ECONOMIC DATA COLLECTION VIA THE WEB: A CENSUS BUREAU CASE STUDY

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BACKGROUND

Past tests by the Census Bureau of diskette Computerized Self-Administered Questionnaires (CSAQs) showed several limitations such as paper laden mail packages, labor intensive mail out operations, costly postage and mail materials, operating system limitations, with no timing savings enroute (Sweet and Ramos, 1995). In theory, using a CSAQ over the Internet (i.e., a Web CSAQ) has the potential to increase data accuracy and reduce respondent burden by controlling the flow of survey questions and performing consistency and completeness edit checks as respondents enter data, which are advantages of diskette CSAQs, while minimizing the mail, preparation, and maintenance costs of diskette CSAQs. This, coupled with the fact that many large U.S. companies have some kind of Internet connection (Groenfeldt, 1995), and the fact that we are developing CSAQs for establishment surveys, prompted our research into using Web CSAQs. Several questions exist since this is such a new mode of collecting data for federal statistics: What is the appropriate software to use for a Web CSAQ? How should one design the questionnaire? And, what is the respondent's perception of and willingness to use the Internet for this purpose?

With these questions in mind, during 1996-97 the Census Bureau investigated whether we could collect data confidentially over the Web with a CSAQ that met respondents' needs. We tested a Web CSAQ on 50 production companies selected for the 1996 Industrial Research and Development (R&D or RD-1S) survey. The 1994 R&D survey had served as a test bed for previous diskette CSAQ studies, and the sponsor, the National Science Foundation (NSF), was agreeable to testing a Web CSAQ within the 1996 survey.

DESIGN OF THE 1996 R&D WEB CSAQ

The 1996 R&D Web CSAQ, authored by in-house staff in HTML and JavaScript, is considered an interactive CSAQ. Unlike batch CSAQs, which are saved to the respondent's hard drive and executed on his/her own PC, an interactive CSAQ is stored on the Web server. Data are stored on the server as well, thus the respondent's machine merely acts as a display and entering device. Interactive Web CSAQs require the respondent to access the CSAQ's URL every time s/he wants to use it. The 1996 R&D Web CSAQ used a username and password for authentication and access control, and encrypted data transmittal over Netscape's Secure Socket Layer (SSL) to ensure confidentiality. This combination of security features allows protection of the reported data as it travels across the Internet and as it resides on the Census Web server (Sedivi and Nichols, 1998).

The addition of JavaScript to the HTML code allowed the 1996 R&D Web CSAQ to do real time editing and branching, implement a screen-based design as recommended by the expert review process (Sweet, et. al., 1997), and open a separate window containing the CSAQ. This window covered the Netscape browser window and icons. Using this design, we hoped to create the sense of a separate application so that respondents would not rely on the "Back" button on the browser. The addition of JavaScript, however, also limited the universe of potential respondents to those with a Windows 95/Netscape 3.0+ configuration.

Six of the 16 screens contained the six data items collected in the short version of the mandatory questionnaire (Form RD-1S) used in 1996. These collect data for company sales and employment, number of scientists and engineers, current R&D expenditures, predicted future R&D expenditures, coverage/operations status, and contact information. In addition to reporting current year data, respondents could revise figures reported for the previous year. Historical prior year data was included if it was reported in the previous year.

Other screens contained help information, review of edit failures, and evaluation questions. The last screen of this Web CSAQ was the exit screen or "Finish" screen. Respondents could either close the application and not send any data, or choose a partial submission or a final submission on the "Finish" screen. Respondents who closed the application or made a partial submission could re-enter the Web CSAQ later and add additional data. We disabled the username/ password for respondents who chose a final submission. They would not be able to access the Web CSAQ again.

On each screen, a menu bar on the right side of the form allowed the respondent to jump to any screen within the form. We refer to this as non-sequential navigation within this paper. Next and previous buttons were available at the bottom of each screen of the form. These moved the respondent through the form in sequential steps, either forward or backward. No scrolling was implemented in this design.

During development, there were numerous discussions as to how, or even if, respondents would use all the navigation and submitting features. Metrics were added to allow some insight into these questionnaire design issues. These metrics, which were programmed as simple counts on the navigation and submitting features, were invisible to the respondent. This added no additional burden.

METHODOLOGY FOR THE PILOT TEST

The R&D Survey is designed to measure levels of research and development activity for U.S. companies. Only companies spending one million dollars or more annually on research and development are included in the survey. On October 23, 1996, a paper screener questionnaire was mailed to 2,615 respondents on the 1995 RD-1L mail panel to determine eligibility in reporting on the Web CSAQ for the 1996 R&D survey. Eligibility was defined by both interest in reporting using that mode and having the Windows 95 and Netscape 3.0+ configuration. Fifty of the 66 eligible screener respondents who matched current year's sample panel (the 1996 RD-1S panel) became the official list of Web CSAQ cases for this pilot. These 50 companies received the Web CSAQ package which included a notification letter containing the URL of the Web CSAQ, username, and the randomly generated password for the company, a letter from the NSF, and a flyer. All other 1996 RD-1S companies received the Form RD-1S paper questionnaire and a diskette CSAQ, custom coded by an outside contractor, Fenestra Technologies Corporation. The 50 selected Web CSAQ test companies were notified of their selection by mail at the same time that the Form RD-1S paper questionnaires and diskettes were mailed. This occurred on April 15, 1997. A maximum of three follow-up letters were mailed to all survey non-respondents, including Web CSAQ non-respondents. A telephone follow-up of delinquent Web CSAQ cases was conducted from August 4 to August 26. This was prior to September 8, 1997, the date the port through the firewall to our CSAQ Web server was closed. After that date respondents could no longer submit data over the Web. One week after the telephone follow-up began, a paper RD-1S questionnaire was mailed to the delinquent companies giving them an optional mode of reporting.

A help desk was typically monitored by the Web CSAQ developer during business hours. A document, containing all the problems and resolutions encountered during the load testing and development, was available to whomever was working at the Web CSAQ help desk. In addition that same person monitored the Web CSAQ server in case there were any system failures.

METHODOLOGY FOR THE ANALYSIS

To address the questions of appropriate software, questionnaire design, and ability and interest in using a Web CSAQ, we examine results from the screener questionnaire, response rate, help desk, evaluation questions and user metrics.

SCREENER QUESTIONNAIRE RESULTS

Forty-two percent (523/1,234) of the screener respondents had Web access and were willing to use it to report. Although we expected a high incidence of interest in and ability to report via the Web since these were large companies, only 73 screener respondents or six percent of the 1,234 screener respondents were willing and able to report on our HTML/JavaScript CSAQ based on its specialized software requirements of Windows 95 and Netscape 3.0+. (In January 1997, when the cases were selected to participate in the test, we had a total of 66 screener questionnaire responses that would qualify to use our Web CSAQ.) Thus, it appears that our stringent browser and operating system needs greatly limited the eligible universe.

Of those screener respondents who had Web access, about 90 percent were willing to use it to report their R&D data. Only fifty-seven of the 1,234 screener respondents were able to report via the Web, but unwilling to do so. Security concerns were the primary reason (39%) why these respondents were unwilling to report via the Web. These respondents were not confident that their sensitive, proprietary data would be secure on the Web. Another large group of respondents (21%) stated that although their company has Internet access, the people who would be entering the data into the survey did not yet. Several indicated that in about a year they would be ready to use the Internet for electronic reporting. Two respondents said that company policy limits the use of the Internet. About 16 percent of the respondents reported that they recently obtained Web access and have not been trained or have not become familiar enough with it yet to report electronically.

RESPONSE RATE RESULTS

The Census Bureau collected data from 34 respondents over the Web for the 1996 R&D survey. The 68 percent return rate for the 50 selected Web CSAQ test companies was lower than expected and is lower than the 84 percent return rate for non-Web respondents. The pattern of higher return rates for non-Web respondents was also seen through all phases of the follow-up. Of the 16 test companies that did not report via the Web, 13 mailed in a paper questionnaire, two were delinquent as of 9/16/97, and one company FAXed their report after an unsuccessful Web transmission.

Table 1: Cumulative Response Rates

	Mail Follow-up			Final
	1st	2nd	3rd	
Mode	5/16/97	6/17/97	7/16/97	9/8/97
NonWeb(n=2552)	42%	64%	76%	84%
Web(n=50)	6%	34%	42%	68%

HELP DESK FINDINGS

Perhaps the most disturbing phenomena of this pilot test was the number of calls to the help desk. In fact, over half (56%) of the Web CSAQ reporters called the help desk. The volume of calls was unexpected and a similar percentage could not be handled in a production setting. Half of the calls arose simply because companies did not have the letter containing their username and password. This information which was on the original letter, was not on any of the follow-up letters. Most likely, the original letter, which did not have any unique features, was simply misplaced or thrown out. A number of the other calls came in due to browser configuration problems. All problems raised during the help calls had been anticipated and were on a preprinted list of potential problems and solutions.

EVALUATION QUESTIONS RESULTS

Eighty-eight percent (30/34) of the respondents who performed a final submission of their data completed at least one of the eight evaluation questions embedded in the 1996 R&D Web CSAQ. These questions pertained to the respondent's opinions about the design and functionality of the CSAQ. These same questions were asked in the 1994 R&D CSAQ test. The 1994 CSAQ respondents were also self-selected using a similar paper screener questionnaire, but the 1994 interface was DOS-based. Based on the responses to the evaluation questions in 1994, recommendations were made to use a Windows environment for future CSAQs. Item nonresponse is ignored in the percentages presented.

Approximately 86 percent (26/30) of the 1996 respondents were either satisfied or very satisfied with the CSAQ reporting system. This same percentage thought the overall system was very easy. No one was dissatisfied with the system or thought it was difficult. Seventy-six percent were satisfied with the 1994 R&D CSAQ. A few 1994 respondents even said that CSAQ system was difficult to use (Sweet and Ramos, 1995).

About 79 percent of the 1996 respondents thought the screen appearance was very good or excellent and over 90 percent of the respondents found moving within a screen, moving between screens, and entering data to be very easy. In the 1994 R&D CSAQ moving within a screen was noted as a problem area (Sweet and Ramos, 1995) and each of those three categories received at least one difficult rating. The change from a DOS to a Windows environment brings many potential enhancements. The use of the mouse, color, and non-character based navigation all could be probable reasons for the 1996 ratings as compared to the 1994 DOS-based system.

Although it is difficult to make sense of an evaluation question that asks how easy it is to exit prior to doing so, about 73 percent of the respondents (n=26) who responded to the evaluation of the 'exit' feature found it to be very easy to use. Perhaps these people answered based on their ability to find the exit, or their ability to interpret and use the no submission or partial submission exit feature. About 82 percent of the respondents found re-entry very easy. Two respondents found it difficult. We do not know why they found it difficult.

Even though most respondents were satisfied with the 1996 R&D Web CSAQ, 44 percent had problems with the system. Three main problems with using the system were gleaned from the open ended evaluation questions. (1) Some respondents did not initially use the Netscape 3.0 browser to access the system even though we selected respondents who reported sufficient operating system/browser configurations and specified the browser version to use on both the initial username/password CSAQ screens and in the flyer in the original Web package mailing. (2) Using client- side memory the CSAQ wrote data to an internal file every time the respondent moved to a different screen within the instrument or anytime the edits were run. Browsers have the ability to notify the user when this happens with a message. Some respondents knew how to turn the message off, but didn't want to; other respondents didn't know how to turn off the message. We were aware of this potential problem during testing. (3)Some evaluation comments suggest that the download time was too long, but did not specify how long it took them. We were unaware of this problem during testing and expected approximately a 1 to 2 minute download time on a 28.8 modem. The HTML/JavaScript Web CSAQ was approximately 200K in size.

The respondents appeared to overcome these difficulties. Assuming the two populations are similar, the evaluation response trend and the open-ended evaluation questions suggests that the 1996 Windows-based CSAQ is more favorable than the 1994 DOS-based R&D CSAQ. They found it easy to use and all but one respondent would select the Web CSAQ for future reporting.

USER METRIC RESULTS

Answers to the evaluation questions, while informing us that respondents were satisfied with the design, do not tell us how they used the design. Results

from the user metrics allowed us to determine which of the navigation and submission options respondents used, and how they use these options.

Navigation

The HTML/JavaScript developer programmed the Web CSAQ to count the number of times the Next, Previous, and Menu buttons were used. Since the form was relatively simple with 16 screens and no screen branching, often we can reconstruct the actual pattern of navigation; other times we can only make a reasonable guess at the pattern. These counts were for the final access into the Web CSAQ only. That is, if a respondent accessed the CSAQ more than once, we did not sum the counts across sessions. With these caveats, our examination leads to these conclusions:

1) The next button was used as the primary mode of navigation. On average, a respondent used the next button to visit 17 screens prior to submitting data. Only one respondent used the next button only once. One respondent used the next button 42 times.

2) The previous button was not used as a primary navigation tool. Although the button was used by a little over half (19) of the respondents, it was only used to move back on average once or twice. Only one respondent used it to move back 12 times.

3) The menu bar was used on average 7 times, but there was some variation. Six respondents never used the menu bar, while three respondents used the menu bar over 20 times. One respondent used the menu bar to navigate through the form while never using the previous button and only using the next button once.

Based on these statistics, we concluded that the two navigational models implemented, both sequential and non-sequential navigation were used by respondents during the final access of the questionnaire. A printout of the sorted navigational data showed patterns of navigation not expressed by the above statistics. Using the average method in SAS' proc cluster, we grouped respondents together based on the number of times the menu bar, the next and previous button were used. Four main clusters of respondents were determined from the 34 respondents. They differed by the number screens visited, and the number of times they used the next button and menu bar.

Cluster	Avg. # of screens	Menu	Next	Previous
1(n=14)	16.86	1.50	14.50	0.86
2(n=7)	28.57	8.43	19.00	1.14
3(n=5)	31.60	4.40	26.0	1.20
4(n=3)	16.33	7.33	8.67	0.33
5 outliers				

Clusters 1 and 4 are similar in the average number of screens visited during their final access to the Web CSAQ, but they have very different navigational patterns. Respondents in both clusters only visited on average between 16 and 17 screens. Cluster 1 respondents used the next button primarily and Cluster 4 respondents used both the next and menu bar. We hypothesize that Cluster 1 respondents progressed sequentially, visiting every screen, through the CSAQ using the next button. We can hypothesize this response pattern because there were only 16 screens (15 Next buttons) in the entire Web CSAQ. (Three of the 14 respondents never used the menu bar, and so we are positive they progressed sequentially.) Unlike Cluster 1, we are not sure what screens Cluster 4 respondents visited. They could have visited all screens once and just changed navigational modes, or they could have visited only a portion of the screens a few times.

Clusters 2 and 3 respondents visited screens more frequently than Cluster 1 and 4 during their final access to the Web CSAQ. Clusters 2 and 3 also have slightly different navigational patterns. Cluster 2 respondents used the menu bar more and the next button less than Cluster 3 respondents. It is possible that Cluster 2 respondents used the next button to go to each screen at least once, or more than once, but we cannot conclude that from these statistics. These respondents also used the menu bar from 4 -14 times to visit the screens. We are not sure if they used the menu bar in a sequential manner or if they jumped back and forth between screens. Cluster 3 respondents are likely to have navigated sequentially through the instrument using the next button, then used the menu bar to return to the beginning of the questionnaire, and proceeded sequentially through the form again using the next button. There was some variance in Cluster 3, and this cluster could potentially have been divided into two groups since two of the five used the menu more frequently than the other three.

Five respondents were outliers. One outlier respondent used the previous button 12 times, far more than anyone else. This person also used the menu bar and next button quite a few times, but these numbers were not so unusual. Another outlier respondent only used the menu bar to navigate to each screen once. The remaining three outlier respondents appear to be either quite curious or confused, since they used the next and menu bar repeatedly. We propose that these three respondents probably are not confused, since comments in their evaluation sections are not problem oriented. In addition, CSAQ literature has documented a novelty effect when CSAQs are used (Pilon and Craig, 1988). A larger sample size might allow us to determine if there is yet a fifth group of "novelty" respondents.

Results from the cluster analysis suggest that during the final access to the CSAQ the majority of

respondents (14/34 + 5/34) navigate in a forward sequential manner, even those who tend to visit screens more than once. The next button provides a means to do so. A smaller group tend to use the menu. Perhaps they too use the menu in a sequential manner (we cannot determine that from these results). A very small group (three outliers) we suspect played with the instrument.

Determining whether these clusters can be replicated, and if so, whether they are correlated to other data, such as computer skill level of the respondent, subject matter material knowledge , whether the respondent printed out the questionnaire prior to entering data, data quality, or even the contentiousness of the respondent, might prove useful in terms of designing real time user guidance.

Access and Submission

The ability to partially answer a questionnaire, save answers, and re-enter the questionnaire at a later time might be an important design feature, especially for economic surveys where a respondent could look up answers in a file, call someone who knows the answer, or experience work place interruptions. We kept track of the access and submissions response pattern for this Web CSAQ test.

Respondents could access the Web CSAQ and close the application on their PC without ever submitting anything to the Census Bureau Web server as often as they wished. Over 40 percent (14 of the 34) of the respondents did so prior to making their final submission. Although we do not have information about what happens in the interim when this type of access is performed, we hypothesize that the questions are probably reviewed and/or printed. Respondents then close the application, find answers to the questions, access the CSAQ again, complete the CSAQ and make a final submission.

Twenty-nine percent of the respondents (10 of the 34) completed and submitted their data with their first and only access to the CSAQ. These respondents did not show a different navigational pattern, based on the cluster analysis, as compared to the other respondents.

Partial submission allowed the respondent to save data entered and re-enter the CSAQ at a later time, to complete the CSAQ, review and/or change their previous answers. About 21 percent (7 of the 34) completed part of the CSAQ and submitted it, only to finish the CSAQ at another time.

Respondents could enter, exit and submit their answers as much as they wanted. Three of the 34 respondents enter and re-enter several times, sometimes saving data, sometimes not, prior to making the final submission.

Results from these submission statistics show a pattern of response to this interactive CSAQ that confirms the need for access without submission and to a lesser extent, access with a partial submission for this relatively short questionnaire. Submission statistics patterns, however, might change with varying lengths and complexities of surveys. The more complex the survey, we would imagine the greater need for partial submission.

DISCUSSION

What is the appropriate software to use for a Web CSAQ?

Even though 34 self-selected respondents completed this Web CSAQ, we determined limitations of the HTML/JavaScript combination that prevent us from recommending this programming language combination for future Web CSAQs. (1) Using this combination with the necessary security only works on particular browser/operating system configurations. This eliminated many of our potential candidates from the testing pool. (2) Browser configuration issues was one of the reasons why over half of the 34 respondents called into the help desk. In a production mode, one developer could not answer a similar percentage of calls, thus a more robust Web CSAQ is needed.

So far, finding ideal software for developing CSAQs and other CAI technology has been somewhat elusive. The combination of end-user hardware and software limitations, complex survey design, limited programming staff resources coupled with the need for multi-mode development has left us with a long list of functional requirements. Outside experts recommend using commercial off-the-shelf (COTS) software to develop CSAQs and other CAI technologies.

How should you design the questionnaire?

From the evaluation questions responses from the 34 self-selected respondents suggest that the Windows based design is more favorable than the earlier DOS CSAQ design. In addition, to the qualitative remarks, we confirmed with quantitative data (i.e., user metrics) that the navigational models implemented were used, as were the different submission options. These results suggest we implemented a reasonable questionnaire design, but our conclusion needs to be confirmed with a larger sample size, and preferably one that is not self-selected. In addition, there were five companies out of the 50 selected Web CSAQ test companies who accessed the CSAQ but never submitted anything. We did not collect enough information from them to determine why the did not respond, but perhaps the questionnaire design was not usable for them. More research might even suggest designing user-centered help based on navigational patterns.

We did learn two critical pieces of information

related to the implementation of the questionnaire. First, many respondents had difficulty keeping track of their username and password. Although no one complained about that task, many called the help desk to get this information which was only sent to them by mail in the original letter. Adding this information to all follow-up letters might reduce these help desk calls. Second, although we screened and attempted to inform respondents about the browser requirements on both the original paper letter and the username and password screen, many still did not follow the instructions. Testing a redesign of the letter and username/password screen could potentially reduce this problem.

And, finally, what is the respondent's perception of and willingness to use the Internet for this purpose?

In general about 90 percent of screener respondents who had Web access were willing to use it to report their R&D data. There is, however, a small percentage who have security concerns about transmitting sensitive data over the Web. This fear might dissipate over time on its own, or it might require additional information.

The security perception has the potential to become a serious issue, especially if there is ever a breach in confidentiality. A more immediate problem, however, is the low response rate to the Web CSAQ. The amount of follow-up needed to get 34 respondents out of a test sample of 50 to report was disheartening, given that these were people who had initially agreed to report via the Web in an earlier screener questionnaire. There could be several explanations such as (1) the Web CSAQ is not as visible as the mail package containing the paper questionnaire, (2) the additional task of keeping track of the username and password was too much for respondents, or (3) the person who completed the screener was not the person who would complete the CSAQ. Although it might have contributed to it, we do not feel that the design of the questionnaire was a primary cause of the poor response rate. The low response rate was driven by companies who never even tried to access the CSAQ. In any event, this tendency should be evaluated since it has follow-up cost considerations.

CONCLUSIONS

From results of this test we found enough positive respondent reaction to continue to pursue collecting data using the Web. Although we have not found the best software for doing this, our results confirm that the questionnaire design was a reasonable model. In addition, we learned some seemingly obvious implementation results, such as including the username and password on follow-up letters.

The Web holds promise for electronic transmission of data, but it also opens up the door for more layers of complexity. The response rate and the help desk findings suggest that there are different issues in terms of motivation and assistance not present in paper questionnaires. These issues need to be studied further. Also, there still are coverage issues, as demonstrated by our screener results. Our hope is that over time coverage issues will dissipate.

One potential advantage of electronic questionnaires, not present in paper questionnaires, is how we can now "peer" into a respondent's pattern of completing forms. If programmed correctly, this data could be used to help respondents who appear to be having difficulty or to prod respondents who have taken a look at the questionnaire, but not completed anything. Again, this type of personalization requires extensive research and potentially extensive programming, but electronic forms, which are smart already in terms of edits and branching, could become smarter.

NOTE: This paper reports the results of research and analysis undertaken by Census Bureau staff. It has undergone a more limited review than official Census Bureau publications. This report is released to inform interested parties of research and to encourage discussion.

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