# NEW TECHNOLOGIES IN DATA COLLECTION FOR BUSINESS SURVEYS

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The arrival of highly sophisticated new technologies brings about many changes in survey methods. Even though data collection becomes faster and more efficient, other problems arise. These problems affect the interviewers and the respondents as well as data transmission. This paper presents a brief overview of the problems and issues associated with the use of new technologies in data collection. The results of a test on the use of a Hand-Held device to conduct the Canadian Consumer Price Index (CPI) are also presented.

## 1 BACKGROUND

The Generalized Survey Function Development (GSFD) Team was created to provide a more general approach to development and production systems. This is possible because of recent technological advances, mainly in the area of micro-computers, which means that tools are now available that enable a more general approach. The main goal of GSFD is to develop generalized tools that will be capable of being adapted easily to the majority of business and social surveys which will undergo redesign in the future. It will eventually provide the facilities to manage mixed mode collection and capture of data in the Regional Offices and at Headquarters, to capture data received on forms, and to collect data over the telephone and capture it as it is collected. Use of the DC2 tool at this time is centralized in Ottawa and at the Regional Offices. As technology advances, further decentralization will become more viable.

Due to the swift pace at which the technological advances are continually bringing new products in the area of data collection and capture systems, a multidisciplinary team was formed to keep abreast of new collection/capture technologies. This team is formed of members from the methodology, operations, systems, and general survey development areas of Statistics Canada. The objectives of the team are to identify potential problems and issues related to the use of new technologies, to develop a plan for the review and testing of new modes of collection and capture (including evaluation criteria), and to disseminate information and provide consultation services about evaluated technologies.

## 2 INTRODUCTION

The arrival of highly sophisticated new technologies brings about many changes in survey methods. New technologies may be split into two broad categories: the technologies that facilitate the self reporting of data by respondents and the technologies that facilitate the interviewer's job. The former category refers to technologies such as touchtone recognition, voice recognition, use of facsimile machines, electronic mail and others. The latter refers to technologies such as touch-screen portables, hand-held devices, laptops and others.

Even though data collection and capture technologies become faster and more efficient, other issues arise. These issues may have an impact on the interviewer, the respondent, the confidentiality of the data, the survey management, and the survey methodology. The main objective of this paper is to provide a forum to raise and discuss issues related to the use of new technologies in data collection. Section 3 presents a brief overview of the impact of new technologies on the collection and capture process, section 4 details the approach that Statistics Canada is using in testing these technologies, and section 5 presents the results of the test of a hand-held device for the collection of the Canadian Consumer Price Index (CPI). The paper ends with a brief conclusion.

## 3 IMPACT OF NEW TECHNOLOGIES

Many aspects have to be considered in the identification of the impact of the use of new technologies in the collection and capture process. This section presents the impact of new technologies on the interviewer, the respondent, the confidentiality of the collected data, the survey management, and the survey methodology.

### 3.1 IMPACT ON THE INTERVIEWER

We consider the impact on the interviewer in an environment where a micro-computer of some type is used at the collection stage. The interviewer's job is affected by two main factors. Firstly, his/her paper, pencil and clipboard are replaced (ideally) by a more sophisticated, expensive and delicate piece of equipment. Secondly, his/her tasks during the interview are affected, since in addition to collecting the data he/she has to capture it.

The physical characteristics of the equipment are the most tangible facets of the use of a machine in a local interviewing collection process. The weight, the size, the lighting conditions and the time the battery pack remains operational are determinant factors. Studies conducted in Sweden [1] and in the United States [2] have shown that weight and battery life are major factors in selecting equipment for local interviewing. If the machine is too heavy or the battery life too short, it greatly complicates the carrying and use of the equipment and may result in health problems for the interviewer.

The second impact on the interviewer is related to the restrictions associated with the use of the new technology during data collection. Does an interviewer have to sit down to type in the data? Does the interviewer have to use the respondent's electrical power? Is the machine too slow, forcing the interviewer to wait between questions? If the equipment is difficult to use and is not adapted to the conditions in which interviews are conducted, it may become a nuisance rather than a help.

The fact that the interviewers are working with the assistance of a micro-computer generates a set of new tasks and responsibilities. The interviewer is responsible for the equipment and its proper functioning. The interviewer has the additional tasks of re-charging batteries, making back-ups, using a modem for telecommunication, etc. These new tasks, even though they do not affect the interview itself, complicate the interviewer's overall job.

The collection task itself is also affected by the use of new technologies. The obligation to capture the responses during the interview may change the dynamics of the interview. The interviewer must be attentive to keying the information correctly and to responding promptly to the computer instructions. The segmentation effect of seeing only one screen at a time may generate the feeling of being lost. In this context, the interviewer may seem remote from the respondent. The personal contact that is normally established in a paper and pencil interview is often not present in a simultaneous collection and capture interview.

Some interviewers may not be at ease having a computer driving the interviews. They may have mixed feelings about having a machine question their entries. As well, they may feel unsafe carrying expensive hi-tech equipment, compared to a paper and pencil instrument.

Studies [3] have shown that the level of stress on the interviewers increases when new technologies are used. This stress can be caused by all the factors previously listed. Regardless of the collection method used, training is an important factor that contributes to the development of good interviewers. In the context of new technologies, training is an even more important factor. It will help alleviate the interviewers' stress. Furthermore, the interviewers have to be somewhat knowledgeable about the equipment they are using since they must be prepared to handle software and hardware failures.

From this short and incomplete list of the impacts of new technologies on the interviewer, it is clear that these issues have to be specifically addressed before converting a paper and pencil application to computer assisted interviewing. The conversion will succeed only if the interviewers' concerns are addressed properly. When this is done, many advantages may be expected from the conversion.

### 3.2 IMPACT ON THE RESPONDENTS

The respondent is the key that allows us to have access to the data. The impact on the respondent has to be carefully examined before implementing a new collection and capture process. This impact has to be considered from the following two broad categories: technologies that facilitate the self

reporting of data by respondents and technologies that facilitate the interviewer's job.

For self reporting, the new collection and capture tools correspond to already available technologies in the business world. The use of facsimile, electronic mail, or the provision of a collection and capture software to the respondent can be considered as an adaptation to the new telecommunication environment of the business community. The mail is no longer the sole way of receiving information from respondents. The use of such tools will bring many advantages to the Bureau and will show that the statistical agency is also a business trying to facilitate, as much as possible, the receipt of raw material from its providers. However, caution is necessary in making these telecommunication functions available to the respondents. The security of the process and the confidentiality of the information collected by such means have to be assessed. The access and the use of these self reporting technologies have to be easy for the respondents.

For the technologies used to facilitate the interview tasks, two main areas can be identified. The first area involves a direct measurement at the business location, such as the Consumer Price Index. The second area involves the use of computer assisted collection and capture in the context of telephone interviewing.

The use of a micro-computer at the respondent's location may create the feeling of an intrusion into the day-to-day operation of the business. It is perceived that few organizations will be given access to a business location with a portable computer. Statistics Canada has the mandate to guarantee the confidentiality and security of the data it collects. Therefore the Bureau has to be very careful while introducing these new collection and capture technologies. The testing and implementation of these new techniques have to be planned and introduced in accordance with the desires of the business community. In surveys where the information is obtained from household respondents, for example the Canadian Survey of Family Expenditures, the use of a portable computer in the respondent's home may make respondents more aware of the presence of computerized files with personal information. We should be very diligent in explaining to the respondent the use of the data and the protection against unauthorized persons or organizations to access the data, in order to avoid the Big Brother syndrome. Many experiences in Sweden, the United States, the Netherlands and Canada have shown that the use of computers in a household survey is well accepted by respondents.

Computer assisted telephone interviewing has the advantage of combining a socially accepted collection process with the new technology. The telephone has been used for many years to collect different kinds of information. The addition of a computer to telephone interviewing allows for the adaptation of the collection process to the respondent constraints. The use of an automatic telephone scheduling system allows the optimization of the scheduling process while meeting the respondents' constraints. A respondent is contacted only when his/her data are available or when he/she requests it. The addition of interactive editing is a step towards reducing the respondent burden. Generally, it is not necessary to contact a respondent more than once since the data are edited and corrected during the interview. This in fact is an advantage with all forms of computer interviewing.

A particular problem may arise in the area of household surveys: respondents also have access to new technologies that may make telephone interviewing more difficult. Technologies such as cellular phones, in-coming phone call filtering systems, answering machines, etc; may complicate significantly the way we conduct computer assisted telephone interviewing. We have to consider this problem and how best we can adapt our collection process to minimize the impact of the use of these new technologies by the respondents. Other issues that have to be addressed also are the speed of the computer and the procedures for computer breakdowns or computer errors.

Without the respondents' cooperation, it is impossible to adequately collect the survey data. In implementing new collection technologies, we must carefully examine the impact on the respondents. We have to make sure that the respondent collaboration is not reduced due to a new way of collecting data. New technologies should not only be used to improve our efficiency but also to ease the respondent's job. The cliché "there should be something in it for them" is quite true in this context. We need to sell the advantages of the new technologies to the respondents.

### 3.3 CONFIDENTIALITY AND SECURITY ISSUES

The confidentiality of the information collected by Statistics Canada is one of the major factors that allows the Bureau to collect accurate survey information with a high response rate. In introducing new modes of collecting data, particular attention has to be paid to the confidentiality and security of the collected data.

Confidentiality procedures have to be developed and tested in the context of new data collection technologies. Three areas have to be considered: the security aspects when the interviewer works locally with a portable computer, the transmission of data from the interviewer's home to the central office and the security aspects related to the self reporters.

In terms of the security related to the use of a micro-computer in the field, basic guidelines should be developed. In that context, it is assumed that the interviewer is working in a stand alone environment and that the only way to have access to the data is to have access to the machine. Security guidelines ensuring that the machine is never accessible by an unauthorized person have to be developed. Furthermore, the hardware and the software should be equipped with sufficient security protection to guarantee a high level of security to the respondent if unauthorized access ever occurs.

Transmission of data between an interviewer's home and a central location has to be carefully analyzed [4]. Should we send diskettes using the mail system? Should we use telephone lines? Should we use dedicated telecommunication lines? Should we use a public electronic mail system with security procedures? If telecommunication or telephone lines are used, what kind of encryption should be used? Should we use software or hardware encryption? If telecommunication is used, should it be initiated by the centralized location or by the interviewer? The issue of security is a global issue that has to be considered not only for a specific application but for a variety of similar applications.

Currently, the use of telephone and telecommunication lines at Statistics Canada is guided by a security policy that allows the transmission of confidential data only if an approved encrypting hardware device is hooked-up to the remote computer. This type of equipment is expensive and adds complexity to the operations. The identification of security procedures that guarantee a high level of security to the respondent while providing an adequate working environment to the interviewer is required.

Many options exist for the self reporters. They may fax in data, use an electronic mail service, use a touchtone recognition software, or communicate their data directly via a telecommunication line.

In the context of the use of a fax machine, the Bureau has developed a security policy that can be considered as an extension to the mail service. The Bureau will acknowledge the receipt of fax and will assume the security and confidentiality of the information from that point on. A similar approach is used when the respondent transmits data via an electronic mail system. In these two circumstances, the respondent is required to sign a letter of agreement recognizing that Statistics Canada will guarantee the security and confidentiality of the information only after it has acknowledged the receipt of it. After the data has been received by Statistics Canada, it is transferred to a computer environment without any links to the external world.

For the touchtone and direct data transmission, a dedicated micro-computer that is not linked directly to the confidential network is used to receive the data. In the case of direct transmission of data via modem, the transfer of data is initiated by Statistics Canada. After the completion of the transmission, the data are transferred to the confidential network using a removable medium. In the case of touchtone or voice recognition, a policy has not yet been established. It is, however, important to note that this technology will be used on a test basis on a very small scale with willing respondents and is not used in any regular collection process. The security issues surrounding the use of the touchtone technology are quite complex. Since many respondents are communicating with the same dedicated micro-computer, either at the same time or at different times, how do we ensure a sufficient level of security while allowing access to confidential data on an individual basis? Theoretically we may remove the collected data after each touchtone session. However, this is practically impossible. Furthermore, if we want to apply historical edits during a touchtone session, the problem remains since we must allow a respondent to have access to his/her own historical data.

One may ask why we are so reserved and cautious about electronic data access and telecommunication when nobody

really worries about confidentiality when the mail system is used. There are two aspects to consider in answering this question. First, in the business world, it is perceived that competitors may have sufficient technological knowledge to access and violate security procedures, while for the mail, if it is lost it is simply lost! Second, regardless of the real risk of disclosure or violation of security procedures, what is important is the perceived risk by the respondent. Collecting survey data is a matter of confidence between the respondent and the statistical organization, and the guarantee of security and confidentiality plays a major role in the establishment of that relationship.

## 3.4 IMPACTS ON SURVEY MANAGEMENT

The impacts of new technologies on survey management are felt at several levels. Because using new technologies often introduces new collection methods and strategies, there is an impact on how the overall survey management is done. Self-respondents in a survey are but one example of these new collection strategies. There are also impacts on the management of the equipment and on the management of the data transmission. Allowing respondents to use new technologies, or having interviewers use them to collect survey data, complicates tremendously the management of the survey, especially when there are a variety of collection modes used.

Usually, when new technologies are considered for the data collection of a survey, they are considered in conjunction with traditional means of collection. For instance, the Current Employment Survey conducted by the U.S. Bureau of Labor uses three collection modes: mail-out/mail-in paper questionnaires, Computer Assisted Telephone Interviews and Touchtone Data Entry. These mixed mode strategies are being used more frequently by statistical agencies. They allow the agencies to allocate respondents of a survey to the most efficient collection mode in terms of costs, timeliness and respondent's needs. However new tools are needed to help manage these true mixed mode survey.

Because each mode has different management requirements, it is difficult to combine them at the general survey level. For instance, controlling the progress of a survey is difficult when several modes of collection are used. How do you control self-respondents, telephone interviews and mail-out/mail-in questionnaires? What tables or figures are needed in order to control the stages of the collection process? What control processes are needed to manage or trigger the migration of units from one mode to another? These requirements will also differ depending on whether the survey process is centralized or decentralized.

Management of the survey also has to include management and monitoring of the equipment that is used to collect the data. If the interviewers are using a sophisticated piece of hardware from remote locations, such as laptop micro-computers from their homes, the maintenance of the machine has to be ensured. There is a need for a replacement procedure in case of hardware failures. This implies that replacement units have to be kept in strategic locations, ready to be sent to interviewers when needed. By the same token, software maintenance has to be accounted for. Procedures for software updates, data handling or even for program debugging, have to be put in place also.

Another aspect that must be considered is the number of different types of micro-computers that will be used by a statistical agency. If the micro-computers are not compatible, it increases the maintenance and the training costs, and it reduces portability. This compatibility puts some limitations when choosing a particular micro-computer. As well, procedures for equipment and software upgrades must be provided.

The transmission and reception of survey data is another area to be managed. This is especially important when interviewers perform the data collection away from the bureau's office. In such a case, the information required by the interviewers to collect the survey data, such as identification of the survey units or historical information for edit purposes, has to be sent to the interviewers' micro-computer. Once the survey data have been collected, they have to be sent back. This can be done through telephone lines or via diskettes in the mail for instance. However procedures have to be put in place to control this process. These procedures will control what data have to be transmitted, at what time and with what type of security measures. They will also indicate who should initiate the data transmission and how the data transmission is to be verified.

The frequency of data transmission, the amount of data transmitted, and several aspects linked to the transmission, will depend on several factors. The capacity of the micro-computer used for a survey is one factor. The timeliness of the survey will also be relevant. For a weekly survey, data transmission will occur more often than for a monthly or annual survey. The costs associated with these transmissions are also important. But the most important factor to consider in the data transmission is the survey management requirements. For instance on a monthly survey, we may desire weekly transmission to control the quality of the interviewers' work, the survey's response rate, the progress of the survey, etc.

As mentioned at the beginning of the section, using new technologies in data collection complicates the management of surveys. These impacts are but a few that affect all aspects of survey management.

## 3.5 METHODOLOGICAL ISSUES

Although new technologies can make data collection more efficient and timely, several methodological issues can be raised when considering their use. The first of these issues is questionnaire design. This issue was raised during the development of CATI systems [5] but is still valid for most new collection strategies using a micro-computer. Branching and tracking problems in a questionnaire, or the segmentation effects are well covered in the literature [5, 6, 7]. More research is needed in these area.

For instance, designing an efficient tracking system is not an easy task. Such tracking should allow an interviewer to go back to the right question in a questionnaire when a respondent has made an error, and then automatically go to the next unasked correct question to ask. Here, the objective is to reduce the response burden to a minimum by trying not to ask again questions already answered. Some research on that issue will be initiated this year at Statistics Canada. This research will be based on articles by Matthew Futterman on the logical structure of CATI instruments [8] and by L. C. R. J. Willenborg on the logical structure of questionnaires [9].

Another problem in the questionnaire design issue is the number of different questionnaires to have in a mixed mode survey. When new technologies are used in a mixed mode environment, should there be only one used, or one for every collection mode? It is clear that to take advantage of any new technologies, one should build the collection vehicle accordingly. An interactive collection mode such as CATI will not have the same editing strategy as a non-interactive mode. However, it is not clear if using different collection vehicles in one survey introduces bias in the estimates. Because of this, a single collection vehicle may be used in a mixed mode survey, even if it is not the most efficient questionnaire for the collection modes.

By the same token, how does one allocate resources for the different modes. Collection modes have different costs. What are the impacts that have to be considered when assigning respondents to the different modes? Of course the respondent's needs have to be considered, but there is more. Each mode has a different operational costs, and different methodological issues related to its use. Is there an optimal way of allocating resources to the different modes that will address these two aspects.

Another concern is the quality assurance or quality control plan. There are many quality control plans to ensure that traditional data capture operations are going well. Even for CATI surveys, several options exist to ensure data quality. One of these options is the audio and video monitoring of the interviews. However, for data collection from a remote area, it is more difficult to ensure data quality. Using interactive editing is one way of doing this but it is not sufficient. It has some drawbacks, especially when edit overrides are possible.

The issues identified in section 3 are a clear indication that we have to be very careful in the implementation of new technologies. The use of new technologies is more than putting a questionnaire with associated edits on a micro-computer [5]. Before implementing new data collection technologies, extensive testing is required to evaluate their impact. The testing would ensure that we create a new environment that will facilitate the interviewer's job while meeting the respondent constraints. Ideally this will also improve the quality and timeliness of the collection process and reduce the costs.

## 4 NEW TECHNOLOGY STUDIES AT STATISTICS CANADA

In order to evaluate any new data collection strategy using new technologies, Statistics Canada has adopted a three stage approach. The first stage is an analysis of the technology required to implement the data collection strategy. The objective is to determine if a new technology can support the needs of a survey. In the second stage, not only the technology but also the collection

methods will be analyzed. At this point, one is interested in how the data collection methods can be modified to benefit from all of the advantages of the new technology. For instance, the modification could correspond to the implementation of an interactive editing strategy. Finally, in the third stage, a complete and integrated test is conducted. The objective of this stage is to test all data collection operations that are affected by the introduction of a new technology. It is only after this third stage that a survey would be converted to the use of a new technology. All these analysis are to be carried out by the Generalized Survey Function Development multi-disciplinary team.

Although this is a three stage approach, it may translate into more than three tests. The number of tests will depend on the complexity of the technology being tested and the survey for which the technology would be used. Following this strategy, Statistics Canada is investigating four areas of data collection using new technologies. These areas are:

1- Computer assisted telephone interviewing from the interviewer's residence (a modified CAPI).
2- Hand written data collection, where the interviewer works in the respondent's location and not necessarily in ideal conditions.
3- Self-reporting data collection, without an interviewer, such as using a touchtone system.
4- Mostly numerical data collection, where the interviewer has to travel among several locations, and be very mobile within each one.

For each of these four areas, some technologies were identified to be tested for a given survey. For the first area, a touch-screen micro-computer was selected. For the second one, a hand-printing text recognition micro-computer was chosen. For the automated collection, among the several modes available, the touchtone system was selected. Finally, for the last area, a hand-held computer was to be tested in the field.

Although other types of technologies will not be tested with a survey, some new technologies, such as image processing, voice recognition and pen point computing are also being investigated. At the moment, these technologies are not quite ready to go into the field but Statistics Canada is trying to keep abreast of these innovations.

With these studies, Statistics Canada will gain the methodological, computer system and operational expertise required for the use of these technologies and the introduction of new data collection strategies. It will be possible to evaluate the potential gains realized by using these technologies and new approaches for data collection, especially if the data capture is combined with data collection. The studies will also enable the evaluation of the impacts of these technologies on the interviewers and on the respondents. Finally, the use of new technologies should reduce the amount of time required for the processing of surveys. The studies will give insights into these time savings.

### 4.1 Modified CAPI Application

As mentioned previously, the new technology selected to test this data collection mode is a touch-screen micro-computer. The touch-screen is a keyboardless micro-computer with a screen that is touch sensitive. The data entry is done by pressing the screen at the right spot. It can be a box or a letter in dichotomy or multiple choice questions, or it can be a key on a virtual image of a keyboard on the screen. It is also possible to attach a keyboard to this micro-computer.

The manufacturer of the computer has also developed an application generator. This software can be used to build applications on the computer, such as a questionnaire. This software has help screens, pre-defined question and answer types (open-ended, multiple choices), pre-defined graphical presentations (tick boxes, circles), and many other options that can be used to generate the collection vehicle.

Two surveys are being used to conduct the study. They are the Canadian Labour Force Survey (LFS) and the Canadian Labour Market Activity Survey (LMAS). These surveys are social surveys, not economic surveys. However, the results of the studies will be used for both types of surveys. One test involving the LFS is currently underway. Three more tests are planned for the LMAS. The decision to conduct subsequent testing with the LFS will depend on the results of the first test.

For the LFS study, the test will last six months and will involve 500 households. It will reproduce the regular LFS cycle. Every month, 20% of the sample will consist of a new panel, introduced as births. These new households will be surveyed through a personal interview. The rest of the sample will be surveyed through telephone calls made from the interviewer's home. The collected data will then be processed through the regular LFS system.

The main objective of this test is to evaluate the micro-computer and the software supplied by the manufacturer. It is mainly a qualitative study. There will be an evaluation of the collection costs and time and operational problems will be documented. Another important point will be the evolution of the response rate throughout the test. In addition, any major discrepancies in the data will be investigated.

Furthermore, the results of a test conducted by Mick Couper and Robert M. Groves at the Survey Research Center [2] have shown that error rates for alpha-numeric data entry is higher with a keyboardless machine than with a keyboard machine. The study will also address and evaluate this effect in a non-laboratory situation.

The first test involving the LMAS will be similar to the LFS test. The main objectives are to test the hardware and software. Since the LMAS is a bigger and far more complex survey than the LFS, it is expected that any aspects not tested with the LFS will be tested with this study. In the LMAS test, 95% of the respondents will be surveyed over the telephone. The rest of the sample are to be surveyed through personal interviews.

The second test will involve a longitudinal portion. This portion is created by linking the data from the LMAS to data collected in the LFS. To do this, the micro-computer will have to retain more historical information in memory. Furthermore, the second test will be used to evaluate an interactive editing strategy. There will be some simple edits in the first test, but the second test will be used to fully test all the edits needed by the survey.

Finally, the third test will be a large scale test. Its content is not completely defined yet. However, it will be used to evaluate the data quality and to test the integration of all the data collection operations.

### 4.2 Hand Written Data Collection

The Canadian For-Hire Trucking survey, a quarterly survey, has been selected for this study. In this survey, interviewers visit selected trucking companies and sample invoices from each companies. They then transcribe all the information on the invoice onto a standard form. This information includes transportation costs, origin and destination as well as type of merchandise. After this collection operation, the forms are captured in the regional offices of Statistics Canada.

The objective of the study is to test whether a computer that recognizes hand-printed text can be used to collect and capture the survey data. The micro-computer has a screen on which the interviewer can write with a special stylus. The micro-computer is able to recognize the hand-printed text. The stylus can also be used to tick boxes in multiple choice questions. The study will test if the hand-printing text recognition technology of the computer can efficiently replace the standard lap-top computer.

This study is at the first stage. It will be used to assess the reactions of the interviewers, as well as to test the technology. For instance, since the interviewers have to learn how to write in a way recognizable by the program, the test will be used to measure the learning curve and error rates. It is expected that the required time period will be shorter than the time that would be required to become a good typist with a keyboard. As for the touch-screen study, the results of Mick Couper and Robert M. Groves [2] for using a keyboardless machine for data entry will be evaluated.

For the technological aspects, the test will be used to verify if this type of micro-computer can be used in diverse locations. Since data collection is done on the companies' premises, the working conditions of the interviewers vary and are not always ideal. The study will test the physical characteristics of the computer under various conditions such as in bad lighting, or without access to an alternate power supply.

### 4.3 Self-reporting Data Collection

The touchtone system was selected to test the self-reporting data collection approach. The touchtone system consists of a computer that recognizes the pulses emitted by a touchtone telephone. The keyboard of the telephone can be used by the respondent to enter survey data. This technology will be tested on small companies in the Canadian Survey of Employment Payroll and Hours (SEPH). This test will evaluate if the results of similar studies and surveys done with this collection mode in the United States are true for Canada.

Although the test is not yet completely defined, several aspects will be addressed in this study. Based on American results [10], it is known that respondents already contacted through a CATI system can be transferred easily to touchtone collection mode. The attitude of mail respondents transferred directly to touchtone will be evaluated.

Two other aspects concerning respondents will also be examined by the study. The first one is the length of questionnaire that can be used with this kind of technology. The problem is the number of questions respondents are ready to answer using this mode of collection. Also of importance is the response rate. In the United States, it was shown that reminder cards were needed in each collection period to maintain a high response rate. This has an impact on the potential gains that can be achieved with the touchtone.

Finally, the study should be used to investigate the feasibility of incorporating interactive edits with the touchtone. Firstly, the study will test if the touchtone system is powerful enough to perform edits at the time of collection. Secondly, the study will assess the reaction of the respondents to such edits, especially when failures occur. Lastly, the study will look at the type of edits that can be performed in this environment.

### 4.4 Numerical Data Collection

This is the last type of data collection that will be tested in the field by Statistics Canada. The hardware chosen for the study is a hand-held micro-computer. It will be used with the Canadian Consumer Price Index. An in-house evaluation of this type of micro-computer done in 1989 showed that the use of such a micro-computer to collect the CPI data should be investigated further. A field test was designed in 1990 and conducted in March 1991. This test and its results are described in more detail in the following section.

## 5 Use of the Hand-held device for the CPI data collection.

This section first describes the Canadian Consumer Price Index and its current data collection mode. The section then goes on to describe the first field test that was conducted. It continues with a description of the results obtained from the test and the main conclusions.

### 5.1 The Canadian Consumer Price Index

The Consumer Price Index (CPI) is an indicator of changes in consumer prices, as experienced by the target population [11]. This target population is composed of families and individuals living in private households located in urban centers of 30,000 or more people. The CPI measures the change in the cost of a fixed basket of goods and services that represents the purchases of the target population for a given reference period. Since the basket contains commodities of unchanging or equivalent quality and quantity, the CPI reflects only pure price movement.

The basket of commodities is revised every four years. This revision is done both on the content of the basket and on the weights of each component. The revision is based on the Canadian Survey of Family Expenditures. This survey is conducted using the same target population.

Currently, the basket is composed of approximately 500 goods and services. They are divided into seven major groups: food, clothing, housing, health and personal care, transportation, tobacco and alcohol, and finally education, leisure and training.

### 5.2 Current collection mode for the CPI

The current data collection process is mainly a manual paper and pencil process. Interviewers receive their paper forms at home. These forms contain the required identification and historical information needed to visit the different outlets and price the goods and services of the CPI basket.

Two types of forms are used to collect the prices. The first one is called the Controlled Feedback and Capture Form (CFCF). The CFCF forms are computer generated and produced in a uniform format that allows the pricing of many commodities and services. The form is currently used to price about 96% of all the components of the CPI basket. The remaining prices are collected on "traditional" pricing forms that is, forms custom-designed to identify various goods and services that cannot be accommodated on the CFCF form due to the detailed information required.

The CFCF process is generally as follows:

- Once a month the data required for pricing are extracted from the CPI database at headquarters, then formatted and transmitted to the regional offices where the paper forms are printed.
- The forms are packaged and sent to the interviewers.
- The interviewers collect the prices on the forms. They visit the indicated outlets, locate the items and collect the price.
- Once an outlet is finished, they review their work, pre-edit the forms and fill out any required supplementary forms (market intelligence information, quality change information, etc.).
- The forms are sent back to the regional offices, where they are batched, and data are captured with both interactive and batch editing. Any edit failures are corrected.
- The final captured data is transmitted back to headquarters for processing to derive the Consumer Price Index.

Currently, the prices are collected over various time periods (semi-monthly, monthly, quarterly, semi-annually, annually). The frequency of the pricing depends on the price stability of the various commodities. For instance, in the food sector prices are collected twice a month. On the other hand, prices of local municipal taxes are collected annually.

The data collection operations for the CPI involve about 100 interviewers. Prices are collected at various levels in 82 cities, and from about 10,000 outlets. Every month, around 100,000 prices are processed in the regional offices.

### 5.3 Test Objectives and Methodology

The test had five objectives, the first three of greater importance. The first objective was to evaluate if it was possible to integrate data collection and data capture of the CPI into one operation, using the hand-held device. The second objective was to evaluate the hand-held device itself. The third objective was to assess the interviewers' reaction to this new way of collecting the CPI data.

Less emphasis was put on two other objectives: the evaluation of an interactive editing strategy and the evaluation of the data quality. These two objectives were less important because they would be fully evaluated in a subsequent test, if this new collection approach was proven successful.

The choice of the technology to be used to test the numerical data collection approach was done according to criteria developed by the project team [12]. After examining the current data collection procedures, it was decided that the device had to be light and easy to hold in one hand, and that the batteries should be able to operate for at least eight hours. The device had to handle the full set of ASCII characters. It also had to have sufficient memory to store the required information to collect the prices (about 1 megabyte of data) and sufficient working space to perform interactive edits. The screen had to be sufficiently large (more than one or two lines on the screen). Finally, the device had to be capable of communication with an IBM-PC-compatible through the RS232 port.

A hand-held micro-computer was selected over lap-top and notebook computers. This type of computer is compact, light and easier to handle. Their battery life is usually longer. After evaluating several hand-held computers on the market, the DAP Technologies 'Microflex PC9000' was selected. It met or surpassed all the criteria established by the team. Its major features are a weight of 2 pounds; a screen of 14 lines by 21 characters; full MS-DOS compatibility; and two sets of batteries, one set for operational purposes and one set for back-up purposes. It also has a 20 megabyte hard disk.

The PC9000 version was under development at the time of selection. It was supposed to be available for the field test. Unfortunately, there were delays and the PC9000 was not available. It was replaced by its predecessor, the PC1000, which has most of the functionality of the PC9000. The main differences were a slightly higher weight of 2.4 pounds, the absence of the hard disk and a slower clock.

After familiarization with the CPI collection procedures, the new technology team selected the grocery component of the CPI for the test. This component is representative of all the items collected with the CFCF forms. Also, since the grocery components are priced twice a month, it represents 80% of the items collected with the CFCF forms.

The data collection and capture program was built on an IBM-PC AT-compatible micro-computer and down-loaded to the hand-held. In the first test, for comparison purposes, the program was designed to mimic the current data collection process as much as possible. For instance, the prototype on the hand-held device contained all the edits that are currently applied during the data capture process. Any improvements to the edit rules were left for a subsequent test.

For the test, the information required to perform the data collection was extracted from the mainframe computer, formatted and down-loaded to the hand-held to be used by the interviewers. The data was presented according to a screen design based on the CFCF forms.

The test was held in Toronto during the week of March 18 to 22, 1991. The data was collected in parallel, which means that in a given store, two interviewers were collecting prices; one with the current CFCF form, and one with the hand-held device. Four interviewers and two senior interviewers collected the prices for sixteen grocery outlets using the hand-held device.

There was one day of training, during which the interviewers were introduced first to the device and then to the program. Finally, they performed simulated data entry. No training was done on the technical aspects of the program or the machine (such as how to reset the device) since all the interviewers were accompanied by observers. The role of the observers was to assist the interviewers if any problem arose, and also to take note of any suggestions, improvements or comments made by the interviewers.

Data collection was performed in the two days following the training session. For each outlet, the prices of 135 items were collected. The last day was used to hold a debriefing session with the interviewers. During the session, there was a second opportunity to comment on the hand-held computer, on the program that was built, on the training session, and on any part of the test.

### 5.4 Results

In general, the test was highly successful. It is clear that it is feasible to integrate the data collection process and the data capture process of the CFCF forms into a one step operation with the help of a hand-held computer.

Although the device tested was inferior to the PC9000 originally selected for the test, it worked well. The physical characteristics were acceptable. The weight was not a problem, although lighter is always better. The battery life proved to be sufficient. The computer was easy to use and the display of the screen was adequate.

The reaction of the interviewers was very positive. They welcomed this new way of performing their work. They particularly appreciated the fact that once they left an outlet, no further manual editing was necessary on their part, due to the interactive edits. All the edits currently used in the capture system were implemented on the hand-held device without any problems. There were no negative reactions from the store managers.

The interviewers also had several suggestions on how the program could be improved. They proposed a new design for the display of information that would facilitate their work. They also mentioned some options that they thought would be desirable. One of these options is the ability to personalize the order in which the items are listed, according to each outlet. They were surprised to find that this is a feasible option that will be evaluated in a subsequent test.

The only negative aspect was the response time of the PC1000. The hand-held device was too slow in the field. That was expected from the results of tests that were performed during the development of the software. However, results of similar tests conducted on a beta version of the PC9000 have shown a 50% improvement in the response time of the program. This would be sufficient for the needs of the data collection process.

The difference in data quality is hard to measure, making the evaluation difficult. With the parallel collection there are two sources of data: the data collected with the hand-held computer and the data collected with the CFCF forms. When the two sources disagree, it is often impossible to determine which source is wrong. Furthermore, because of the short duration of the test, two days, and due to operational constraints, no experimental design was made for the test. This again complicates the analysis.

Another aspect that makes the results difficult to analyze is the parallel collection. The interviewers were waiting for each other before moving to the next outlet. Because of the extra time it took to perform the collection with the hand-held (3 1/2 hours instead of 2 hours), the interviewer doing the paper collection had extra time to review their work and consult with the outlet's personnel.

Overall, what can be said concerning the data quality is that the hand-held device collection does not seem to improve or deteriorate the quality of the information collected. Even though there are differences between the data collected with the hand-held device and the data collected with the paper forms, they are not major. In the end, the differences cancel each other. However, it is expected that, with a faster machine and improved edits, the quality of the data collected with the hand-held device would be better. This is an aspect that will be tested in a later test.

### 5.5 Conclusion and Future Work

As mentioned in the previous section, the test was successful. It has proved that the use of a hand-held device to integrate the data collection and data capture process for the CPI is feasible. The PC9000 is now available, and it should remedy some of the problems encountered during the first test.

For the application itself, further testing is needed to produce accurate estimates of potential savings produced by the hand-held device. Testing is also needed to evaluate the improved design of the program and the PC9000 performance. The interactive edits will also be revised and enhanced. The test will involve all the components that are currently collected with the CFCF forms. It should be executed on a larger scale, and will be designed to permit a thorough data quality evaluation. These issues should be covered in a subsequent test.

The following issues, which require further development, may not be covered in the second CPI test because they are of a more general nature. They concern any remote data collection technology. These issues are the provision of confidentiality at all stages of the process, the case management of the survey and the management and protection of a variety of equipment. These issues may be tackled in other studies.

## 6 CONCLUSION

Due to current budgetary constraints, statistical agencies have to become more efficient in their operations. Major savings are expected in the data collection and capture processes. The uses of new technologies seems to be a way to reduce these costs.

However, the collection of data is not only a question of costs, but also a question of quality, timeliness and response burden. The implications of the uses of new technologies on these aspects have to be carefully analyzed before their implementation. The impacts on interviewers, respondents and data quality have to be carefully addressed. For these reasons, Statistics Canada has adopted a cautious pace in introducing new technologies in its collection and capture operations.

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