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`iefieldkit`: Stata commands for primary data collection and cleaning

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Abstract. Data collection and cleaning workflows implement highly repetitive but extremely important processes. This article introduces iefieldkit, a package developed to standardize and simplify best practices for high quality primary data collection across the World Bank's Development Research Group Impact Evaluations department (DIME). `iefieldkit` automates: error-checking for electronic ODK-based survey modules such as those implemented in SurveyCTO; duplicate checking and resolution; data cleaning including renaming, labeling, recoding, and survey harmonization; and codebook creation.

Keywords: st0001, iefieldkit, primary data collection, ODK, SurveyCTO, data cleaning, survey harmonization, duplicates, codebooks

1 Introduction

The `iefieldkit` package is a set of commands designed to simplify a series of tedious and repetitive tasks for Stata users who are in the process of collecting primary survey data in the field. This package currently supports three major components of that workflow: survey design; survey completion; and data cleaning and survey harmonization.

The commands described in this article have grown out of the work of the DIME Analytics team, a group of data scientists working in the World Bank's Development Research Group Impact Evaluations team (DIME). DIME Analytics is tasked with supporting the data management workflows for the entire unit, which comprises over 20 principal investigators and 100 research assistants and field coordinators working in 60 countries.

One of the most important developments in economics research over the past two decades has been the rise of empirical data collection, especially with unique primary datasets collected by the researchers themselves (Angrist et al. 2017). The authors of `iefieldkit` have supported the implementation of a wide range of primary data col-

lection in fields including agriculture, health, energy and environment, edutainment, financial and private sector development, fragility, conflict, and violence, gender, governance, and transport. They have developed workflows to support general best practices for data collection, and as a rule develop new packages only when they fill an essential gap in Stata functionality.

The `iefieldkit` package provides commands that support workflows in primary data collection. There are relatively few Stata-based tools for managing that process, mainly due to its complexity and to the diversity of practices adopted. The DIME Analytics team has worked to standardize some of the tools and processes used for data collection to save time during the more tedious elements of the process, improve documentation, and reduce error. Most importantly, since the quality of data collection is as important to credible research as the quality of analysis, these tools are intended to allow researchers to focus on ensuring that the data they collect is high-quality. The commands in the package are therefore a first attempt to provide Stata-based tools for managing the primary data collection process using native tools from start to finish.

Specifically, `iefieldkit` performs three essential tasks. Before data collection occurs, `ietestform` allows for rapid error-checking of ODK-based[1] electronic surveys, including best practices for SurveyCTO-styled forms[2]. This ensures that data, once collected, will import in Stata-friendly formats – for example, avoiding name conflicts and ensuring compliant variable naming and labeling. While data collection is ongoing, `ieduplicates` and `iecompdup` provide a workflow for detecting and resolving duplicate entries in the dataset, ensuring that the final survey dataset will be a correct record of the survey sample to merge onto the master sampling database. Finally, once data collection is complete, the `iecodebook` commands provide a workflow for rapidly cleaning, harmonizing, and documenting datasets.

All three commands utilize spreadsheet-based workflows so that their inputs and outputs are significantly more human-readable than Stata do-files completing the same tasks would be, and these tasks can be supported and reviewed by personnel who specialize in field work rather than code tools. The increasing diversity and specialization of research teams has made accessibility to non-Stata-proficient personnel an essential component of data management workflows, and the `iefieldkit` takes this development seriously. All code for the package is open-source and available for public contribution and comment on GitHub at https://www.github.com/worldbank/iefieldkit.

2 The `ietestform` command

Many contemporary data collection efforts use digital survey technologies, such as the open-source Open Data Kit (ODK) or proprietary extensions of ODK, like SurveyCTO. Since data is often collected for researchers by third party firms or local partners, quality assurance prior to sending surveys to the field is essential. Since the surveys themselves are often created collaboratively between topic experts, field staff, and data analysts,

1. https://www.opendatakit.org
2. https://www.surveycto.com

our teams identified the possibility to save a large amount of time by automating a "quality checklist" that is often overlooked in practice. This section provides extensive details on that specific functionality, some of which requires some familiarity with ODK practice and terminology, but anyone who collects data using third-party software may be interested in how these checks can be implemented using Stata even before data is in hand.

In ODK and SurveyCTO, survey forms are typically built in Excel using a specialized structured syntax.[3] Because the survey forms are long and often created using copied-and-pasted syntax or sections from other surveys or from demo files, it is easy to make minor syntax errors or omit Stata-optimized practices which may have major consequences later. The `ietestform` command is used to test ODK and SurveyCTO-based survey forms before they are used in the field for a range of technical issues and Stata-optimized practices. This section assumes you are familiar with ODK syntax. If you are not using ODK-based tools, you will not likely use this command, and should skip to section 3.

The SurveyCTO server has a built-in test feature that tests the ODK syntax of the form of a form when it is uploaded. The `ietestform` command is not meant as a substitute for these tests, but a complement, since the built-in test only identifies strict syntax failures. For example, `ietestform` uses a heuristic search to test for potential typos that would lead to unintended logic, and whether the data generated will be in Stata-suitable format, whether or not these issues would fail strict syntax checks. The command also points out commonly-used best practices if not already implemented in the survey. Specifically, it creates an easily-readable output report to ensure that survey practices which may produce unexpected behaviors are only used intentionally. The command thereby provides an iterative, documented workflow for the quality-assurance stage of survey development.

The `ietestform` command is intended to be used when developing a survey form after it is tested on a SurveyCTO server to make sure there are no syntax errors, but before the survey is deployed in the field. The `ietestform` command performs several tests. The syntax for the command is:

```
ietestform
    , surveyform("filename.xlsx")
    report("report.csv")
```

The `ietestform` command outputs a test report with various flags indicating potentially improper practices in a CSV format, which is optimized for display in a number of software applications as well as for version-tracking with software like Git. Some of the report entries flag code errors, and others detect practices that are not strictly wrong, but that may indicate potential errors or bad practices (and are therefore intended for manual review). There will often be cases where the command flags a line as suspicious,

3. SurveyCTO provides a web-based click-and-drag survey builder, but our experience is that the Excel method is much better suited for the large questionnaires `ietestform` is developed for.

but it is in fact the best way to construct the questionnaire. The goal of `ietestform` is not to produce a report with no flags; but to ensure that practices that may cause serious problems if used unintentionally or incorrectly are validated for functionality.

2.1 Tests run by `ietestform`

This section describes tests related to best practices on how and how not to use features in the ODK programming language in order to ensure data quality and reduce the risk of creating errors that interrupt the field work. Again, note that the the command does not check whether the ODK syntax is valid. The command is intended to be used after the survey form has passed the ODK syntax test on the SurveyCTO server, and some tests in the command assume that the ODK syntax has already been tested and is correct.

All non-`note` fields are required and no `note` fields are required

The *required* column ensures that enumerators (the people collecting data in the field) cannot proceed onward in the survey before a response has been filled in for the indicated field. This is in general a useful data quality feature, as it prevents incomplete surveys from being submitted, and helps ensure that enumerators complete surveys in the intended order. A field that is required cannot be bypassed until data has been entered for it.

`ietestform` tests that all fields that are not of type `note` (i.e. fields with only a pre-written text note to be read by the enumerator and no data input) have the value "Yes" in the *required* column. This test adds to the report a list of all fields that are not required and not of type `note`. Even when some type of non-response (such as "Declined to answer") is acceptable, the absence of a recorded answer to represent that response should not be accepted. The absence of a recorded answer should only mean that the question was not asked during the survey. When applicable, there should always be a valid method to record meaningful reasons for non-response. When it may be acceptable for a question to be skipped, an appropriate *relevance* expression should be used to implement this functionality.

Some fields that are often intentionally not required are fields that record GPS coordinates. Such fields have the type *geopoint*, *geoshape* and *geotrace*. If you know that the devices you will be using for data collection will have no problem collecting GPS coordinates, then keeping those fields required ensures you will get valid data points. However, if you are working in a context where GPS coordinates may be difficult to collect, then it could be a good idea to not require these fields, so that the enumerator can complete the other fields and submit the survey even when it was not possible to record GPS coordinates. These fields will still be flagged in the report, but as long as you are happy with your decision you can still deploy the survey.

Fields of type `note` can be required, but cannot record data. Therefore, is it not possible to advance a survey past a *required* `note` field. If an enumerator encounters

a *required* `note` during a live survey, there is no way to continue with the interview or to submit the data already collected. There are cases when this functionality is intentionally utilized. Since it is not possible to skip *required* `note` fields, they can be used alongside a relevance condition to create the equivalent of an "error" state: if some previous input is absolutely incorrect, this will force the enumerator to go back and correct it before continuing data collection.[4]

All `begin_group` and `begin_repeat` fields have a corresponding `end_` field

This test checks that all `begin_group` fields are matched by an `end_group` and that all `begin_repeat` fields are matched by an `end_repeat`. The primary functionality of this test is also implemented by the ODK syntax tester on the SurveyCTO server. However, the report outputted by `ietestform` provides additional information that makes it easier and less time consuming to solve this problem, especially when the survey form is very large. For example, ODK does not require the `end_group` and `end_repeat` to have field names, making it difficult to provide pointers to the source of the error in the underlying survey form. `ietestform` fills that gap by requiring those fields to have names, and including the names as well as the form row number of non-valid `begin_`/`end_` pairs in the report.

For a `begin_`/`end_` pair to be valid in `ietestform`, the following three criteria need to be fulfilled:

1. For each `begin_` field there is an `end_` field
2. The corresponding `end_` field is of the correct type, so that a `begin_group` is not closed by an `end_repeat` and a `begin_repeat` is not closed by an `end_group`.
3. The `end_` field names match the `begin_` fields. The SurveyCTO test makes sure that the `begin_` names are unique, so each pair will also be unique if this part of the test is valid.

Variable naming and labeling is Stata-optimized

ODK applies very few restrictions to field names and other inputs. These are converted into metadata for Stata, which places many more restrictions on these values. Therefore, it is not uncommon for ODK-created datasets to contain, for example, variable names

4. For example, enumerators are often asked to enter respondent IDs twice to be extra careful that there is no typo in the ID. Let's say those two double entry fields are `id1` and `id2`. Then they can be followed by required note-field that has the relevance expression triggering its appearance, `${id1} != ${id2}`, such that the required `note` only appears if the two IDs are not identical. The note can then inform the enumerator that the two ID fields are not identical and that the enumerator must go back and change the values in order to continue. The same functionality could have been achieved using the constraint condition on the second ID field when the ID is re-entered, but the label in a note field can be made more informative than a constraint message, and when the conditional test is more difficult than just testing that two fields are identical, then this method is easier by using intermediate calculate fields that are then used in the relevance column for the required note-field.

and labels that are not valid in Stata and will cause error. In ODK, for example, all names must be unique, and there are a few special characters that are not allowed. These restrictions are tested by the ODK syntax test on the SurveyCTO server. The additional tests done by `ietestform` ensure that names that will be imported by Stata are valid and optimized for use there.

First, `ietestform` returns a flag if you have not programmed the survey to return Stata-specific labels. SurveyCTO forms can be programmed to display questions in multiple languages. This is done by creating label columns named `label:english`, `label:swahili`, `label:hindi`, and so on. When exporting data into Stata format through SurveyCTO Sync, you can choose which language to use for labels. Labels can obviously be added and modified once the dataset has been opened in Stata. However, the simplest way to add them to a dataset created in SurveyCTO is using this feature to create Stata-optimized labels by adding a "language" called `label:stata`. If this practice is not used, the dataset is often not labeled as intended. Labels in ODK contain the full survey question, which is rarely a suitable variable label in Stata. Most often they will be too long, but they may also include special characters, line breaks or HTML code that may be difficult to handle. The same test is applied to the *choices* sheet, so that all labeled variables use Stata-compliant value labels.

Stata variable names are limited to 32 characters and variable labels to 80. Longer names or labels will be truncated or replaced with a generic name of the format `var1`, `var2`, and so on, if the truncated name is no longer unique. All of these cases can be resolved in Stata, but it is much simpler to ensure that all names are collectively unique at 32 characters before collecting data. `ietestform` therefore flags all fields with variable names longer than 32 characters or Stata labels that longer than 80 characters. Furthermore, `ietestform` also flags any fields with leading (" ABC") or trailing ("ABC ") spaces, as these can cause unexpected problems.

This test is extended to fields in `repeat` groups whose names will be too long when imported to Stata in wide format; as well as to fields in repeat groups where the risk of overlong names is high, but not certain. When using a SurveyCTO-generated Stata import do-file or exporting a dataset in wide format, a suffix is added to the names of variables that are created inside `repeat` groups For example, if a group of questions is repeated three times, the wide version of the resulting dataset will contain three variables for each question in the repeat group. Each of these three variables will have the same name, followed by `_1`, `_2` and `_3`. Therefore, variables created inside a `repeat` group may not have a name longer than 30 characters. If the field is in a nested repeat group (a `repeat` group inside a `repeat` group), it will be suffixed once for each `repeat` group. So the actual constraint used in this test is given by this formula: $32 - (2 \times \text{depth of nested repeats})$. This test lists all variables that have longer names than that constraint. It assumes that there are no more than 9 iterations in each `repeat` group. If there were more than 9, the suffixes would be `_10`, `_11`, etc., which take up three characters. The second test lists all fields with a field name longer than $32 - (3 \times \text{depth of nested repeats})$. Whether this will create an issue with long names is uncertain, but if field names are so long that they might be caught in this test, then it is probably a good idea to make them shorter.

`ietestform` also flags name conflicts that could result from `repeat` suffixes that are added to fields inside a `repeat` group. SurveyCTO's ODK syntax tester tests that all names are unique. The names `myvar` and `myvar_1` are not duplicates in the ODK syntax test, but if `myvar` is in a repeat field, it will be suffixed with `_1` for the first iteration of that variable, and that will create a name conflict with the variable created from field `myvar_1`.[5] Therefore, `ietestform` flags all fields inside a `repeat` group that are at risk of creating this type of name conflict. For example, if there is a field named `myvar`, the command checks if there are any other field names names with the format `myvar_#`, where `#` is one or more digits. This is extended to nested `repeat` groups sensibly.

Test choice lists for typos, missing values and redundancies

The ODK syntax is very lenient when it comes to the definition of *choice* lists, which are translated into Stata value labels. It does not have robust checks for typographical errors, duplication, or missingness which will affect Stata datasets in unexpected ways. `ietestform` flags these and other "suspicious" patterns, as they are common byproducts of coding errors or redundant code likely to cause future errors; for example, unused choice lists and duplicated labels could indicate that the list elements were copied and pasted accidentally or incompletely. `ietestform` checks that all lists defined in the *choices* list sheet are actually used in at least one `select_one` or `select_multiple` field in the *survey* sheet.[6] `ietestform` also flags any duplicates in list names and elements in the choice sheet as these will cause unexpected behavior when converted to Stata data.

In Stata, categorical data are often stored as integers attached to value labels. In SurveyCTO, other formats for categorical response questions are allowed, such as strings. Although not strictly required, our team recommends using labeled integers rather than strings. Strings take up significantly more memory in large datasets and cannot be used in many Stata functions that handle categorical variables. `ietestform` therefore flags all list items that have a non-numeric value in the *value* or *name* column. `ietestform` also flags any list item that has a value in the *label* column but no value in the *value* or *name* column. It then flags any cases where the opposite occurs. This is common when a survey is programmed in multiple languages and one is not fully completed. `ietestform` also flags labels in the same choice list that are identical, i.e. one label that is listed twice for the same choice list but with different codes, as this is likely a typo.

5. However, if the fields `myvar` and `myvar_1` are both in a non-nested `repeat` group then there will be no name conflict, as the first iteration of both fields will generate the variables `myvar_1` and `myvar_1_1` as the variables from both fields are suffixed. These fields are still listed by this test as it will be confusing that the variable `myvar_1` is from field `myvar` and not from the `myvar_1` that has the same name, even though this is technically not a name conflict.
6. For example, if you have 10 villages in a choice list called `village` but you incorrectly type `vilage` for one of them. Then, according to ODK syntax you have two lists, one called `village` with 9 items and one called `vilage` with 1 item. It is unlikely that there is a `select_one` or `select_multiple` field that uses the choice list `vilage`, so listing unused choice lists is a good way to spot a typo like this one.

3 The ieduplicates and iecompdup commands

The `ieduplicates` and `iecompdup` commands were designed as part of a workflow to process duplicate observations in primary data in a reproducible and transparent manner. In such workflow, these commands are used to identify and resolve duplicated occurrences of an ID value in raw survey data, ensuring that observation is uniquely and fully identified. The commands combine four key tasks involved in solving duplicated ID values: (i) identifying duplicated entries; (ii) comparing observations with the same ID value; (iii) tracking and documenting any changes made to the identifying variable; (iv) applying the necessary corrections to the data.

On the first run of `ieduplicates`, a duplicate correction template is created listing all observations containing duplicated values of an ID variable that is intended to be unique. Observations are required to have a "key" variable that is unique in the raw data by construction so that they can be identified in processing.[7] After creating this correction template, `ieduplicates` will, by default, display a message pointing out that the intended ID variable does not uniquely and fully identify the data and stop your code, so you know to fill the correction template.

Once the correction template is created, `iecompdup` helps identify the reason why duplicated entries were created, so they can be resolved. The decision on how to correct a duplicate is always a qualitative decision. `iecompdup` compares the duplicated entries variable-by-variable. The output format can be selected by the user, depending on their decision process.

The commands are therefore intended to be used as follows:

1. Run `ieduplicates` on the raw data. If there are no duplicates, you are done. If there are duplicates, the command will output an Excel file containing a duplicates correction template, display a link to this file, stop the code execution and show a message listing the duplicated ID values. You can prevent the command from stopping your code by specifying the option `force`, in which case it will remove all observations with duplicated ID values and allow the code to continue.

2. Open the duplicates correction template. This template will list duplicated entries of the ID variable, information about each observation and 5 blank columns. Fill the blank columns with the necessary corrections and comments on the solution process.

3. If the information in the duplicates correction template is not enough to solve a case, use `iecompdup` for the listed ID value to obtain more information.

7. To be clear on the terminology: the key or unique variable is created within a survey or dataset to identify an observation and its uniqueness is guaranteed, while the ID variable is *intended* to uniquely identify an individual respondent and its non-uniqueness is therefore a data quality error. For example, an ID variable could be respondents' taxpayer number. If one person was accidentally interviewed twice or if a taxpayer number was mis-recorded as someone else's, each interview must still have its own unique key value, but some taxpayer number would appear twice as the ID variable even though it was intended to uniquely identify respondents.

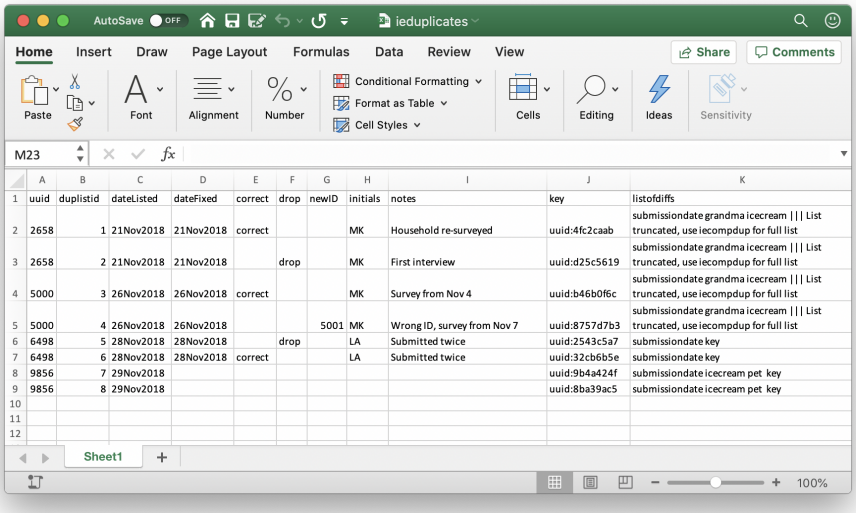
4. After entering all the corrections to the duplicates correction template, save it in the same location with the same name, overwriting the previous file.

5. Run `ieduplicates` on the raw data again. The corrections you have entered in the duplicates correction template will be applied, and only duplicates that are still not resolved will be removed this time.

6. Save the resulting dataset under a different name so the raw data is not overwritten.

7. Repeat these steps every time you receive new data.

An example of a basic duplicates correction template created by `ieduplicates` is displayed in Figure 1. The first six duplicated entries have been solved by filling columns E to I. When `ieduplicates` is run again, they will be dealt with as indicated. The other two are still to be resolved, so the next time you run the command, your code will stop unless the template is filled for them, or you choose to drop them through the `force` option. The function of this report is to impose a clear and consistent structure to document changes made to the information contained in the identifying variable.



	A	B	C	D	E	F	G	H	I	J	K
1	uuid	duplistid	dateListed	dateFixed	correct	drop	newID	initials	notes	key	listofdiffs
2	2658	1	21Nov2018	21Nov2018	correct			MK	Household re-surveyed	uuid:4fc2caab	submissiondate grandma icecream ||| List truncated, use iecompdup for full list
3	2658	2	21Nov2018	21Nov2018		drop		MK	First interview	uuid:d25c5619	submissiondate grandma icecream ||| List truncated, use iecompdup for full list
4	5000	3	26Nov2018	26Nov2018	correct			MK	Survey from Nov 4	uuid:b46b0f6c	submissiondate grandma icecream ||| List truncated, use iecompdup for full list
5	5000	4	26Nov2018	26Nov2018			5001	MK	Wrong ID, survey from Nov 7	uuid:8757d7b3	submissiondate grandma icecream ||| List truncated, use iecompdup for full list
6	6498	5	28Nov2018	28Nov2018		drop		LA	Submitted twice	uuid:2543c5a7	submissiondate key
7	6498	6	28Nov2018	28Nov2018	correct			LA	Submitted twice	uuid:32cb6b5e	submissiondate key
8	9856	7	29Nov2018							uuid:9b4a424f	submissiondate icecream pet key
9	9856	8	29Nov2018							uuid:8ba39ac5	submissiondate icecream pet key
10											
11											
12											

Figure 1: Partially filled `ieduplicates` correction template

3.1 Listing and resolving duplicate observations with ieduplicates

The purpose of ieduplicates is to ensure that observations are uniquely and fully identified. As inputs, ieduplicates requires, first, a singular unique ID variable, which, if repeated, would be an unacceptable duplicate in the dataset.[8] A file name for the duplicates correction template, including an absolute file path,[9] must be specified through using. Finally, the command requires a guaranteed way to uniquely identify each observation in the dataset, in the form of one or multiple variables. Software like SurveyCTO create these automatically by design, commonly naming such a variable a "key". Other data collection methods should have such an identifier built into their data collection process, as solutions such as using _n will usually not be sufficient. The formal syntax is:

```
ieduplicates id_varname using "filename.xlsx"
    , uniquevars(varlist)
    [force keepvars(varlist) tostringok droprest nodaily
    duplistid(string) datelisted(string) datefixed(string) correct(string)
    drop(string) newid(string) initials(string) notes(string)
    listofdiffs(string)]
```

When ieduplicates runs in a data set, it identifies all observations with duplicated values with regard to the variable specified as *id_varname*. If there are no duplicates, the command will display a message saying the data set is uniquely and fully identified by this variable. In this case, no output will be saved, and data will be left unchanged. If there are duplicates, the command exports an Excel sheet, saved to the file specified after using, with information on these observations, and stops your code with a message listing the values in the ID variable that are repeated. This is meant to operate similarly to the command isid, but offering both information to help identify the duplicated observations and a self-documenting method to easily fix them.

Alternatively, if the force option is specified, it will remove all observations containing duplicated values of *id_varname* from the data, and return only uniquely and fully identified observations. This may be useful because many other quality checks require unique IDs in the dataset and cannot be completed until the ID variable uniquely and fully identifies the data; yet resolving duplicated IDs is often among the slowest correction processes. For example, if a household with ID A123456 was selected for survey audit, but you incorrectly have two observations that were given the ID A123456,

8. Though this is not strictly necessary either for Stata or ODK, it is our preferred practice to use a single variable to identify an individual in the sample, as opposed to a combination of variables. This simplifies both the identification of duplicated entries and the tracking of individuals across survey rounds and datasets. If you adopt a different standard which uses multiple variables, this variable can be easily created by concatenating a set of variables or using Stata's egen , group function. (This variable can be string or numeric.)
9. For a discussion on why absolute file paths are required, see the article on file paths in the DIME Wiki: https://dimewiki.worldbank.org/wiki/Stata_Coding_Practices#File_paths.

then it is better to resolve that duplicate first before trying to compare the audit survey answers to either of the observations the ID potentially represents. The option `force` is required in this case so you know that `ieduplicates` is making changes to your dataset, and do not overwrite the original raw data with the one that has been returned, as you would lose the original data. To avoid this, always save the dataset with removed duplicates with a different name.

The duplicates correction template exported by `ieduplicates` contains at least 11 columns, in the following order: *id_varname*, indicating the value of the ID variable in the observation; *duplistid*, the unique identifier of the observation in the duplicates correction template; *datelisted*, indicating the date the observation was first included in the template; *correct*, *drop*, *newid*, *initials*, and *notes*, blank columns to be filled by the user to correct the data; *varlist*, one or multiple columns containing the values of the variables specified in `uniquevar` for the observations in the template; and *listofdiffs*, which lists the variables in the data set that are different across the duplicates observations. The names of the columns can be changed by specifying the column title desired within their respective options.

Inside the template, you can indicate corrections to resolve the duplicated observations. By this method, the completed template becomes a permanent documentation on how duplicated IDs were resolved from the raw data. There are three options for resolution offered as columns in the template: *correct*, *drop*, and *newID*. If you want to keep one of the duplicates and drop another, as they are double recordings of the same observation, then write "correct" in the *correct* column for the observation with the *key_varname* you want to keep, and "drop" in the *drop* column for the one you want to drop. If you want to keep one of the duplicates and assign a new ID to another one, write "correct" in the *correct* column for the observation you want to keep, and the new corrected ID value in the *newID* column for the observation that you want to assign a new ID to. You can combine these two methods if you have many duplicates with the same ID. Note that you must always indicate which observation to keep for each duplicate set. After you have entered your corrections, save the file and run `ieduplicates` again to apply the corrections – `ieduplicates` will automatically recognize that a partially completed template is already there.

Since the expectation is that the command will be used frequently as the data is collected, `ieduplicates` also manages a subfolder called `/Daily/` where it saves dated backups whenever it is re-run, in case the main corrections template or any contents are deleted. If two different templates are generated the same day, the second will be saved with an additional time stamp on the name. To restore a backup version, simply copy it out of the Daily folder and remove the date from the name. The option `nodaily` suppresses the creation of backups.

3.2 Analyzing duplicate observations with `iecompdup`

`ieduplicates` not only identifies duplicates, but also gives you some hints on how to resolve them by listing the names of the variables that are different across the compared

observations. Although this list could be very long, we restrict it to 250 characters to save space – it will be most helpful when only a few variables are different, and listing out all the variables in the dataset does not help. Furthermore, this comparison can only be done when there are exactly two duplicates. When there are more differences than can be stored by `ieduplicates`, or more than two duplicates, you can use `iecompdup` to explore differences. `iecompdup` requires as inputs the name of the intended unique ID variable (the same one as in `ieduplicates`) and the value that variable takes in the duplicate observations you wish to compare

`iecompdup` *id_varname* [`if`]`, id(`*id_value*`)`
[`more2ok didifference keepdifference keepother(`*varlist)*]

where *id_varname* is the name of the ID variable, and *id_value* value of the ID variable that is duplicated.

If you have several pairs of duplicates, you will need to run this command multiple times to see the comparison for each duplicated value of the ID variable. If there are more than two observations with a particular ID value to be compared, the command will return an error. This is because `iecompdup` can only be run on two duplicates at a time: the multi-way relationships among duplicate groups larger than two may be too complex to be informative. In this case, the `if` option should be used to select the pair of observations to be compared, usually by specifying the values of a uniquely identifying variable in the selected observations. Another solution is to use the option `more2ok`. This option allows the command to pick the two first observations in the sort order by default, in which case a warning message will be shown so that the user is aware that the sorting of observations will affect the result.

The default output for `iecompdup` is information on the number of variables where the duplicate pair has identical values and where the duplicate pair has different values. Two lists with the names of these variables are returned as macros. Specifying option `didifference` will also make the command print the list of variables with different values. The option `keepdifference` will `keep` a dataset containing only variables with different values across the duplicate pair (effectively, dropping those that are not of interest). The option `keepother(`*`varlist`*`)` may be used to retain additional variables that are useful for analyzing the duplicate pair.

After running `iecompdup`, you will be able to browse the dataset and explore the differences between observations to determine the best way to correct the duplicates. We have identified three cases as the main reasons for the occurrence of duplicated IDs when working with SurveyCTO. The section below lists them and indicates how `iecompdup` can be used to identify which of these cases applies to a particular pair of duplicates. The general picture should be the same even if you are using different software, but some details might be different. No output from `iecompdup` can guarantee any of the cases below, but most of the times the output will still be conclusive for one of the three cases.

- Case 1: Double submission of the same observation, with the same survey data values.

- Case 2: Double submission of the same observation, but with modified survey data values.

- Case 3: Incorrectly assigned ID.

Case 1 error is often a consequence of a circumstance like poor internet connection during data collection. If submission of data to the server is interrupted before completion, the incomplete data may still be saved (SurveyCTO servers never delete any data). When a second submission is received, it is also saved. The server cannot tell intentional and accidental submissions apart. In `iecompdup`'s output, such cases would result in two observations with very few differences, coming mostly from metadata such as submission time or submission ID (the `KEY` variable in SurveyCTO). If no media files (audio, images, monitoring) were used and all differences come from metadata, the user can resolve this according to their own practice. However, when a submission is interrupted, it is common for large media files such as audio or video to not upload correctly. Those files do not always appear as variables in Stata, depending on the data collection software, so in some cases only metadata variables will be different. This could be a field such as a filename pointer variable, that sometimes is submitted even when the file is not; therefore media files external to the data will need to be checked carefully in duplicated observations.

Case 2 errors are possible but rare in most data collection software, as it is bad practice to allow multiple complete observations with the same ID to be validly submitted. Recent advancements in "case management" workflows are available on most survey software to control this process. However, Case 2 errors may still occur if an observation if modified after the first submission and then resubmitted. Sometimes there is a need for modifying data already submitted; but then it is much better practice to do so in a do-file when the dataset is cleaned (such as through "revisions" workflows in the survey software). This way, the manual modifications are properly documented. In `iecompdup` this would show up as a pair where the submission metadata differs, and some observational data also differs. These cases have to be manually examined and followed up with the field team responsible for the submission to confirm which entry should be kept.

Case 3 errors can occur by mistake any time. This can be due to typos or to protocols not being followed correctly in the field. In `iecompdup` this would show up as submission data differing, as well as a many differences in survey responses. You will need to follow up with enumerators and supervisors responsible for this submission and assign a new ID to one of the observations based on what you learn when investigating this case.

4 The iecodebook commands

Once data collection is complete, the data must be cleaned before they can be analyzed. The `iecodebook` commands are designed to automate repetitive data cleaning tasks in two typical situations: `iecodebook apply`, where a large number of variables need to have arbitrary `rename`, `recode`, or `label` commands applied to them; and `iecodebook append`, when two or more datasets need to be harmonized to have the same variable names, labels, and value labels ("choices") in order to be appended together. `iecodebook` also provides an `export` subcommand so that a human-readable record of the variables and their labels in a dataset can be created at any time; and a `template` subcommand which prepares the codebooks for the other subcommands.

As its name suggests, the `iecodebook` command is structured around Excel-based "codebooks". The purpose of these codebooks is to process and document data cleaning in a format that is both human and machine-readable. By completing these codebooks with data cleaning instructions for Stata, a metadata record is created which is easier to write than a long sequence of data cleaning commands in a do-file; and easier to read later. This functionality is implemented via four subcommands:

- `iecodebook template`, which creates an Excel template that describes the current or targeted dataset(s), with empty columns for you to specify the changes or harmonizations for the other `iecodebook` commands.
- `iecodebook apply`, which reads an Excel codebook that specifies renames, recodes, variable labels, and value labels, and applies them to the current dataset.
- `iecodebook append`, which reads an Excel codebook that specifies how variables should be harmonized across two or more datasets - rename, recode, variable labels, and value labels - applies the harmonization, and appends the datasets.
- `iecodebook export`, which creates an Excel codebook that describes the current dataset, and optionally produces an export version of the dataset with only variables used in specified do-files.

4.1 Apply cleaning commands to the open dataset

The most common data cleaning tasks are renaming variables, applying variable and value labels, and recoding values. The `iecodebook apply` subcommand provides a workflow to execute any number of these commands without writing Stata code. Instead, the dataset is first translated into a template with each line describing the contents of a single variable. Then, the user fills out the template, creating a codebook that specifies all the cleaning commands they wish to execute. The `iecodebook apply` subcommand reads these commands and executes them all with a single line of Stata code. The resulting output is a cleaned dataset and a highly-readable record of the cleaning commands applied to it.

First, create an `apply` template with the dataset open:

`iecodebook template using "`*filename.xlsx*`" , [replace]`

Next, fill out the template with the specific instructions desired, then apply the completed codebook to the open dataset by writing:

`iecodebook apply using "`*filename.xlsx*`"`
`, [drop] [missingvalues(# "`*label*`" [# "`*label*`" ...])]`

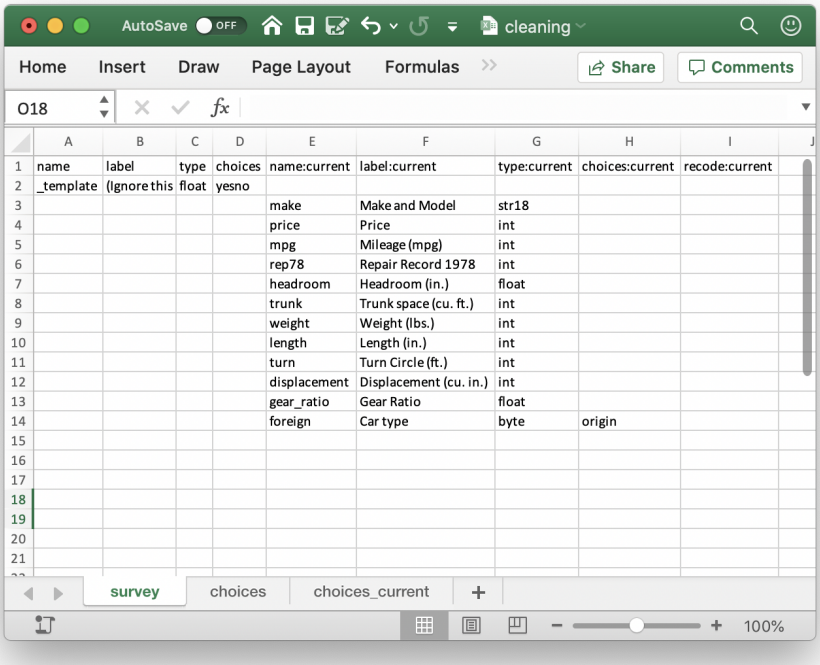
For example, running:

```
// Load data
sysuse auto.dta, clear

// Create cleaning template
iecodebook template using "cleaning.xlsx"
```

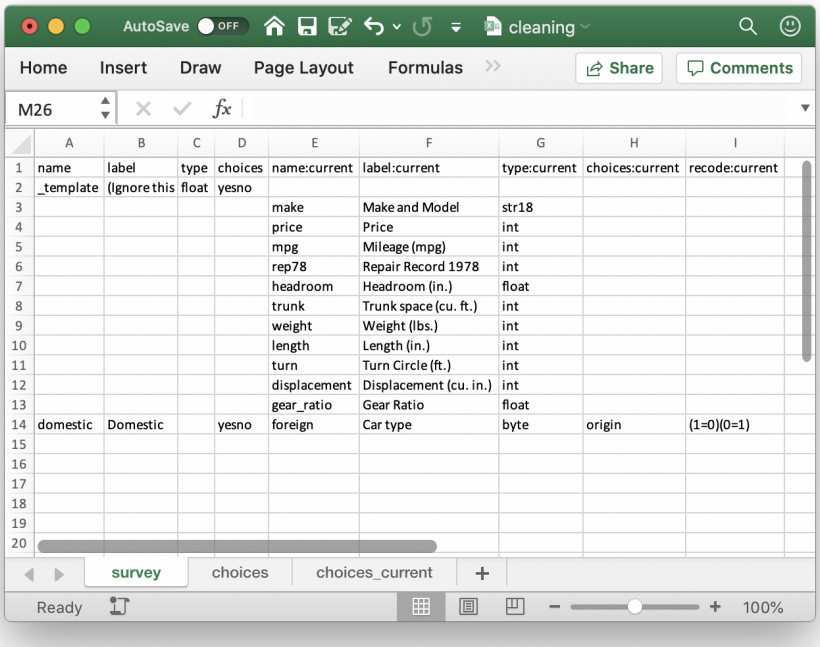
produces a template codebook reflecting the current state of the data, as displayed in Figure 2 after resizing the columns.

To apply changes to the data, complete the *name* and *label* columns to prepare `rename` and `label variable` commands for the current dataset, respectively. To apply value labels, enter a label name in the *choices* column and create the corresponding value label in the *choices* sheet (every template includes a demo `yesno` label as a guide). To `recode` data values, use the usual syntax `(`*rule*`) [(`*rule*`) ...]` in the *recode:current* column. The data types are given for reference only; the `iecodebook` command cannot change them. Figure 3 shows an example of what you might write to make some adjustments to the `foreign` variable.



	A	B	C	D	E	F	G	H	I
1	name	label	type	choices	name:current	label:current	type:current	choices:current	recode:current
2	_template	(Ignore this	float	yesno					
3					make	Make and Model	str18		
4					price	Price	int		
5					mpg	Mileage (mpg)	int		
6					rep78	Repair Record 1978	int		
7					headroom	Headroom (in.)	float		
8					trunk	Trunk space (cu. ft.)	int		
9					weight	Weight (lbs.)	int		
10					length	Length (in.)	int		
11					turn	Turn Circle (ft.)	int		
12					displacement	Displacement (cu. in.)	int		
13					gear_ratio	Gear Ratio	float		
14					foreign	Car type	byte	origin	

Figure 2: `iecodebook apply` data cleaning codebook template



	A	B	C	D	E	F	G	H	I
1	name	label	type	choices	name:current	label:current	type:current	choices:current	recode:current
2	_template	(Ignore this	float	yesno					
3					make	Make and Model	str18		
4					price	Price	int		
5					mpg	Mileage (mpg)	int		
6					rep78	Repair Record 1978	int		
7					headroom	Headroom (in.)	float		
8					trunk	Trunk space (cu. ft.)	int		
9					weight	Weight (lbs.)	int		
10					length	Length (in.)	int		
11					turn	Turn Circle (ft.)	int		
12					displacement	Displacement (cu. in.)	int		
13					gear_ratio	Gear Ratio	float		
14	domestic	Domestic		yesno	foreign	Car type	byte	origin	(1=0)(0=1)
15									
16									
17									
18									
19									
20									

Figure 3: `iecodebook apply` codebook filled out with changes to be applied

To apply the changes, you would then run the following command:

```
// Apply cleaning commands to open dataset
iecodebook apply using "cleaning.xlsx"
```

Note that the correct command is created by replacing `template` with `apply`. By default, all variables with no adjustments will be left as-is. However, this is not required: the `drop` specifies that all variables lacking a final variable name in the *name* column be dropped from the dataset. Alternatively, the user can place single periods "`.`" in the *name* column to drop variables one by one. The `missingvalues()` option allows global missing-value codes to be propagated to all value labels. All value label lists must be re-created in the *choices* sheet (it is blank by default except for a demonstrative `yesno` value label), but all value labels from the original dataset are available for copy-paste from the *choices_current* sheet.

4.2 Append and harmonize multiple datasets

A common downstream task in data collection is to combine two or more sequential rounds of surveys; or, similarly, to combine similar survey instruments conducted in different settings. This is always harder than it first sounds. Inevitably, updates and/or contextualizations have been made to at least one of the datsets, so that a simple `append` command will not produce the desired data structure. Most often, these changes cause desynchronisation of variable names, variable labels (including translation), value labels, and data types.

The `iecodebook append` subcommand offers a rapid workflow for documenting and resolving these differences across multiple datasets. The general syntax of its `template` subcommand is:

```
iecodebook template "filename.dta" "filename.dta" [...]
    using "filename.xlsx"
    , surveys(Survey1Name Survey2Name [...])
    [generate(varname)] [match] [replace]
```

The `match` option automatically aligns variables from multiple datasets if they share a name with a variable in the first dataset and is optional for the `template` subcommand only. To append the datasets using the rules from the codebook, use the `append` subcommand:

```
iecodebook append "filename.dta" "filename.dta" [...]
    using "filename.xlsx"
    , surveys(Survey1Name Survey2Name [...])
    [generate(varname)] [keepall] [report] [replace]
    [missingvalues(# "label" [# "label" ...])]
```

The `surveys()` option is required in both steps, and *must* match between them. The user should specify, as a list of single words, the names of the surveys (which the command will place and then look for in the codebook headers). The command will also create a `survey` variable in the resulting dataset by default, whose value label contains these names – to change the name of that variable, use the `generate()` option in both commands. The `report` option exports a codebook with the results for quick reference of the resulting dataset; the `replace` option allows it to be overwritten.

To demonstrate the usage, we will create two datasets that have similar data but with different structures, then combine them using a codebook. Run the following:

```
// Create demonstration datasets
sysuse auto.dta , clear
save data1.dta , replace
```

```
rename price cost
rename mpg car_mpg
    recode foreign (0=1 "Domestic") (1=0 "Foreign"), gen(origin)
    drop foreign
save data2.dta , replace

// Create harmonization codebook template
iecodebook template "data1.dta" "data2.dta" using "harmonization.xlsx"
    , surveys(First Second)
```

This should produce the a harmonization codebook template as shown in Figure 4.

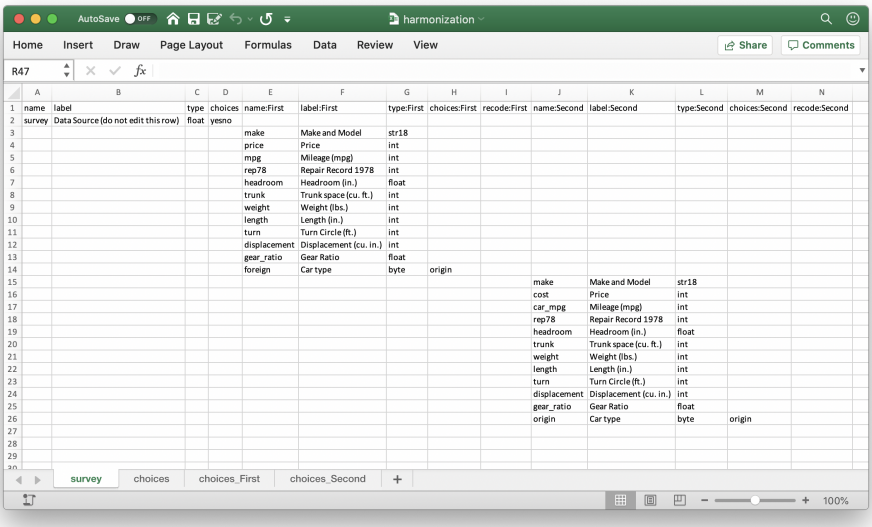
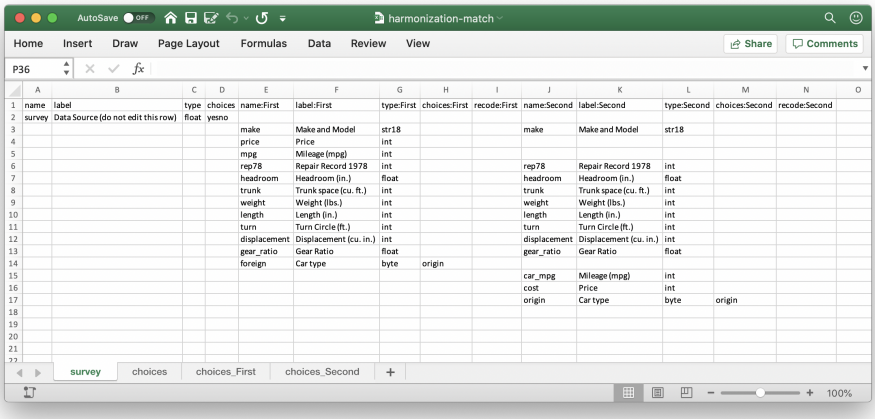


Figure 4: `iecodebook append` harmonization codebook template

Specifying `match` would cause it to appear as in Figure 5. Note that in this case the variables are ordered according to the first dataset they are encountered in; they are unaltered in the underlying datasets and `iecodebook` will never reorder variables beyond the functionality of the built-in `append` command.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	name	label	type	choices	name:First	label:First	type:First	choices:First	recode:First	name:Second	label:Second	type:Second	choices:Second	recode:Second	
2	survey	Data Source (do not edit this row)	float	yesno											
3					make	Make and Model	str18			make	Make and Model	str18			
4					price	Price	int								
5					mpg	Mileage (mpg)	int								
6					rep78	Repair Record 1978	int			rep78	Repair Record 1978	int			
7					headroom	Headroom (in.)	float			headroom	Headroom (in.)	float			
8					trunk	Trunk space (cu. ft.)	int			trunk	Trunk space (cu. ft.)	int			
9					weight	Weight (lbs.)	int			weight	Weight (lbs.)	int			
10					length	Length (in.)	int			length	Length (in.)	int			
11					turn	Turn Circle (ft.)	int			turn	Turn Circle (ft.)	int			
12					displacement	Displacement (cu. in.)	int			displacement	Displacement (cu. in.)	int			
13					gear_ratio	Gear Ratio	float			gear_ratio	Gear Ratio	float			
14					foreign	Car type	byte	origin							
15										car_mpg	Mileage (mpg)	int			
16										cost	Price	int			
17										origin	Car type	byte	origin		
18															
19															
20															
21															

Figure 5: `iecodebook append` harmonization codebook template using the `match` option

In either case, to resolve the differences in naming and labeling between datasets, the completed codebook might then be modified to look as in Figure 6. Note the key functionality of harmonization – variables from different datasets that are intended to be represented by the same variable in the final dataset are placed by the user into the same row. `iecodebook append` understands this to mean that they should have the same final variable names, labels, and value labels applied to them so that they `append` properly. `recode` commands must be handled dataset-by-dataset to prepare for this; therefore there is one *recode:* column for each data source as well as *choices_* sheets for reference.

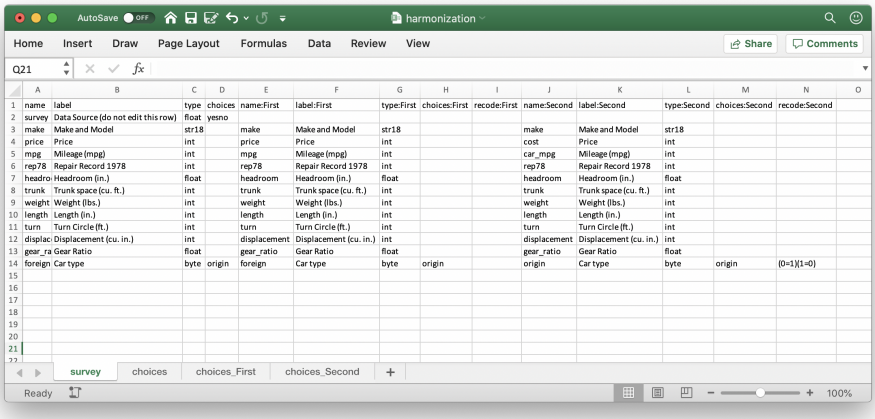
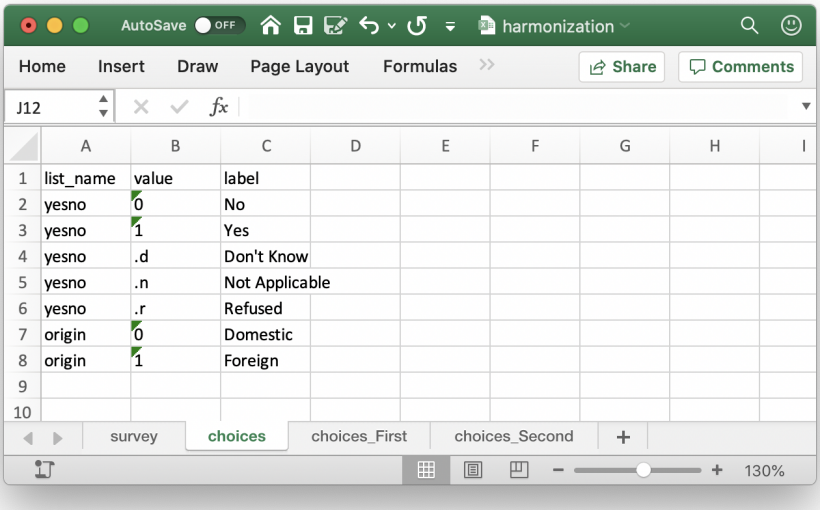


Figure 6: `iecodebook append` codebook, filled out with data harmonization instructions

There are two important differences from the `apply` syntax. First, the default is to keep only those variables which are explicitly given final names in the *name* column. This is to encourage explicit manual review of each variable. We note that this process can be sped up dramatically using Excel features such as splitting panes and formulae to rapidly move information from one portion of the spreadsheet to another. The `keepall` option may be specified to retain all variables from all datasets (except those flagged for deletion with a single period in the *name* column), but the user should check the final dataset carefully since appending variables without explicit review may cause unintended results (identical to use of the built-in `append` command without the `force` option). Again, note that you will have to manually recreate the value label lists in the *choices* sheet, but that the data labels from your original datasets are available for copy-paste from respective *choices_* sheets, as in Figure 7.



	A	B	C
1	list_name	value	label
2	yesno	0	No
3	yesno	1	Yes
4	yesno	.d	Don't Know
5	yesno	.n	Not Applicable
6	yesno	.r	Refused
7	origin	0	Domestic
8	origin	1	Foreign
9			
10			

Figure 7: *choices* sheet in a codebook

To execute the command, run:

```
// Harmonize and append the datasets
iecodebook append "data1.dta" "data2.dta" using "harmonization.xlsx"     ///
  , clear surveys(First Second)
```

The combined dataset will yield the following crosstabs, and, if the `report` option is specified, a codebook titled *codebook_report.xlsx* will be created in the same location as the append codebook documenting the final state of the dataset for quick reference.

```
. ta survey foreign

      Data |        Foreign
    Source |  Domestic    Foreign |     Total
-----------+----------------------+----------
     First |        52         22 |        74
    Second |        52         22 |        74
-----------+----------------------+----------
     Total |       104         44 |       148
```

4.3 Export a codebook for an existing dataset

The `iecodebook export` command provides a simple utility for documenting the current state of a dataset, and for preparing a trimmed "release" version of a dataset. The syntax is:

`iecodebook export using "`*filename.xlsx*`"`
`, [ replace trim("`*filename.do*`" ["`*filename.do*`"] [...]) ]`

The base command will simply produce a record of the dataset's contents at the specified location. If the `trim()` option is specified, `iecodebook export` will read the contents of the specified do-files; `drop` any variables that do not match the contents; restrict the dataset according to `if` and `in` as specified; and `save` the results in the same location as the codebook as a `.dta` file with the same name. Note that this is a new functionality and is imperfectly implemented: `trim()` will not, for example, correctly parse code that relies on macros to select variables. Therefore, please check that your results run and reproduce correctly after using this option. (We are working on a more fully-featured version for future release.)

For example, given a do-file titled `analysis.do` containing only the line `sum foreign mpg trunk`; and the `auto.dta` dataset, the command

```
iecodebook export using "codebook-trim.xlsx" , trim("analysis.do")
```

saves a codebook called `codebook-trim.xlsx` and a dataset called `codebook-trim.dta` in the same location. Both contain only the variables `foreign`, `mpg`, and `trunk`, since they are mentioned in the do-file.

5 Reference

Angrist, J., P. Azoulay, G. Ellison, R. Hill, and S. F. Lu. 2017. Economic Research Evolves: Fields and Styles. *American Economic Review* 107(5): 293–97. http://www.aeaweb.org/articles?id=10.1257/aer.p20171117.

About the authors

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All three authors are members of the DIME Analytics team, which creates tools and workflows that improve the quality and reproducibility of development research. There, they support best practices in econometrics, statistical programming, and research reproducibility across the i2i portfolio with the World Bank's Development Research Group Impact Evaluations department (DIME). This work comprises code and process development, research personnel training, and direct support for data analysis and survey development. The findings, interpretations, and conclusions expressed here are those of the authors and do not necessarily represent the views of the World Bank, its executive directors, or the governments they represent.