

The Methodology of Assessing the Economic Census¹

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The Economic Census

The Economic Census is an extensive questionnaire that collects data regarding the many facets of a business's operation from a wide array of industries, and is the foremost method of data collection for the U.S economy. The survey is conducted every five years, in years ending in a "2" or "7". The first Economic Census was collected in the early 1800's and contained only data from the manufacturing industry. By the 1950's the Economic Census had expanded to include businesses from the retail, wholesale trade, and the services industries. Today the scope of the Economic Census survey has broadened even further to provide a detailed picture of nearly the entire economy (Census Bureau History Staff, 2017). Now, the only industries excluded from the Economic Census are agricultural services, rail, and employment by private households, which are collected from surveys outside of the Bureau of the Census. As the amount of data collected has changed over time, so have the ways in which the data are collected.

Through the 2012 collection, the Economic Census was distributed to respondents via the mail. More recent iterations had respondents receive an authentication code and be required to download a computer program that would keep their data secure. Now, the Economic Census is taken entirely online via the Centurion instrument.

Centurion is a website designed by the Census Bureau that provides a secure environment for economic surveys to be housed. This website also offers several features that give respondents an opportunity to choose how they fill out and arrange their businesses data. Examples of these features include a downloadable spreadsheet template, the ability to print the survey, and several ways to review and edit the data among others described in this paper.

Due to the feature-heavy nature of the site and its novelty, usability testing was conducted to measure whether respondents would be able to successfully navigate through the site, and to what degree they would utilize its most critical components. The intention of this paper is to describe the methodology and results of that testing.

Usability Testing

"Usability" as a general term, is a *quality attribute* that can be used to help define how simple a user interface is to use. Usability is more formally defined as, "the extent to which a product can be used by specified users to achieve specified goals, with effectiveness, efficiency, and satisfaction in a specified context of use" (Rubin & Chisnell, 2008). Jakob Nielsen (2012) described the most prominent quality attributes associated with usability to include:

- learnability (how easy is it for a novice user to accomplish tasks?);
- efficiency (once design is learned, how quickly can they complete the tasks?);
- utility (How functional is the design, does it have all the features it needs?);
- errors (how many errors are made when attempting a task, are the errors easily amended by user?), and;
- satisfaction (how pleasant is it to use the design?)

Ultimately, one of the most important reasons to conduct usability research in any context is that if a user interface is not usable, then people are less likely to use it. In a business context, if people cannot navigate a business's website or trust that a secure transaction would take place, they might not place orders for products, resulting in lost income. In the context of data collection, poor usability often leads to survey breakoff and increases respondent burden, which in turn results in higher costs for the data collector by way of nonresponse follow-up efforts, less reliable data, or both.

¹ This report is released to inform interested parties of research and to encourage discussion. Any views expressed on statistical issues are those of the authors and not necessarily those of the U.S. Census Bureau.

“Usability” also refers to the *method* researchers use to improve a site. Usability testing is effective as a scientific approach to determine problem areas of an interface, by analyzing user behaviors that are observable and measurable. For example, a participant interacting with a website for the first time, may be asked by a researcher to locate the “save and logout” button. Simply by observing the participant, researchers can, a) time how long it takes the participant to find the button to get an efficiency quotient, b) rate the success of the task as a pass or fail, c) record how many clicks of the mouse it took to access the button to make inferences about the difficulty of the task, d) collect a rating of satisfaction once the task is completed. Now with the advancement of eye-tracking technology (which can demonstrate where a respondent is looking, for how long, and in what order), there are even more ways to assess the usability of a user interface. This all falls under the bracket of usability research, and many of these methods were used to assess the 2017 Economic Census Instrument.

Methods

Usability testing of the Economic Census was conducted during the months of May and June in 2017. Researchers traveled to coastal Texas, central Colorado, and eastern Missouri. Local visits were also made to northern Virginia, southern Maryland, and the District of Columbia. Each testing session consisted of the respondent navigating the website while being observed by a Census Bureau test administrator. Sessions were conducted at the participants’ place of business.

Thirty-eight participants interacted with the Centurion site by completing tasks that matched the actions that respondents will need to take when completing the actual 2017 Economic Census. All sessions included video and audio recording of the participant’s actions and verbalizations with respondent consent. Each usability session lasted approximately one hour.

Participants were instructed to think aloud while interacting with the website. The think-aloud technique is adapted from Ericsson and Simon’s (1993) method of collecting verbal feedback. This technique was used in this study to capture participant’s conscious thoughts, expectations and decisions that they verbalize, as they interacted with the site and completed the tasks.

This running commentary is of particular use when a respondent’s expectations are violated. The commentary highlights potentially problematic areas of the site, and allows researchers to gain an understanding of the participant’s underlying cognitive processes. Test administrators prompted participants to, “keep talking,” if they fell silent for more than ten seconds.

We preferred the think-aloud technique of verbal feedback rather than a retroactive approach, in which a researcher asks a respondent to recall their thoughts at the end of the session. The retroactive approach often fails to capture the more ephemeral thoughts that a participant has which may be forgotten or otherwise overlooked in retrospect Willis, (2004). The think-aloud technique gives researchers the opportunity to ask participants in the moment why they may have taken a certain action, or paused in the middle of a task. These on-the-spot inquiries often illuminate problem areas of a site that would have otherwise gone unnoticed or disregarded.

Tasks

Respondents reporting for multi-unit (MU) businesses (e.g., businesses having more than one establishment) have access to different features on the site than respondents reporting for single-unit (SU) businesses. The primary difference between these being that businesses with ten or more establishments have the option to submit their survey data through a downloadable spreadsheet that they can fill out, wherein each row of the spreadsheet represents an individual establishment. This approach is intended to ease the burden of filling out data for multiple establishments. Rather than filling out a web form from start to finish for every establishment separately, the respondent can populate from their business’s records into a spreadsheet template which has all their business locations and the survey questions located in one place. Because the survey experience can be so different between MU respondents and SU respondents, the tasks for participants were broken into two groups; those for MU participants, and those for SU participants. The tasks outlined for the MU participants included:

- a) Logging into the Centurion instrument;
- b) Locating and moving through the steps to print the survey;
- c) Downloading the spreadsheet template, then uploading the spreadsheet;
- d) Fixing any errors or warnings within the survey, and;

e) Submitting the survey.

The tasks for SU participants were all the same, save for the tasks involving downloading and uploading a spreadsheet. Instead of completing this step, SU participants were tasked with changing the address of their company. This task was designed to ensure that the participants could successfully enter data into the survey form. See Appendix A for list of tasks.

Participants

Thirty-eight participants were recruited for this study. Before performing the tasks for the study, participants first filled out a demographic questionnaire and answered several questions regarding their prior experience with the internet. All participants reported having experience with the internet. Researchers also recorded the respondent's familiarity with the Economic Census Survey itself. See Table 1 for highlighted details about participants' computer use and Internet experience.

Table 1. Participants' Computer Use and Internet Experience (n=38)

	<i>Experience (1: No Experience; 10: Very Experienced)</i>		<i>Comfort (1: Not Comfortable; 10: Very Comfortable)</i>	<i>Familiarity with Economic Census (1: Not Familiar; 10: Very Familiar)</i>
	Internet	Computers		
<i>Average rating</i>	8.32	8.24	8.81	6.32

A total of twenty-nine participants were recruited from MU businesses and the remaining nine were recruited from SU businesses. The multi-unit businesses are further categorized into their respective sizes according to the LMNS code (L=9; M=4; N=11; S=5), where 'L' represents highest number of employees (2,500- 10,000 or more), down to 'S' representing companies with the fewest employees (1-19). To maintain a representative sample, attempts were made during the recruitment process to get respondents from establishments of varying sizes and industries. The Manufacturing, Wholesale Trade, Healthcare, and Other Services were among the industries included in the sample for the usability evaluation.

A plurality of participants were over 51 years of age, while the rest of the age ranges were distributed relatively evenly. Nearly all participants received at least a bachelor's degree. Respondents came from a variety of company positions including Controller, CFO, Accountant, and Director of Operations, among others. Participants' tenure in these positions ranged from 3 months to 20 years, with an average of 6.6 years. See table 2 for a complete list of participant characteristics.

Table 2. Participants' demographic characteristics

Age Range (in years)	Number of Participants (n=38)
26-35	8
36-45	10
46-50	6
51+	14
Educational Level	Number of Participants (n=38)
Less than High School	1
High School	1
Some College	5
Associates degree	1
Bachelors	17
Post Bachelors	13

Usability Metrics and Data Scoring

Researchers utilized three primary metrics to assess the success of each task that the participant completed: a) Efficiency, as measured by completion time; b) Effectiveness, (or accuracy) by way of measuring the percentage of successful completions for each task, and c) Subjective Satisfaction, which was measured using a System Usability Scale questionnaire once each task had been completed. See Table 3 for a consolidated list of each data scoring metric. Each session was recorded using Camtasia Studio, which is a screen recording program that captures the audio well as every action taking place on the screen which allows researchers the opportunity to capture, and subsequently analyze, every action the participants take during the session.

Table 3. Performance data scoring metric

Measures	Scoring
<p>Effectiveness (accuracy) <i>Task Completion</i></p>	<p>A task is considered as being successfully completed if the participant was able to navigate through the instrument to complete a given task (via the optimal paths) without assistance from the test administrator. If the participant was able to successfully complete majority of the task with no assistance from the test administrator, the task will be coded as a partial success. Otherwise, if the participant failed to complete the task or required assistance, it will be coded as a failure.</p>
<p>Efficiency <i>Completion Time</i></p>	<p>Task completion time is defined as the amount of time (in seconds) it takes the participant to complete a given task using the 2017 Economic Census site.</p> <p>The start time begins when the participant is done reading the task question aloud and begins to interact with the site and ends when the participant states that they have completed the task or that they would like to move on to the next task.</p>
<p>Subjective Satisfaction <i>Ratings</i></p>	<p>Satisfaction ratings will be assessed based on subjective satisfaction ratings from the System Usability Scale questionnaire administered at the end of the usability session.</p>

By reviewing the tapes researcher documented the start and stop time of each task. There are several benefits to capturing timing data. Timing data was used as a measure of general efficiency. After taking an average across all participants, researchers were able to make inferences not just about how long the task will take for the average respondent, but also about the level of difficulty of the task.

The second means of assessing the usability of the site was to get an accuracy score for each task. For our purposes we used a straightforward means to record this data, where 1 indicated a success, 0 indicated a failure, and 0.5 was used to indicate a partial success. An example of a partial success might be a case in which the participant successfully navigates to the appropriate download spreadsheet button, but then fails to figure out the other aspect of the task, which is to upload the completed template.

Once participants had completed all the tasks, researchers administered the System Usability Scale (SUS), which is a post-test satisfaction questionnaire about the participant's overall experience using the site. See table 4 for a list of SUS questions and corresponding average scores across participants. The SUS has 10 questions on areas of the sites usability such as the sites' navigational properties, general functionality, and learnability among qualities. Response categories for the questionnaire are answered using a 10 point Likert Scale where 10 is the most positive response. The overall SUS score (using the SUS scoring rubric) for the 2017 Economic Census site was 71.74 (out of a possible 0-100 range) across all participants (n=38). Based on existing research, a score above 68 is considered above average.

Table 4. SUS questions and scores

Questions		Average SUS score (1-Strongly Disagree; 5-Strongly Agree)	
		Multi-units (n=29)	Single- units (n=9)
Q1	I think that I would like to use the site to complete the Economic Census	4	3.89
Q2	I found the site to be simple	3.72	3.78
Q3	I thought the site was easy to use	3.79	3.94
Q4	I think that I could use the site without the support of a technical person	4.14	4.22
Q5	I found that the various functions in the site were well put together	3.72	3.67
Q6	I thought there was a lot of consistency in the site	3.97	3.89
Q7	I would imagine that most people would learn to use the site very quickly	3.79	3.89
Q8	I found the site to be very intuitive	3.59	3.56
Q9	I felt very confident using the site	3.79	3.78
Q10	I could use the site without having to learn anything new	4.10	4.33

Each of these various methods of assessing the site, were implemented to ensure that researchers would be able to recognize issues as they arose and measure them quantitatively. In combination with the think-aloud procedure, the participants' running commentary throughout each session also insured that researchers could address respondent's difficulties in real time.

Future Directions

While results from this study were satisfactory, future studies of similar nature may benefit from the inclusion of tools such as an eye-tracker, and further analysis, such as behavior coding. There is a growing body of research regarding the benefits of eye-tracking tools, wherein participants' eye movements can be tracked and recorded in real time. Eye-tracking tools generally allow researchers to view the path of eye movements in numerical order, the amount of time someone is fixated on something, and produce heat maps.

Conclusion

Researchers primary goals of this study were to (1) evaluate the instruments' performance in terms of efficiency, accuracy, and user satisfaction (2) identify areas of the instrument that are problematic for users (3) identify instructions/features that are difficult for users to understand, and (4) provide recommendations for improvements to the design of the instrument that will enhance its usability. Through usability testing, researchers were able to meet these goals. In the months following the 2017 Economic Census usability evaluation, several significant changes were made to the instrument.

The methodology used during this study to meet these goals included a combination of usability metrics, observed behaviors, and participant commentary. Using this multi-mode approach to data collection allowed researchers to gain an elucidated understanding of the functionality and usability of the Economic Census instrument.

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References

- Census Bureau History Staff. (2017, July 18). *History of the Economic Census* . Retrieved February 2, 2018, from https://www.census.gov/history/www/programs/economic/economic_census.html
- Ericsson, K. A., & Simon, H. A. (1993). *Protocol Analysis: Using Verbal Reports as Data*. Cambridge, MA: The MIT Press.
- Nielsen, J. (2012, January 4). *Usability 101: Introduction to Usability*. Retrieved February 16, 2018, from <https://www.nngroup.com/articles/usability-101-introduction-to-usability/>
- Rubin, J., & Chisnell, D. (2008). *Handbook of usability testing: how to plan, design, and conduct effective tests*. John Wiley & Sons.
- Willis, G. B. (2004). *Cognitive interviewing: A tool for improving questionnaire design*. Sage Publications.

Appendix A: Multi-unit and Single-Unit Task Questions

Multi-unit Task Questions

Task 1: To get started, log into the survey using the information provided.

Task 2: Your company has gone through some changes and you need to make some updates to the location listing.

- **Part A:** Your company has added 2 new locations. Please update the listing to reflect these additional locations.
- **Part B:** The locations you added in Part A no longer exist. Remove the locations from the listing and Return to the Dashboard
- **Part C:** View/arrange locations by EIN

Task 3: Does the website allow you to see a copy of the survey questions before beginning the survey? If so, how would you do that?

Task 4: You would like to begin reporting. Please identify how you could report using this site. *Any other ways to report?*

Task 5 : Report using the spreadsheet functionality and do the following:

- **Part A:** Download and save a full survey spreadsheet to the desktop and Save as *Test*. *Note: Save only one survey form*
- **Part B:** Upload the saved *Test* spreadsheet to the instrument

Task 6: You would like to view what you have already reported prior to sending.

- **Part A:** Please review your data on the site
- **Part B:** The test administrator will show you a survey that has errors and warnings, how would you resolve problems with the data? Please do so.

Task 7: You are now done with the survey and ready to send your data. Please send your data for the Economic Census.

Single-unit Task Questions

Task 1: To get started, log into the survey using the information provided.

Task 2: Does the website allow you to see a copy of the survey questions before beginning the survey? If so, how would you do that?

Task 3: You would like to begin reporting. Identify how you could report using this site?

Task 4: Begin reporting to a survey and do the following:

- **Part A:** Update the company's mailing address to 123 TEST LANE

Task 5: You would like to view what you have already reported prior to sending.

- **Part A:** Please review your data on the site

- **Part B:** The test administrator will show you a survey that has errors, how would you resolve problems with the data

Task 6: You are now done with the survey and ready to send your data. Please send your data for the Economic Census.

Appendix B: Report Dashboard before and after recommended changes were implemented

Screenshot of Report Dashboard During the Usability Study

Help Site About Contact

Messages 0
Logout

2017 Economic Census

OMB No.: 0607-0998 | Approval Expires: 05/31/202
 OMB No.: 0607-0937 | Approval Expires: 05/31/202
 OMB No.: 0607-0444 | Approval Expires: 05/31/201

Go to Overview

Go to Step 1 - Report

Go to Step 2 - Review

Go to Step 3 - Submit

Step 1 - Report Dashboard

A. Review our list of your locations below

B. Add locations that are missing by selecting the "Add Location" button

C. Start reporting data by

- Individual locations (click "Start" buttons)
- All locations (click "Download Spreadsheet Template" button)

D. To preview or print questions and instructions, click the icon under the "Preview Questions and Instructions" column

- This document will contain your answers to the survey as you fill it out.
- You can print this document to have a copy of your responses for your records

E. To see the list of locations for a consolidated report, click "(View All)" under the "Num. Estabs. in Survey" column

+ Add Location
✖ Delete Added Location
 Download Spreadsheet Template
 Upload Completed Template
 Summary Data

Status	Preview Questions and Instructions	Errors / Warnings	Num. Estabs. in Survey	Survey	Title	CFN	Store / Plant	Name
Start		0/0		MC-31320	Broadwoven Fabric Mills	ADD_500002		
Start		0/0		MC-31320	Broadwoven Fabric Mills	ADD_500001		
Start		0/0		MC-33110	Iron and Steel Mills and...	7710010034	ME4	TEST I
Start		0/0		MC-31320	Broadwoven Fabric Mills	7710010033	TN2	TEST I
Start		0/0		MC-31310	Fiber, Yarn, and Threa...	7710010032	CA2	TEST I
Start		0/0		MI-21110	Crude Petroleum and N...	7710010031	WV7	TEST I
Start		0/0		MC-33110	Iron and Steel Mills and...	7710010024	ME4	TEST I
Start		0/0		MC-31320	Broadwoven Fabric Mills	7710010023	TN2	TEST I
Start		0/0		MC-31310	Fiber, Yarn, and Threa...	7710010022	CA2	TEST I
Start		0/0		MC-31310	Crude Petroleum and N...	7710010021	WV7	TEST I

Total Items: 14

Screenshot of Report Dashboard After Recommendations had been implemented:

Help Site How-To Videos About Contact

Messages 1
Logout

2017 Economic Census
OMB No.: 0607-0998, Approval Expires: 05/31/2020 | OMB No.: 0607-0937, Approval Expires: 05/31/2020 | OMB No.: 0607-0444, Approval Expires: 05/31/201

Go to Overview
Go to Step 1 - Report
Go to Step 2 - Review
Go to Step 3 - Submit

Due Date: June 12, 2018

✎ Step 1 - Report Dashboard

1. Update our record of your company's locations by adding locations as needed using the Add Location button at the bottom of the screen.
(Note: To see the list of locations of a consolidated report, click "(View All)" under the "Number of Establishments in Survey" column.)

2. Begin reporting using one of the following options:

Option 1: Start the survey for each location listed in the table below OR

Option 2: Download, and then Upload a completed spreadsheet template to complete the survey for many locations at once

Download Spreadsheet Template
Upload Completed Template

Status	Print / Preview Survey Questions	Errors / Warnings	Number of Establishments in Survey	Survey	Title	CFN	Store / Plant
				<input type="text" value="Filter"/>	<input type="text" value="Filter"/>	<input type="text" value="Filter"/>	<input type="text" value="Filter"/>
Resume	✖ Preview Survey	0/5		WH-42311	Motor Vehicles	ADD_500002	
Resume	✖ Preview Survey	0/0		WH-42311	Motor Vehicles	ADD_500001	
Start	✖ Preview Survey	0/0		RT-45231	Warehouse Clubs and...	7609010043	SD1
Start	✖ Preview Survey	0/0		OS-8111X	Repair, Laundry, and O...	7609010042	VA7
Start	✖ Preview Survey	0/0		WH-42311	Motor Vehicles	7609010041	MA1
Start	✖ Preview Survey	0/0		RT-45231	Warehouse Clubs and...	7609010033	MI4
Start	✖ Preview Survey	0/0		OS-8111X	Repair, Laundry, and O...	7609010032	VA7
Start	✖ Preview Survey	0/0		WH-42311	Motor Vehicles	7609010031	SCH NY
Start	✖ Preview Survey	0/0		RT-45231	Warehouse Clubs and...	7609010023	SD1
Start	✖ Preview Survey	0/0		OS-8111X	Repair, Laundry, and O...	7609010022	VA7

Total Items: 14

Print Surveys to PDF
+ Add Location
✖ Delete Added Location

Overview

Step 2 - Review