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Manual for ESUM (2.0.1): Excel VBA Macros for Summarizing Equating Conversions over Multiple Links

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1 Introduction

In many, if not most testing programs that employ equating, the new form is equated to at least two previously equated forms, say k of them. In such cases, the final conversion table is typically taken as some weighted average of the k conversions, where each of the k conversions is based on some particular equating method. (Kolen & Brennan, 2004, provide detailed descriptions of numerous methods for equating forms of a test.) Typically, the results for multiple methods are examined for each link, a particular method is chosen for each link, and then the final conversion table is some weighted average of the one particular user-selected method for each link. ESUM (Equating SUMmary) is intended to facilitate these tasks. Note that ESUM does not perform the equating for any particular method; computer programs available on the CASMA website (www.education.uiowa.edu/casma) can be used to do so. (See, in particular, *Equating Recipes* by Brennan, Wang, Kim & Seol, 2009.) Rather, ESUM displays numerical and graphical results that can help a user select a method for each link and ultimately choose the final conversion for the new form.[1]

ESUM takes as input the conversion tables and related information for each of the equating methods employed with each of the k links. Note that the equating methods for the various links need not be the same. Indeed, even the designs used for equating may differ by link, although this is rare (e.g., the random groups design could be used for one link and the common-item nonequivalent groups design could be used for another link). In short, ESUM has no information about how the conversion tables for each method and link were generated.

The output for ESUM is of two types:

- equating results and plots for each link (one worksheet per link); and
- equating conversion tables and related plots for the "new" form based on a weighted average (weights chosen by user) of the equating conversion tables for the user-selected method for each link.

Letting the second type of output be called an "equating summary," ESUM permits the user to obtain as many equating summaries as desired. Specifically, the user can obtain equating summaries for as many different sets of methods (one per link) and weights (one per link) as desired.

ESUM is a set of Excel VBA (Visual Basic for Applications) macros. VBA is the programming language used to automate procedures in Microsoft applications, including Excel. In this sense, VBA enables users to add their own custom features to Microsoft applications. Using VBA, tasks in Excel can generally be performed more quickly. So, the user can think of ESUM as a computer program that "sits on top" of Excel, which means that after ESUM is run, all

[1] The maximum number of links in ESUM is four; the maximum number of methods per link in 50.

the features and capabilities of Excel are available to the user to manipulate, compute, or plot any of the ESUM results.

The ESUM VBA macros code and this ESUM manual are freely available on www.education.uiowa.edu/casma, which is the website for the Center for Advanced Studies in Measurement and Assessment (CASMA) at the University of Iowa. Typical copyright rules apply. The VBA code is available under the open-source license conditions discussed in Section 7.

Almost all of the major components of ESUM were originally coded using Excel 2003, and ESUM will run under Excel 2003. ESUM will also run under Excel 2007 and Excel 2010 in what is called "compatibility mode." As far as ESUM is concerned, the major difference between Excel 2003 and Excel 2007/2010 is that floating toolbars in Excel 2003 have been replaced by Add-Ins in Excel 2007/2010. (See Section 6.2 for more details.) Section 6 discusses, in considerable detail, a number of issues associated with differences between these three versions of Excel as they relate to ESUM.

Importantly, in this manual, we generally follow the convention of discussing issues from the perspective of Excel 2003. Then, at the end of certain sections, relevant differences between Excel 2003 and Excel 2007/2010 are discussed.

In this manual, filenames are in typewriter style (e.g. `filename`), underlining indicates a pop-up menu (e.g., <u>File</u>), and italics is used for menu items and commands (e.g., *Save*). Occasionally, typewriter style is also used to identify a variable name.

2 Running ESUM: The Basics

ESUM is in the format of an Excel workbook named `ESUM.xls`. After double-clicking on `ESUM.xls`, Microsoft Excel is launched. Note that in order to run ESUM, Excel macros must be enabled. (See section 6.1 for more information about enabling macros and security.)

When `ESUM.xls` is launched, a Welcome Window appears with a brief introduction, contact information, and disclaimers. At the bottom of the window are four buttons:

- *New*: begin a new ESUM workbook (see also Section 4.1.1),
- *Open*: load an already created ESUM workbook (see also Sections 4.1.2 and 4.1.4),
- *Continue*: continue working on the present workbook, and
- *Exit*: closes `ESUM.xls` and removes the ESUM toolbar.

The functionality of the last three buttons is explained more fully in subsequent sections. For now, we assume the user has just downloaded ESUM from the CASMA website and wants to process the sample run. To do so, perform the following steps.

- Click *New* and note that the ESUM floating toolbar appears. The toolbar is described in great detail later in section 4, which also discusses what to do if the toolbar does not appear.

- Under the File menu, click *Input Window*. A blank Input Window appears. (Typically, the user would enter the required information in this window.)

- At the bottom of the Input Window, click *Load Example*. This automatically enters the required information for the sample run, which has two links. This example is purely hypothetical data.

- At the bottom of the Input Window, click *OK*. This signals that all the required information has been entered in the Input Window. When *OK* is clicked, the Input Worksheet appears that summarizes the information entered in the Input Window.

- In the ESUM toolbar, click *Run Analysis*. Worksheets are created for each of the k links. Each worksheet includes conversion tables for all methods for rounded and unrounded scale scores, comparisons of these conversion tables with a user-specified baseline (e.g., conversion table for the old form), moments of score distributions, and plots.

- In the ESUM toolbar, click *Summary*. A popup window appears in which the user picks one method for each link, as well as a weight for each link. (The weights must sum to 1.0.) For the first link (named "aaa"), suppose the user picks "Tucker" with a weight of 0.5; and for the second link (named "bbb"), suppose the user picks "L-obs" with a weight of 0.5.[2] When *OK* is clicked a new worksheet is created named "Summary1" that provides the new form conversion table averaged over links (unrounded and rounded versions), along with various comparisons, moments, and plots. Additional summary worksheets can be created in the same manner, which allows the user to examine the effects on the final new-form conversion of choices of different methods and/or weights.

2.1 Saving and Opening Workbooks

Once the user is through with an analysis, the user can exit Excel by choosing the *Exit* command in the ESUM Welcome window on the ESUM toolbar, or the *Exit* command under the File menu on the ESUM toolbar. Alternatively, the user can save the workbook using the *Save* command under the File menu on the ESUM toolbar. If the user chooses *Save*, a file-dialogue window appears that allows the user to save the workbook with any name desired in any folder. The default name is `temp.xls`, and the default location is the folder in which

[2] Each weight should begin with 0., and the weights must sum to 1. If a weight is a repeating decimal (e.g., one-sixth), provide at least ten decimal digits (e.g., 0.1666666666).

`ESUM.xls` resides.[3] It is particularly important to note that the Excel *Save* command should *not* be used to save an ESUM Workbook.

Suppose the user saves the workbook as `my-first-try.xls` and exits Excel. If the user then double-clicks on `my-first-try.xls`, the workbook will appear, and all Excel functions can be used in that workbook. However, the ESUM macros are NOT available, which means, for example, that a new summary analysis cannot be performed. To make the ESUM macros available with a saved workbook, the user can follow these steps:

- open `ESUM.xls` if it is not already open
- click *New* in the Welcome Window or in the File menu on the ESUM toolbar
- click *Open* in the Welcome Window or in the File menu on the ESUM toolbar
- from the file-selection dialog box, open `my-first-try.xls`

Another way to save a workbook and still have access to the ESUM macros later is to do the following:

- from the File menu of the ESUM toolbar choose *Exit*
- a dialog box will appear asking if you want to save your work—choose *Yes*

Then, to use the original workbook with the ESUM macros enabled,

- open `ESUM.xls`
- click *Continue* in the Welcome Window

2.2 Using Excel 2007/2010

When using Excel 2007/2010, double-clicking `ESUM.xls` opens the Welcome Window described above, but clicking *New* in the Welcome window does not reveal the floating toolbar. The floating toolbar functionality is provided by the Add-Ins tab in the Excel ribbon.[4] When using Excel 2007/2010, after clicking *New* in the ESUM Welcome Window, click the *Add-Ins* tab. Then, just below the Excel ribbon, the following horizontal list of menu items will appear: ESUM, File, *Run Analysis*, *Summary*, and Help. The last four menu items are discussed in Section 4. Clicking the ESUM menu item in the `ESUM.xls` Add-Ins can be used at any time to begin a new analysis.[5] Throughout this manual the phrase "`ESUM.xls` toolbar" should be understood in the sense of "`ESUM.xls` toolbar for Excel 2003 or `ESUM.xls` Add-Ins for Excel 2007/2010."

[3] Currently, sometimes when saving a file four error messages appear in succession. Click "Yes" each time, and the file will be saved properly.

[4] For Excel 2010, if the Add-Ins tab is not in the ribbon, see Section 6.2.

[5] Usually it is advisable to save the current analysis before beginning a new one. To do so, see Section 4.1.4.

3 Input Files

For each link, there must be an input file that provides the equating conversion tables for the various methods employed by the user, as well as some other information. For the example, there are two links, and, hence, two files. They are named `scale1.txt` and `scale2.txt`.

Let the number of methods for link j ($j = 1, 2, \ldots, k$) be denoted m_j. If there are n possible raw scores (integers that may be positive, zero, or negative), there must be $n + 1$ records in the input file. The first record is a type of user-defined header, described below. The remaining records contain the following data in the indicated order:

1. raw score for new form
2. scale score for old form
3. frequency for new form
4. relative frequency for new form
5. scale score for first method
6. scale score for second method

...

$4 + m_j$. scale score of m_j-th method

Strictly speaking, ESUM does not know what forms are involved in columns 2–4, and for columns 3 and 4 ESUM does not know what (sub)sample or (sub)population generated the frequencies and relative frequencies. So, the user has to exercise some appropriate judgment in generating the input files. Generally, the frequencies and relative frequencies should be the same for each link, but this consistency is not enforced by ESUM.

The scale scores are usually unrounded scale scores.[6] Each piece of data should be separated by one or more tabs or spaces. Each record should end with a carriage return, including the last record. Make sure that there are no spaces and/or tabs at the beginning of any record. The records should be ordered in terms of raw scores from low to high, or from high to low.[7] The file should be saved as a text-only file.

The first record provides the labels used by ESUM. If a label includes any blanks or tabs, the entire label must be enclosed in quotes. For example, suppose there are two links, the Tucker and Levine observed-score methods are used for the first link, and the Tucker and Levine true-score method are used for the second link. Then the first record for the first link might be

[6] If rounded scale scores are entered in the input files, certain ESUM output will be trivial, but not wrong per se.

[7] Strictly speaking the records do not have to be ordered low to high or high to low, but failure to do so can increase the likelihood of inadvertent input errors.

```
Raw Y-1 Freq Rel-freq Tucker L-obs
```

and first record for the second link might be

```
Raw Y-2 Freq Rel-freq Tucker L-true
```

Alternatively, the first record for the first link might be

```
Raw Y-1 Freq Rel-freq Tucker "L obs"
```

and first record for the second link might be

```
Raw Y-2 Freq Rel-freq Tucker "L true"
```

The names of the old-form scale scores (e.g., `Y-1` and `Y-2` for the above example) should be different unless the links are associated with the same old form.

For each link, starting in column 5, Records 2–$(n+1)$ provide the old-form equivalents of each of the new-form raw scores in column 1. These equivalents—as well as the scale scores for the old form in column 2 and especially the relative frequencies in column 4—should be provided with considerable accuracy. The authors generally use 10 decimal digits of accuracy. In most cases, a high degree of accuracy is necessary if moments reported by ESUM are to match those reported by the computer program used to compute the equivalents in the first place.

The authors typically use *Equating Recipes* (Brennan, Wang, Kim, & Seol, 2009) to get equated scores for various methods. The addition of a relatively simple module of code can be used to create the input files for ESUM with equated scores provided to any desired degree of accuracy. When 10 decimal digits are used in the input files for ESUM, experience suggests that the ESUM moments will match those reported by *Equating Recipes* to at least five decimal digits.

4 ESUM Toolbar

The ESUM toolbar is the operation center of ESUM, which uses ESUM's VBA functions for analyzing equating results. Five menu items, which are either pop-up menus or commands, are found on the ESUM toolbar and are outlined below. The menu items and associated commands are:

1. *ESUM* which give the ESUM Welcome Window discussed in Section 2
2. <u>File</u>
   - *New*
   - *Open*
   - *Input Window*
   - *Save*
   - *Exit*

3. *Run Analysis*
4. *Summary*
5. Help
   - *Manual*
   - *About*

4.1 File

The File menu includes five commands: *New*, *Open*, *Input Window*, *Save* and *Exit*.

4.1.1 *New*

The *New* command will clear each existing worksheet in the ESUM workbook without a prompt so that the user can start a new analysis. This command has the same functionality as the *New* command in the `ESUM.xls` Welcome Window.

4.1.2 *Open*

The *Open* command loads worksheet(s) from a previous run of ESUM. The name of the workbook containing the worksheet(s) can be obtained through the file browser. The loaded worksheet(s) include at least an Input Worksheet; additional worksheets may be present that contain analyses for the k links (called Link Worksheets in this manual) and summary analyses (called Summary Worksheets in this manual). The *Open* command will delete all the existing worksheets in ESUM before loading another workbook. The Open command in the File menu has the same functionality as the *Open* command in the `ESUM.xls` Welcome Window. It is strongly advised that the user click *New* before clicking *Open*.

4.1.3 *Input Window*

The Input Window of ESUM provides an interface for inputting information about links. There are three ways to input information.

1. Type the necessary information in the spaces. This is the usual way to input linking information.
2. Load the linking information for the example that comes with ESUM (click *Load Example* at the bottom of the Input Window). This is a good way to learn quickly about what ESUM does.
3. Linking information can be loaded using the Input Worksheet of ESUM by clicking *Load Input* at the bottom of the Input Window. Almost always, this way of inputting information would be employed only when the user

wants to change a piece of input in the Input Worksheet. (See discussion at end of this section.)

The blank spaces of the Input Window should contain the following information:

- Title: any alphanumeric text to identify this analysis
- Scores
  - Lowest raw score (can be negative)
  - Highest raw score
  - Rounding digit for scale scores: specify the number of integer digits to which the user wants the program to round numbers for scale scores. For example, if the rounding digit is 0, then scale scores are rounded to the nearest integer and if the rounding digit is 1, then scale scores are rounded one digit to the left of the decimal point. Note that both unrounded and rounded output are always provided.
- Links. The number of links (maximum is 4) must be provided at the top of the Links rectangle. At the bottom of the rectangle there is a button labeled *Add a Link*. When this button is clicked, a Link Information dialog box appears that permits the user to enter the following information.
  - *Name*. In the textbox, provide an alphanumeric name for each link, which is printed at the top of the worksheet associated with the link.
  - *File*. In the textbox, provide the name of the input file for each link (see Section 3). It is assumed that the file is in the folder containing ESUM.xls; if not, the full pathname must be provided. Alternatively, a little box containing "..." appears to the left of the textbox. Clicking on "..." brings up a file browser that can be used to select the filename.
  - *Number of Methods*. Provide the number of equating methods used for each link.
  - *Plot difference scores relative to*. Initially, a radio button indicates that difference scores will be provided relative to old-form scale scores. Alternatively, the user can click the *Method* radio button and indicate the sequential number of the method to be used for comparison purposes. For example, suppose that the input file for a particular link has two methods labeled `Tucker` and `Levine`. If the user types 1 in the box after *Method* then the difference scores computed and plotted are for `Tucker` minus `Levine`. At this point the sequential method number, as opposed to a method name, must be provided because the file containing the method names for the link has not yet been read.
  - *Notes*. Notes for each link may be provided.

When all the information has been provided in the Link Information window, click *Add Link* which will update the information in the Input Window. The same process can be used to add more links.

To edit or delete a particular link, double-click on the name of that link in the Input Window. A pop-up window with the information for the chosen link appears. The user can edit the link through the pop-up window and then click the *Update* button to save the editing. Or, the user can click the *Delete* button to delete the link.

After all the necessary link information is given, click the *OK* button in the Input Window. Doing so causes four actions to occur. First, ESUM checks whether there are worksheets created from a previous run; if so, the user will be prompted to save them. Second, all the worksheets, except the Input Worksheet, are deleted, and the content in the Input Worksheet is cleared. Third, the linking information provided in the Input Window is listed in the Input Worksheet. Fourth, ESUM closes the Input Window.

As noted at the beginning of this section, linking information can be loaded using the Input Worksheet of ESUM by clicking *Load Input* at the bottom of the Input Window. Almost always, this way of inputting information would be employed only when the user wants to change a piece of input in the Input Worksheet. The process for doing so is as follows:

- make whatever changes are desired in the Input Worksheet;
- click *Input Window* in the File menu of the ESUM toolbar;
- click the *Load Input* button at the bottom of the Input Window;
- click the *OK* button at the bottom of the Input Window;

An easier way to alter most information is to use the edit/delete capability discussed above.

4.1.4 *Save*

The *Save* command in the File menu causes all the current worksheets in ESUM (which may include the Input Worksheet, the Linking Worksheets, and the Summary Worksheets) to be saved in an Excel workbook. However, the ESUM macros will not be saved if the name of the workbook is anything other than `ESUM.xls`. That is, the ESUM macros have been restricted to work only for a workbook named `ESUM.xls`. No ESUM workbook should be saved with any extension other than `.xls`. See Section 4.1.2 for a discussion of how to open a workbook with a name other than `ESUM.xls`. It is particularly important to note that the Excel *Save* command should *not* be used to save an ESUM Workbook.

4.1.5 *Exit*

Exit brings up a dialog box with *Yes*, *No*, and *Cancel*. These buttons have the functionality indicated next.

- *Yes* saves work in `ESUM.xls`, closes the ESUM toolbar, and closes `ESUM.xls`. In this case, when `ESUM.xls` is launched, the user can click *Continue* in the Welcome Window to continue work.
- *No* does not save work in `ESUM.xls`, closes the ESUM toolbar, and closes `ESUM.xls`.
- *Cancel* removes the dialog box and allows the user to continue using the current workbook.

4.2 *Run Analysis*

Based on the information provided in the Input Worksheet, an analysis of equating results for each link is performed by clicking the *Run Analysis* command on the ESUM toolbar. Since the analysis is based on the Input Worksheet, any change to a cell value of the Input Worksheet will take effect for a subsequent analysis, but will not affect the previous analysis. The changed value is highlighted in blue.

For each link, data in the input file is loaded into a new worksheet, which is referred to as a Link Worksheet in ESUM. The link name is used as the name of the new worksheet. ESUM computes the rounded conversion tables, scale-scores differences for both unrounded and rounded equivalents, and moments of distributions. Also, ESUM generates four plots: the Raw-to-Scale Score Conversions (Unrounded) Plot; the Scale Score Differences (Unrounded) Plot; the Raw-to-Scale Score Conversions (Rounded) Plot; and the Scale Score Differences (Rounded) Plot. These four plots are located at the bottom of the Link Worksheet.

In the sections containing the rounded conversion tables and the rounded scale score differences, all non-modal cell values across columns are highlighted in red; if there is more than one mode, ESUM will highlight all values in red.

Any change made by the user to a cell value in a Link Worksheet is highlighted in blue.[8] ESUM automatically updates any cells in that worksheet that are linked to a changed cell, as well as any plots in that worksheet that use data in the changed cell. If an entry is changed in a Link Worksheet, such a change does not affect any previously created Summary Worksheets (discussed next).

4.3 *Summary*

After *Run Analysis* has been used to generate the Link Worksheets, across-links equating results can be created and put into a Summary Worksheet, which is

[8] If such changes are made, they are almost always associated with scores at the extreme of the score scale to keep the score scale within some predetermined boundaries. It is more common to make such changes in the Summary Worksheets, rather than the Link Worksheets.

named "Summary" followed by a serial number starting with 1. Clicking on the *Summary* button on the ESUM toolbar causes a pop-up window to appear that permits the user to select:

- the link used for comparison purposes—specifically, the old-form scale scores (designated Y in the Summary Worksheet) for the selected link are used for comparison purposes;
- one method for each link; and
- a weight for each link.

Note that weights must be between 0 and 1 (inclusive) and they must NOT begin with a decimal point. So, if the desired weights are one-half and one-half, 0.5 should be used for each of them. If a weight is a repeating decimal (e.g., one-sixth), it is suggested that the weight be provided with at least ten decimal digits (e.g., 0.1666666666).

ESUM first computes the new-form unrounded conversion table over links, which is the weighted average of the scale-score equivalents for the chosen methods for each link. Then ESUM computes the new-form rounded conversion table, as well as various difference scores, moments, and plots for both unrounded and rounded scale-score equivalents. For the rounded equivalents and the rounded scale score differences, all non-modal cell values across rows are highlighted in red; if there is more than one mode, ESUM will highlight all values in red.

Any change to a cell value in the summary is highlighted in blue. ESUM automatically updates any cells that are linked to a changed cell as well as any plots in the worksheet that use data in the changed cell. This is an especially useful feature when reported scale scores have a priori fixed lower and upper limits.

4.4 Help

Help provides two kinds of help for ESUM through a pop-up list that includes *Manual* and *About*.

4.4.1 *Manual*

A manual in PDF format is provided. If the user does not have a PDF reader, one can be downloaded from http://www.adobe.com/products/acrobat. The manual must be located in the same folder as ESUM.

4.4.2 *About*

About displays the contact information for ESUM.

5 Worksheets

ESUM generates three types of worksheets that are called (1) the Input Worksheet, (2) Linking Worksheets, and (3) Summary Worksheets. These are described below.

5.1 Input Worksheet

The Input Worksheet is generated, and the cells are populated, based on the information provided by the user in the Input Window. The Input Worksheet provides basic information used to generate the Linking Worksheets and Summary Worksheets.

Strictly speaking, the Input Window does not have to be used to populate the Input Worksheet; the user could simply enter the information directly in the Input Worksheet. This is not advised, however, since it is easy to make errors inputting data directly into the Input Worksheet. On the other hand, it is sometimes convenient to alter some information (e.g., change the name of a link) in the Input Worksheet directly and then redo the analyses.

5.2 Linking Worksheets

Clicking *Run Analysis* generates a Linking Worksheet for each link. Cell A1 contains the title followed by the date and time in parentheses; cell A2 contains "Results for Link `link-name`"; and cell A3 contains the user note for the link, if any. The remainder of the worksheet consists of four parts:

- Top left: numerical results for unrounded scale scores
- Top right: numerical results for rounded scale scores
- Bottom left: graphical results for unrounded scale scores
- Bottom right: graphical results for rounded scale scores

5.2.1 Numerical Results

The basic numerical results (rounded and unrounded) are: (1) scale scores and scale-score equivalents for the various equating methods; and (2) the first four moments for scale scores and scale-score equivalents. For each link, the numerical results (except the moments) in the first $4 + m_j$ columns are read directly from the input file for the j-th link. For each of these columns, the column headings are those specified in the first record of the input file. As indicated in section 3, these columns are:

1. raw score (designated `Raw_Score` below)
2. scale score for old form (designated `Old_Form_Scale_Score` below)
3. frequency for new form

4. relative frequency for new form

5. scale score for first method (designated `M1` below)

6. scale score for second method (designated `M2` below)

...

$4 + m_j$. scale score of m_j-th method (designated `Mj` below)

If the user has specified that differences should be plotted relative to the old-form scale scores (see page 8), the subsequent m_j columns are

$5 + m_j$. `Old_Form_Scale_Score - M1`

$6 + m_j$. `Old_Form_Scale_Score - M2`

...

$4 + 2m_j$. `Old_Form_Scale_Score - Mj`

If the user has specified that differences should be plotted relative to scale scores for particular method (see page 8), there will be $m_j - 1$ subsequent columns.

In the section containing the rounded equivalents and the rounded scale-score differences, all non-modal cell values across columns are highlighted in red; if there is more than one mode, ESUM will highlight all values in red.

Below each column for a scale score or scale-score difference, the first four moments are provided. Note that these moments are based on the relative frequencies in the fourth column.

Any numerical entry in the columns (other than the moments) can be changed by the user. If so, the changed value is colored blue and all results (numerical and graphical) based on the changed value are altered appropriately. The most likely use of this feature of ESUM is to alter scale-score equivalents that are outside some predefined range. Note the following:

- If a value is altered and then *Run Analysis* is clicked, the altered values are not retained, Linking Worksheets are cleared, Summary Worksheets are cleared, and new Linking Worksheets are created based on the Input Worksheet.

- If a change is made in a Linking Worksheet, the change does not affect any existing or subsequently-created Summary Worksheets. That is, each Summary Worksheet must be altered directly.

5.2.2 Graphical Results

Below the moments in the Linking Worksheets are graphical results (rounded and unrounded). The first graph plots the scale-score equivalents in columns 5–$(4+m_j)$ against raw scores. The second graph plots the scale-score differences against raw scores.

5.3 Summary Worksheets

Clicking *Summary* generates a Summary Worksheet across all links. A Summary Worksheet is based on a user-defined weighed average of the user-selected method for each link. There can be as many Summary Worksheets as desired. Cell A1 contains the title followed by the date and time in parentheses. Cell A2 contains "Summary over Links (Comparison: Y = old-form scale scores for link: `link-name`". (For the specified link, this is the second column in the Linking Worksheet.) The remainder of the worksheet consists of four parts:

- Top left: numerical results for unrounded scale scores
- Top right: numerical results for rounded scale scores
- Bottom left: graphical results for unrounded scale scores
- Bottom right: graphical results for rounded scale scores

5.3.1 Numerical Results

For the first $1 + k$ columns, the numerical results are:

1. raw score
2. old-form scale score for selected method for link 1
3. old-form scale score for selected method for link 2

...

$1 + k$. old-form scale score for selected method for link k

One of these columns begins with the designator `Y =`, as specified by the user in the dialog box entitled "Create a Summary over Links" that appears when the user clicks *Summary* (see Section 4.3). The `Y`-column old-form scale scores are used as a basis for comparison in the last few columns in the Summary Worksheet.

The next $2 + k$ columns are:

$2 + k$. frequency

$3 + k$. relative frequency

$4 + k$. new-form scale score for selected method for link 1

$5 + k$. new-form scale score for selected method for link 2

...

$3 + 2k$. new-form scale score for selected method for link k

Usually, for the k links the frequencies and relative frequencies are the same. If they are different, for a Summary Worksheet ESUM uses the frequencies and relative frequencies for link k.

The remaining columns are:

$4 + 2k$. weighted average of new-form scale scores for selected methods; this is the principal result in a Summary Worksheet

$5 + 2k$. difference between `Y` and weighted average

$6 + 2k$. difference between `Y` and scale score for link 1 (i.e., column $4 + k$)

$7 + 2k$. difference between `Y` and scale score for link 2 (i.e., column $5 + k$)

...

$5 + 3k$. difference between `Y` and scale score for link k (i.e., column $3 + 2k$)

The next set of columns contain the "rounded scores" version of those discussed above. For the rounded equivalents and the rounded scale-score differences, all non-modal cell values across columns are highlighted in red; if there is more than one mode, ESUM highlights all values in red.

Below each column for a scale score or scale-score difference, the first four moments are provided. These moments are based on the relative frequencies in column $3 + k$.

Any numerical entry in the columns (other than the moments) can be changed by the user. If so, the changed value is colored blue and all results (numerical and graphical) based on the changed value are altered appropriately. The most likely use of this feature of ESUM is to alter scale-score equivalents that are outside some predetermined range.

5.3.2 Graphical Results

Below the moments in a Summary Worksheet are graphical results (rounded and unrounded). The first graph plots column $5 + 2k$ (difference between `Y` and weighted average) against raw scores. The second graph plots columns $(5 + 2k)$–$(5 + 3k)$ (scale-score differences for each link) against raw scores.

6 Notes

No suggestion is made here that the output from ESUM is necessarily optimal or sufficient for making all decisions about choice of equating methods in an actual testing program. Almost all testing programs have unique features that warrant paying attention to additional, program-specific information to make equating decisions.

6.1 Enabling Macros and Security

There are four levels of Microsoft Excel security: Very High, High, Medium and Low. With Low security, macros run automatically, but Low security may allow unsafe macros. Medium security is recommended for running ESUM. With High security, only trusted Excel macros are allowed. A macro is trusted when it has been digitally signed and the user chooses to trust the source. With Very High security, only macros installed in trusted locations are allowed to run. All other signed and unsigned macros are disabled.

6.1.1 Excel 2003

The Microsoft Excel macro security setting can be found under Tools→Macros→Security. With Medium security, a pop-up window appears each time a workbook is opened, and the user is asked to "Enable" or "Disables" Excel macros.

6.1.2 Excel 2007

In Excel 2007, the steps for setting the security level are as follows:

1. Click the large button (called the Office Button) on the left of the ribbon
2. Click "Excel Options" at bottom of the list
3. Click Trust Center→Trust Center Settings→Macro Settings and select the box labeled "Disable all macros with notification." In the same window make sure the box labeled "Trust access to VBA project object module" is checked.
4. Click "OK" to close the "Trust Center" window.
5. Click "OK" to close the "Excel Options" window.

Each time ESUM is run a dialog box will ask you to Enable Macros.

Rather than selecting the "Disable all macros with notification" box in Step 3 you can select "Enable all macros," but this is not generally recommended. If "Enable all macros" is selected, no dialog box will appear that asks you to enable macros when ESUM is run.

6.1.3 Excel 2010

In Excel 2010, the steps for setting the security level are as follows:

1. Click File→Options→Trust Center→Trust Center Settings→Macro Settings and select the box labeled "Disable all macros with notification." In the same window make sure the box labeled "Trust access to VBA project object module" is checked.
2. Click "OK" to close the "Trust Center" window.

3. Click "OK" to close the "Excel Options" window.

When ESUM is run, click the button labeled "Enable Content" (which enables macros), if the button appears.

Rather than selecting the "Disable all macros with notification" box in Step 1 you can select "Enable all macros," but this is not generally recommended. If "Enable all macros" is selected, it is not necessary to click "Enable Content" each time ESUM is run.

6.2 Add-Ins

When `ESUM.xls` is opened in Excel 2003, the floating toolbar described in Section 4 appears automatically. For Excel 2007 and 2010, however, obtaining the functionally equivalent Add-Ins is more complicated.

6.2.1 Excel 2007

Rather than double clicking on `ESUM.xls`, open Excel 2007 first and then open `ESUM.xls` using the *Open* command in the Office Button on the left side of the ribbon. (The Workbook window will be labeled "ESUM [Compatibility Mode].") Just below the ribbon there will be a security warning saying "Macros have been disabled." Click the *Options...* button next to the warning and select "Enable the content." The ESUM Welcome Window will appear. When one of the buttons in the ESUM Welcome Window is clicked, an Add-Ins tab will be added to the ribbon. Clicking the Add-Ins tab will put the ESUM Add-Ins (i.e., toolbar) just below the ribbon. This toolbar is not a floating toolbar, as it is in Excel 2003. At any time, if the ESUM Add-Ins disappear, simple click the Add-Ins tab.

6.2.2 Excel 2010

If the Add-Ins tabs is not in the ribbon, click File→Options→Customize Ribbon. To the right, under "Main Tabs", check "Add-Ins." Then click "OK" to exit. When ESUM is opened, the Workbook window will be labeled "ESUM [Compatibility Mode]" and the ESUM Welcome Window will appear. When *New* or *Continue* is clicked, an Add-Ins tab will be added to the Workbook window. Clicking the Add-Ins tab will put the ESUM Add-Ins (i.e., toolbar) just below the ribbon. This is not a floating toolbar, as it is in Excel 2003. At any time, if the ESUM Add-Ins disappear, simple click the Add-Ins tab.

6.3 Modifications of ESUM

All functions in Excel can be used in ESUM, which means that Excel can be used to modify the computed data and plots created by ESUM, as well as add additional information and notes. The ESUM VBA code is open-source. Users may modify it in any way desired. The rest of this section discusses how to access the ESUM code.

6.3.1 Excel 2003

In Excel 2003, while using the `ESUM.xls` workbook, choose Tools→Macro→ Visual Basic Editor. If Project Explorer is not visible, choose View→Project Explorer. Click "+" beside Modules, and double click "Module2." To see the code for any form, click "+" beside "Forms," click the form name, and click the first box just below "Project - VBA Project."

6.3.2 Excel 2007

In Excel 2007, the code is accessed through the Developer tab on the ribbon. if the Developer tab is not present,

1. click the large button (called the Office Button) on the left of the ribbon,
2. click "Excel Options,"
3. select "Popular,"
4. check the box labeled "Show Developer tab in the Ribbon,"
5. click "OK" to exit the window.

To see the Visual Basic code, click the Developer tab, click the Visual Basic icon, click "+" beside Modules, and double click "Module2." To see the code for any form, click "+" beside "Forms", click the form name, and click the first box just below "Project - VBA Project."

6.3.3 Excel 2010

In Excel 2010, the code is accessed using the Developer tab on the ribbon. If the Developer tab is not in the ribbon, click File→Options→Customize Ribbon. To the right, under "Main Tabs", check "Developer." Then click "OK" to exit.

To see the Visual Basic code, click the Developer tab, click the Visual Basic icon, click "+" beside Modules, and double click "Module2." To see the code for any form, click "+" beside "Forms," click the form name, and click the first box just below "Project - VBA Project."

7 Open Source License

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8 References

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