Dissimilarity X<K | Similarity C<E<S<T<J 3<2<1 |

use of Canadian and Japanese male white-collar workers.

1. As for the primary activities such as sleep, meals, and personal care, they have a similar style.
2. As for the paid work, one of representative secondary activities, they show a similar style.
3. As for the activities such as TV watching, Radio listening, Newspaper, and Magazines reading, one of representative tertiary activities, they have a similar style.
4. As for the residual activities except the main activities listed above, they do not show a similar style.

As the standard rules of working conditions are prevailing in the world labor market, and the competitions for higher audience share are heating up at golden hours among broadcasting companies, the work style and/or the TV watching style of people might become more similar or converged in our advanced industrialized countries. We have also to ask if the life style of people in the industrialized societies become converged or diverged also in time use study.

## 5. Time Slots Analysis

(1) Procedures of time slots analysis

Let us explain the procedures of time slots analysis using a Matrix Canada and a Matrix Japan. The shape of each matrix is 20 rows and 48 columns.

a. Making a minimum matrix from Matrix Canada and Matrix Japan.

The minimum matrix(MM) is defined as a matrix that is made from the smaller elements of Matrix Canada(MC) and Matrix Japan(MJ). The shape of MM is 20×48.

$MM_{ij} = \min[MC_{ij}, MJ_{ij}] \qquad 1 \leq i \leq 20, \ 1 \leq j \leq 48$

b. Adding the column vectors of MM, and dividing them by the sum of the column vector of MC or MJ.

In this case, we suppose that the sum of column data of MC and MJ is respectively 100%. The length of the ratio column vector of MM is 48.

$$\text{Ratio of column vectors of MM}(\%) = \left(\frac{\sum_{i=1}^{20} MM_{ij}}{\sum_{i=1}^{20} MC_{ij}}\right) \times 100 = \left(\frac{\sum_{i=1}^{20} MM_{ij}}{\sum_{i=1}^{20} MJ_{ij}}\right) \times 100$$

$$1 \leqq J \leqq 48$$

In this case, we suppose the following condition.

$$\sum_{i=1}^{20} MC_{ij} = \sum_{i=1}^{20} MJ_{ij} = 100\%$$

The ratio of column vector shows how many percentages of persons do the same activities at the same time slot between two countries regardless of their nationality. Put simply, we call this the size of similarity.

Figure 5 is the result of time slot analysis. As is explained, each value shows the size of similarity at every time slot. We can see the size of similarity changes for 48 time slots of a day.

(2)Testing the similarity of activities of time slots

Then, we try to verify the similarity of activities between Canadian white-collars and Japanese ones. As is in the case of shape of graph analysis, we apply Chi-square test to them.

We set the following null hypothesis.

Null hypothesis: The kinds of activities of Canadian and Japanese male workers at each time slot have no relation at all.

Put differently, Canadian and Japanese white collar workers are engaged in quite different activities at every time slot.

The expected frequency of participation of Canadian and Japanese workers in the same kinds of activities at each time slot is 50%, because it has a half of the total frequency 100%. The critical value 5% and 1% is respectively 3.84 and 6.63 under one degree of freedom.

$$x^2 = \frac{(O_s - E)^2}{E} + \frac{(O_d - E)^2}{E} = \frac{(O_s - 50)^2}{50} + \frac{(O_d - 50)^2}{50} \qquad \phi = 1$$

$O_s$ : the size of similarity(%) = the ratio of collumn vector of MM(%) at a time slot

$O_d$ : the size of dissimilarity(%) = 100% − the ratio of column vector of MM(%) at a time slot

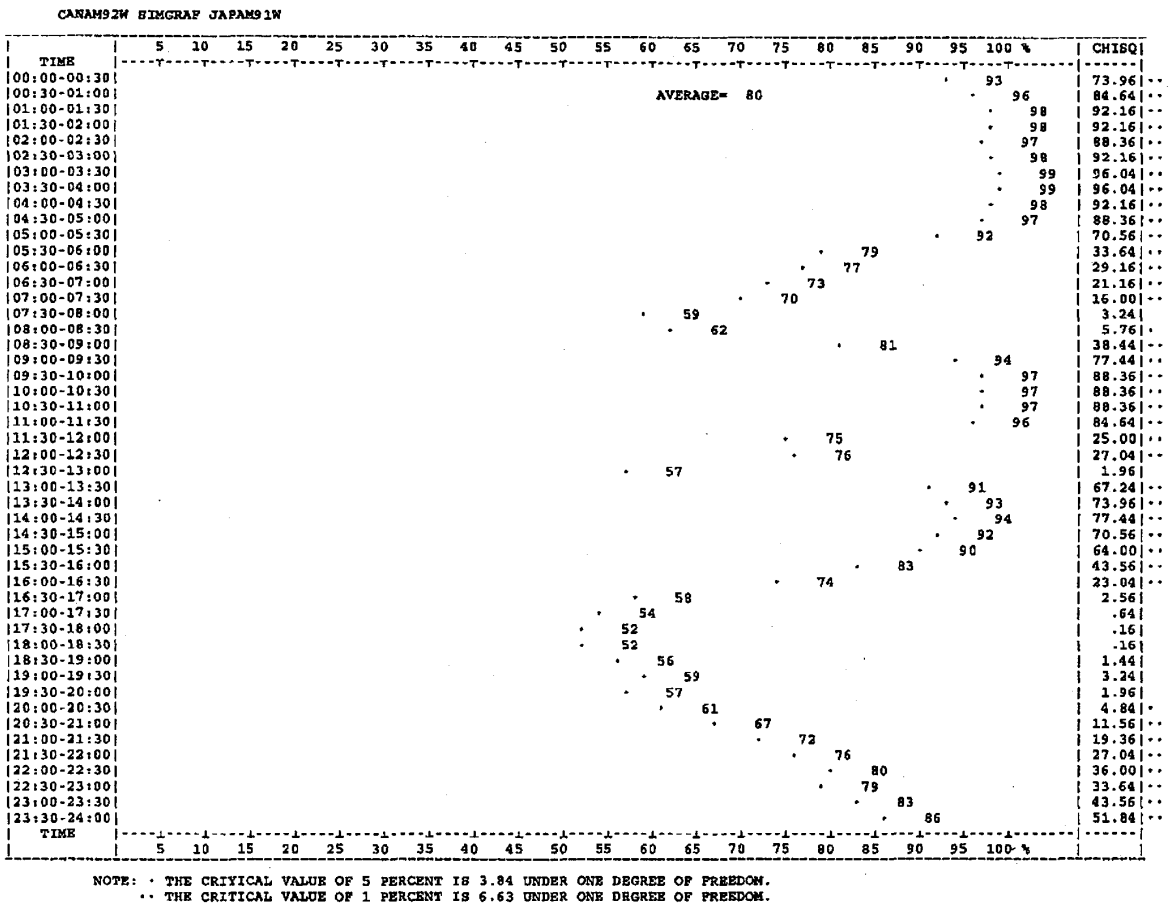
E : the expected frequency of the participation of each workers in the same kinds of activities = 50%

(3)The findings obtained through time slots analysis

In Figure 5, we can see not only the size of similarity, but also the Chi-square value at every time slot.

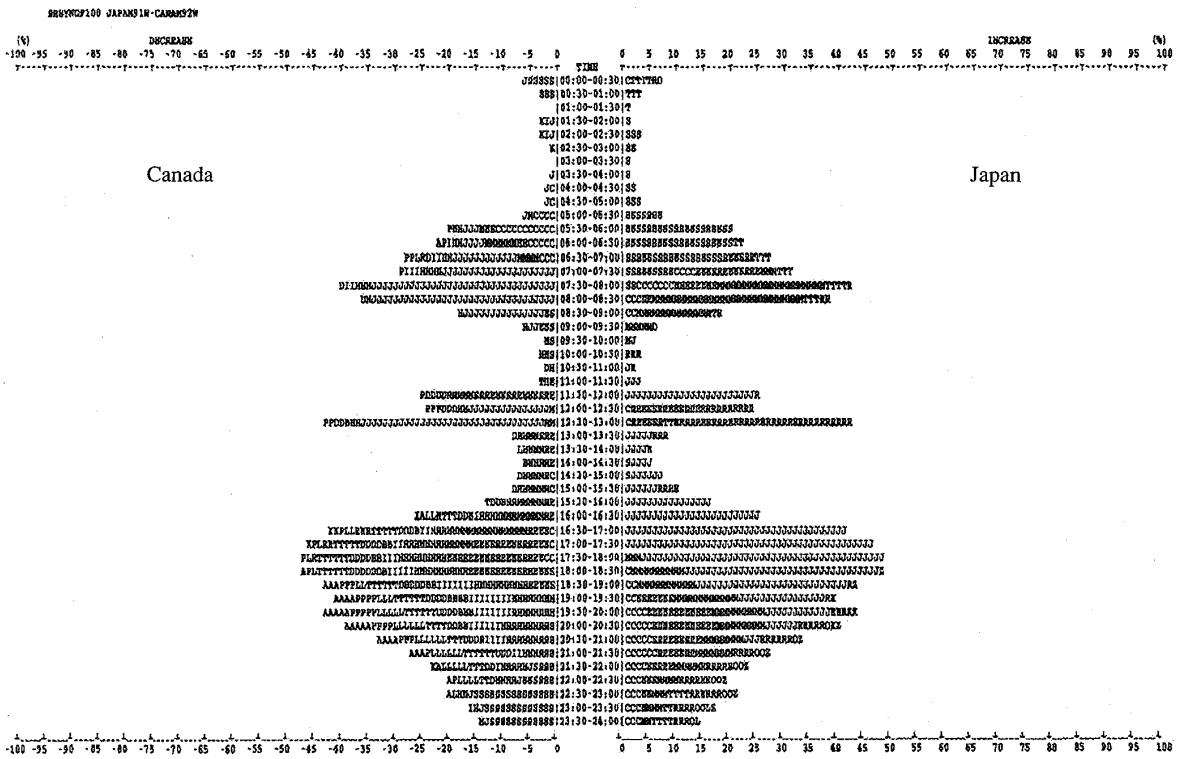
Looking at the Chi-square values, we can find that many verified similarities are prevailing at the time slots in the daytime and nighttime. Let us sum up the findings obtained through Figure 5.

Figure 5 The results of time slots analysis




NOTE: * THE CRIYICAL VALUE OF 5 PERCENT IS 3.84 UNDER ONE DEGREE OF FREEDOM.
** THE CRITICAL VALUE OF 1 PERCENT IS 6.63 UNDER ONE DEGREE OF FREEDOM.

Figure 6 Contents of dissimilar activities between Canada and Japan



1. Much similarities are found in daytime and night time between Canada and Japan.

This finding is consistent with the facts found in the activity analysis, because the activities made mainly in nighttime such as sleeping and TV watching are verified as having similarity.

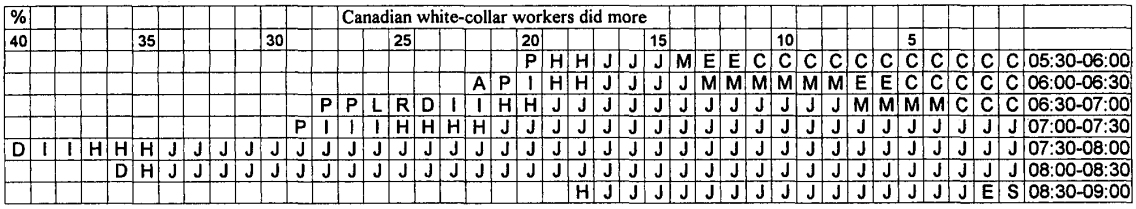
2. Dissimilarities are found early in the morning and in the evening.

Let us look at the contents of dissimilarities, examining Figure 6.

This figure shows the size and contents of dissimilarities. We can find the size of dissimilarities is large early in the morning and in the evening after work.

To look into the contents of the similarities, we show another enlarged size of letter graphs as is shown in Figure 7 and Figure 8. We can obtain the following findings through looking into them.

Figure 7 The contents of dissimilar activities early in the morning



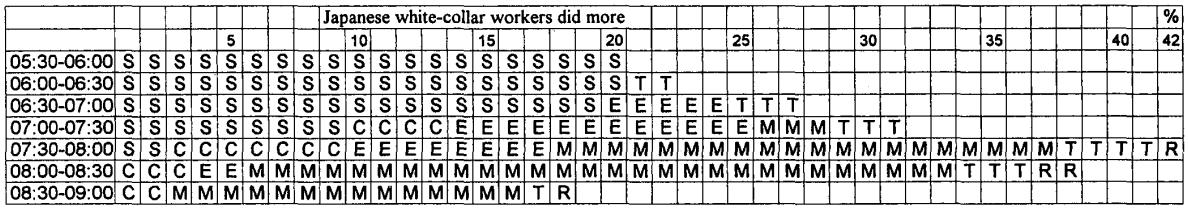
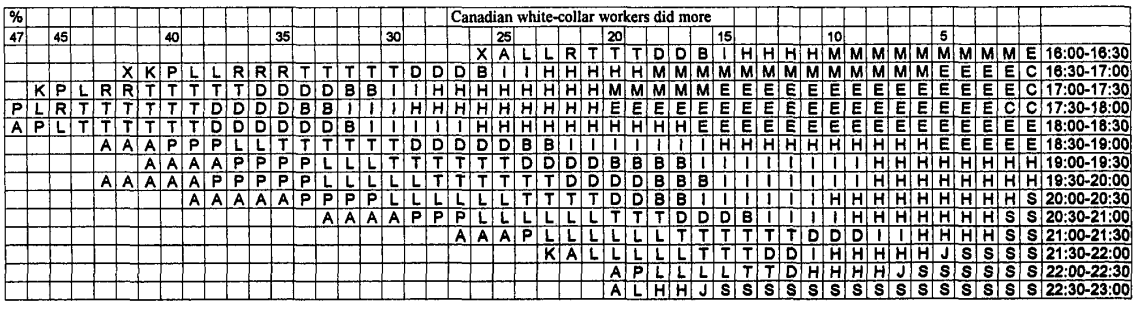
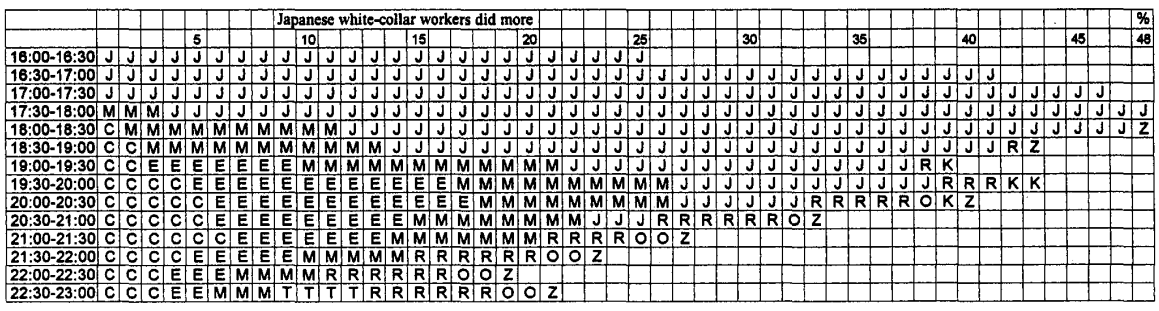




Figure 8 The contents of dissimilar activities in the evening



1. Early in the morning, Canadian workers start their work(J) earlier than Japanese workers.
2. At the time slots when most Canadian workers are working, many Japanese worker are sleeping(S), eating meals(E), and commuting(M).
3. After 16:30 in the evening, most Japanese workers are engaging in their work, while Canadian workers are commuting home, taking dinner, and begin to enjoy hobbies(H), sports(U), watching TV(T), volunteer works(A), and child care(I).
4. After finishing work, Japanese workers are commuting home, taking dinner, having relax and rest time(R), and taking personal care(C).
5. Generally speaking, Canadian white-collar workers are early to bed, early to rise, and early to work, while Japanese workers are late to bed , late to rise, and late to work.

This fact-findings are not contradictory with those obtained through activity analysis, because the activity analysis can only judge and regard some activities as more similar than other activities from the statistical point of view.

## 6. Conclusion

As is shown in this paper, through our activity rates approach, we could obtain many fact-findings that had never been made clear by the conventional average hours approach. The activity rates approach is a promising method for advancing time use studies. We hope this approach could contribute to comparing time use survey data in international level, and become popular time use method.

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