Title: A Software Product for the Pairwise Comparison Method of Judgment Quantification, User Manual

Course:
Year: 1991
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Report No: P91003

Abstract: The pairwise comparison method (PCM) is a technique for turning vague perceptions or impressions into objective values, i.e. normalized weights or a measure of internal discrepancy. This software product performs calculations of (normalized, relative weights, discrepancy, and disagreement), as well as the minimum, maximum, and average relative weights for each item. It is designed to assist in arriving at the highest quality result possible, with computer speed and accuracy.

A Software Product For The Pairwise Comparison Method of Judgement Quantification

USER MANUAL

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EMP-P9103

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User Manual

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Prepared for EMGT 506X

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Introduction

The pairwise comparison method (PCM) is a technique for turning vague perceptions or impressions into objective values, i.e. normalized weights and a measure of internal discrepancy. These values are referred to as weights. The weights can then be used as is (as a measure of subjective probability) or as part of a larger technique, such as Hierarchical Dimensional Modeling. The PCM can be used by a single person or a group of people. When used by a group, the PCM provides a measure of disagreement among the respondents in addition to the measure of discrepancy for each individual. The measures of disagreement and discrepancy can be referred to as measures of quality. Through refinement, a higher quality result is achieved.

To use the PCM, a respondent is asked to compare all items in pairs (hence the name). The respondent is instructed to divide 100 points between the two items being compared, based on his or her feelings about the relative weights of the characteristic or parameter under consideration. For example, if a respondent is asked to compare the likelihood of occurrence (the parameter under consideration) of two events (the items) he or she may feel that the first event is 3 time more likely to occur than the second event. In this case, 75 points would be assigned to event one and 25 points would be assigned to event two. These figures (75 and 25) are the respondent's weights. Note that the total number of points assigned is 100 and that only whole positive numbers are used. The most extreme case of point assignment is 99 to 1, not 100 to 0, as might be expected.

Discrepancy can be thought of as the internal inconsistency which affects the quality of weights. Assume that a respondent is asked to compare 3 lines, labeled A, B, and C. Assume also that he or she says (through assignment of points) that A is twice as long as B, B is twice as long as C, and A is as long as C. In this example, you can see that the respondent's weights are inconsistent. You would have expected that A would be four times longer than C, not the same length. In comparisons with more items to compare and more complicated parameters being considered, it becomes very difficult, if not impossible, to spot inconsistencies. Fortunately, there is a way to determine that inconsistences do exist. The PCM provides a measure of internal inconsistency (discrepancy). While this measure will not indicate where inconsistencies lie, it will give a relative idea of the magnitude of the problem. If the discrepancy of a particular respondent is low, i.e. less than 0.016, you can conclude that the respondent's weights are internally consistent. If the discrepancy is higher you should return to the respondent, explain the problem and ask him or her to refine his or her point assignments. The higher the discrepancy is, the more inconsistent the weights were. This process can be repeated as long as the discrepancy is too high (or until the respondent's patience gives out).

If this technique is used for a group of people, the above process is repeated for each

respondent in the group. In that case, an additional measure of quality is provided. This measure of quality is known as disagreement. This is a measure of how closely members of the group agree with one another's weight assignments. As with discrepancy, lower numbers indicate higher quality weight assignments. If the disagreement is high, once again, go back to the group and ask them to re-evaluate the weights. As before, this is an iterative process that lasts until the disagreement and all discrepancies reflect desired levels.

This software product performs the calculations of the above (normalized, relative weights; discrepancy; and disagreement), as well as the minimum, maximum, and average relative weights for each item. It is designed to assist in arriving at the highest quality result possible, with computer speed and accuracy. Since this is a PC based product, it can be used anywhere there is access to a PC (i.e. IBM PC, IBM-compatible, or PS2). This product allows multiple re-editing, and re-calculating, entering only the information that has changed.

You will find this flexibility especially convenient if the PCM technique is used frequently (such as a consultant might).

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Installation

This product can be used from floppy disks or installed on a fixed (hard) disk. Unless you plan to move your projects to different computers frequently, I recommend that you install it on a fixed disk. The main advantage is that the speed of creating, saving, and recalling projects is much greater on a fixed disk. There are two sets of instructions below. The first set tells you how to install the software on your fixed disk. The second set tells how to create a backup of the software for floppy-based operation.

1. Hard Disk Installation.

This set of instructions assumes that you will place the PCM software source diskette into the 'A' drive on your computer. It also assumes that your hard drive is 'C'. If you are using different drives than those shown, simply change the drive letters in the instructions to match those that your system uses.

- Place the PCM source diskette in drive A and close the door.
- At the DOS prompt, type **C:** and press RETURN.
- Type **MKDIR \PCM** and press RETURN. This will create a directory named 'PCM' to hold the software and the projects that you will create.
- Type **CD \PCM** to go into the new directory.
- Type **COPY A:*.*** to copy the PCM software and its supporting files into the new directory.

The PCM software is now installed and ready for use on your fixed disk. Skip past the next section on how to create a backup copy on another floppy diskette.

2. Floppy Disk Use.

The procedure for floppy disk use is simpler than the procedure for hard (or fixed) disk installation. For floppy-based use, you will only be making a backup copy to use. This set of instructions assumes that the source diskette is in drive 'A' and the target diskette is in drive 'B'. If you only have a single floppy drive, your computer will tell you to switch disks

periodically. Other than that, the instructions for one- and two-floppy systems are identical.

- Place the PCM source diskette in drive 'A' and close the door.
- If you have a 'B' floppy disk drive, place a newly formatted and labeled diskette in it and close the door.
- At the DOS prompt, type **DISKCOPY A: B:**. If you only have only have one floppy drive, you will be prompted to switch diskettes at least once.

Remove both diskettes from the computer and make sure that they are properly labeled. In order to run the PCM software, you must place the floppy diskette which contains it into one of the drives each time you plan to use it.

Hardware/Software Requirements

Hardware

This software is designed to run in the following hardware configuration.

- IBM PC, PC compatible, or PS2 (the software may need to be copied onto a 3 1/2 inch diskette for a PS2).
- A printer connected to the LPT1 connector on the computer. The printer is optional, but useful if a hard copy of the calculation results is needed.

Software

The software is designed to run under DOS 3.0 or later. Earlier versions of DOS will probably work, but have not been tested. To determine you version of DOS, type VER at the DOS prompt.

Use of the PCM Software

General Screen Navigation

The various screens in the PCM program are designed to be very similar in function and appearance. Listed below are the elements that are common to all screens.

Escape Key

The escape key (sometimes labeled Esc) has several different but similar uses. Pressing the escape key in a screen will cause you exit the screen and return to the previous one without saving any changes. This is useful if you just want to look at the contents of a screen with making any changes.

If a window is opened on the screen (e.g. help window, menu window, etc.), pressing the escape key will close the window without making any changes, entering any data, or taking any actions. That way, if a function key that opens a window was pressed in error, you can simply press the escape key to close it safely.

Finally, at the main (project selection) screen, the escape key will allow you to leave the program and return to DOS.

F1 (help) key

Help information is available at any time by pressing the F1 key. When the F1 key is pressed, a window will open in the screen containing information that describes:

- what type of information to enter,
- what the menu selections do,
- or general information about the screen.

Some help windows are more that one page long. To get to the other pages, press the Page Up (for previous pages) or Page Down (for subsequent pages) keys. Pressing the Home key displays the first page. The help window is exited by pressing the Esc (escape) key.

Screen Displays

All screens have a double line border. At the top of each screen, centered in the border, is the screen title. At the bottom of each screen, starting at the left side in

the border is a list of all function keys that are available in the screen and the actions they perform.

Windows are very similar to screens. Most windows also have a title centered in the top border and a list of available function keys in the bottom border.

Creating a new project

To create a new project, perform the following steps. Only perform the first step if the PCM software was installed on a fixed disk. Otherwise, skip the first step and proceed to the second step.

- At the DOS prompt, enter CD\PCM.
- At the DOS prompt, enter PCM.

The main (Project Selection) screen displays. If this is the first time that you have run this software, **No projects have been set up**, will appear in the window. Otherwise, there will be a list of project titles.

- Press the F2 key to open the Edit Project menu.
- Press the F2 key again to add a new project.

The edit project window will close and a new window will open that will prompt you to enter the new project name. Type in the name (really a description) of the project and press Enter. The project name may be up to 40 characters long. The project selection screen will be replaced by the project set up screen. This screen (which can only be entered once) allows you to enter the number items being compared, the number of people doing the comparison, and whether on not the order of the comparisons is randomly generated by the computer or you will enter them.

- Enter the number of items being compared (from 3 to 12) and press Enter.
- Enter the number of people doing the comparison (from 1 to 50) and press Enter.

Since the number of people cannot later be changed, it is best to specify more people than you think will be doing comparisons. That way, if more people will be added to the project, their responses can be entered at any time. Specifying extra people and not entering information for them causes no harm since it will not affect the calculations or the reports.

- Enter R if you want the computer to generate the order the pairs will be entered. If you want to define your own pair entry sequence, enter U.
- Press F2 when the setup is complete. You may use the arrow keys to get to an entry and change it if desired.

If you entered U, a window will open where you can enter the pair order. This window

is unique to all other windows in this package in that it cannot be exited by pressing Esc. Enter the pairs in the order that you wish the users to be prompted. When all pairs have been entered, press F2. The project is now created.

At this point, you will be in the Relative Weight Screen. At the top of the screen is the project name that you entered earlier. The body of the screen contains:

a list of people,

3 to 12 numbered columns of zeroes,

a column of zeroes headed "Disc",

and three rows of zeroes labeled "Mean", "Min", and "Max".

The numbered columns will contain the calculated relative weights, each row corresponding to the respondent whose name appears to the left of that row. The column labeled "Disc" will contain the discrepancy for the respondent. The bottom three rows ("Mean", "Min", and "Max") contain the arithmetic mean, the minimum value, and the maximum value for each column. It is important to note that these values only apply to rows where an entry has been made. This allows the correct values to be displayed even when not all respondents have entered data.

The final value in the "Mean" row (under the "Disc" column) is the disagreement for all respondents who have entered data. As with the mean, minimum, and maximum values, blank rows (all zeroes) are excluded from the disagreement calculations.

The next step is to enter the names of the respondents and a description of each item being compared. It is important to note that the names and descriptions may be changed again at any time.

- Using the up and down arrow keys, move the highlight bar to the first name you wish to change.
- Press the F2 key. The Edit Select menu will appear in the screen.
- Press the F2 key again. The Edit Select menu will disappear. A window will open where you can type the name of this respondent, a maximum of 12 characters is allowed.
- Type the name and press Enter. The name window will close and the highlighted name will changed to the name you typed in.

Repeat the above 4 steps for each name you will be changing.

To changed the names (descriptions) of the items, perform the following steps on the Relative Weights screen.

- Press the F2 key. The Edit Select menu will appear.
- Press the F3 key to edit the list of item names.

The Edit Select menu will close. A window will open which contains a list of item names. There will be a minimum of 3 and a maximum of 12 names, depending on how many items you will be comparing.

- Move the highlight bar to the item name you wish to change.
- Type in the new name and press Enter. You may enter a maximum of 65 characters.

Repeat the above two steps for each item name you wish to change.

- Press the F2 key when you are finished.

At this point, the project is now set up. You may either continue and enter the pairwise comparisons or press the F3 key to save your changes and exit the project.

Entering Pairwise Comparisons

To enter the comparisons (assuming that you are starting from the main Project Selection screen) perform the following steps.

- Using the up and down arrow keys, move the highlight bar to the project you wish to enter comparisons for.
- Press Enter. The Project Selection screen will be replaced by the Relative Weights screen.
- Move the highlight bar to the name of the person who will be entering the comparisons.
- Press Enter. The Relative Weights screen will be replaced by the Enter Pairwise Comparisons screen.

This screen is where the comparisons are entered. At the top of the screen is displayed the project title and the name of the person entering the weights. The description of the pairs of items highlighted appears at the bottom of the screen.

The center portion of the screen contains from 3 to 66 sets of number triplets. The first two numbers or each triplet are the items. The last number is the amount of points assigned to the first of the two items being compared. As you move through the entry of the comparisons, the descriptions of the items at the bottom of the screen will change to reflect the pairs being compared.

- Enter the number of points you wish to assign to the first of the two items being compared and press Enter. The highlight bar will move to the next triplet.
- Use the arrow keys to move the highlight bar around the screen if necessary.
- When all comparison have been made, press the F2 key to begin the calculations.
- During the calculations, the F5 key may be pressed to check the progress of the calculations (or to quit entirely). Pressing the F5 key will halt the calculations and open a window that displays the number of iterations that have completed and how many need to be done in total. You will be prompted to abort the calculations or continue them. If you choose to abort the calculations, the original values of the comparisons and the weights will be restored.

When the calculations have completed, you will be back in the Relative Weights screen. The results of the calculations for this person may be viewed, as well as the "Mean", "Min", and "Max" for all respondents who have entered comparisons.

Printing Calculation Results

The following describes how to print the results of the calculations on a printer. In order to do this, you must have a printer connected to LPT1. Most PC's that have printers will be set up this way. The report can be set to display either a single person's weights or all persons' weights. In the latter mode, the mean, minimum, and maximum weights for each item will also be displayed. From the Relative Weights screen, perform the following steps.

- Press the F4 key. The Select Data Display Option menu will appear the screen.
- Press either the F2 (for the highlighted respondent) or the F3 (for all respondents) key. The report will being printing.

Deleting an Existing Project

If it becomes necessary to delete a project, it can be done with the following steps. These steps are performed from the Project Selection screen.

- Using the up and down arrow keys, position the highlight bar on the project you wish to delete.
- Press the F2 key. The Edit Project menu will appear on the screen.
- Press the F3 key. The Edit Project menu will disappear. A window will open asking if you want to delete the project.
- Press Y. The project will be deleted, and the list of projects will be redisplayed.

Renaming an Existing Project

If you decide to rename a project or need to correct an error, this can be done through the following steps. This is done from the Project Selection screen.

- Press the F2 key. The Edit Project menu will appear on the screen.
- Press the F4 key. The Edit Project menu will disappear. A window will open, prompting you for the new project name.
- Type in the name fo the new project. The name may be up to 40 characters long.
- Press Enter. The window will close and the list of projected will be redisplayed, with the new name.

Glossary

Cursor

A blinking box or underline that indicates where the next characters will appear. In those places where all input is through function keys, the cursor will not be displayed.

Disagreement

A measure of how similar the respondents comparisons were. A value near zero indicates that all respondents entered very close weights.

Discrepancy

A measure of the internal consistency of a particular respondent's weights assignments were.

Display data menu

A menu that opens on the Relative Weights screen when the F4 key is pressed. This menu allows the user to print one or all respondents' relative weights.

Edit select menu

A menu that opens on the Relative Weights screen when the F2 key is pressed. It allows you to edit either the highlighted name or the list of item names.

Edit project menu

A menu that opens on the Project Selection screen when the F2 key is pressed. It allows you to choose between adding a new project, deleting the highlighted project, or to change the project title.

Enter pairwise comparison screen

This screen allows you to enter pairwise comparisons for the items. It is from this screen that the relative weights are calculated.

Enter pair order window

This window appears in the Project Setup screen when U is entered for the pair generation option. This allows you to enter the exact order of the item pairs for comparison. Normally you would allow the computer to assign a random pair order for you.

Fixed disk

A disk drive that is non-removable. It has much greater capacity and speed than a floppy disk. Also known as a hard disk.

Floppy disk

A removable disk. The PCM software comes on a floppy disk.

Function key

A key, labeled F1 through F12 or Esc, that causes an action to take place. The F1 key always means Help and the Esc key always exits the current screen or window.

Hard disk

See fixed disk.

Highlight bar

A reverse video section on the screen or window that indicates the project, name, etc under consideration. Any action that affects a particular name or project usually works on the highlighted object.

Item

One of a group of things that are being compared. The entire item is usually not under consideration, just a particular attribute.

LPT1

A place to connect a printer to a PC.

Menu

A list of actions that you choose one of, usually by pressing a function key associated with it.

PCM

Pairwise Comparison Method.

Project

A group of things for which relative weights will be calculated and the people who will be making comparisons.

Project setup screen

A screen that appears only during project setup where the number of items, the number of people, and the way pair order method will be assigned.

Project selection screen

The first screen that appears when starting the PCM software. This screen contains a list of the projects that have been created. From this screen, a project can be selected to enter, a new project created, an existing project deleted, or an existing project renamed.

Relative weight screen

This screen displays the calculated relative weights. From this screen, a user can be selected to enter comparisons, the users' names changed, the item names changed, or the relative weights printed.

Respondents

The group of people who make the pairwise comparisons.

Screen

A display that takes up the entire visible area of the computers monitor. Every screen is bordered by double lines, has a title across the top, and displays the active function keys across the bottom.

Window

An area that opens inside a screen that takes up only a part of the entire area. A window may contain help information, error messages, a list of menu selections, or a prompt for information.

Project Comparison Weights
Project Title: Example project / test print
Weights for ALL users
12/16/1990 18:06:13

Weights for J. Jones

Weight	Item
0.167	Project A
0.167	Project B
0.167	Project C
0.167	Project D
0.167	Project E
0.167	Project F
0.000	Discrepancy for this respondent

Weights for B. Smith

Weight	Item
0.151	Project A
0.142	Project B
0.170	Project C
0.206	Project D
0.179	Project E
0.153	Project F
0.148	Discrepancy for this respondent

Weights for A. Wilson

Weight	Item
0.201	Project A
0.136	Project B
0.176	Project C
0.156	Project D
0.155	Project E
0.176	Project F
0.035	Discrepancy for this respondent

Weights for A. Cooper

Weight	Item
0.136	Project A
0.201	Project B
0.156	Project C
0.176	Project D
0.177	Project E
0.155	Project F
0.035	Discrepancy for this respondent

Weights for F. Zappa

Weight	Item
0.096	Project A
0.072	Project B
0.148	Project C
0.219	Project D
0.173	Project E
0.291	Project F

0.153 Discrepancy for this respondent

Combined Weights

Weight	Item
0.150	Project A
0.144	Project B
0.163	Project C
0.185	Project D
0.170	Project E
0.188	Project F

Minimum Weights

Weight	Item
0.096	Project A
0.072	Project B
0.148	Project C
0.156	Project D
0.155	Project E
0.153	Project F

Maximum Weights

Weight	Item
0.201	Project A
0.201	Project B
0.176	Project C
0.219	Project D
0.179	Project E
0.291	Project F

0.007 Disagreement for all Users