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Topic (ii): Economic issues associated with the implementation of modern IT and management of human resources as driving forces to improve timeliness and quality of statistical data

**PUTTING THE PIECES TOGETHER: MEASURING THE COST-EFFECTIVENESS OF INFORMATION
TECHNOLOGY INVESTMENTS AT THE BUREAU OF THE CENSUS**

Submitted by United States Bureau of the Census¹

1. As statistical organizations gather, process, and disseminate data, they increasingly rely on information technology (IT) to carry out their work. This increased reliance on IT not only changes human resource and budget priorities but also may affect the timeliness, quality, and cost-effectiveness of statistical products. Moreover, as information technology develops, statistical organizations, such as the United States Bureau of the Census (Census Bureau), need to choose carefully among different technology alternatives in order to collect, process, and disseminate information to provide the most value to the user in a cost-effective manner. This is particularly important to the Census Bureau, as it is a governmental organization, accountable to the United States Congress and other stakeholders including the general public.

2. This paper will discuss factors the Census Bureau needs to include in measures of the cost-effectiveness of information technology investments.

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These are addressed in three major investment areas: (1) the change from pencil and paper interviewing to computer assisted personal interviewing; (2) standardizing information technology across demographic and economic programs; and (3) the development of a data access and dissemination system for major censuses.

3. In accordance with the nature of the Census Bureau's work, we define cost-effectiveness as follows: the cost of producing a unit of data at a particular quality level over a given unit of time (Rossi & Freeman 1993). A related tool for measuring information technology efficiency is a cost-benefit analysis, wherein the tangible and intangible costs and benefits of different alternatives are compared. Together, cost-effectiveness and cost-benefit analyses measure the efficiency of investments.

4. Although the definition of cost-effectiveness offered above is straightforward, it represents an ideal that is difficult to reach. Developing measures of cost-effectiveness is often complex. It is particularly difficult to examine cost-effectiveness over time at the Census Bureau, as the cost accounting system has been updated over the past few years. Moreover, it is hard to assess whether projected cost-effectiveness has been realized, due to transition between data processes that do not involve IT and those that do. There is a loss of efficiency during a longer than anticipated transition period resulting from insufficient funding, requiring the agency to maintain old systems for some work, and to develop new systems for other work.

5. Cost-effectiveness analysis must also adequately factor in risks associated with various investments. Decision-makers need to be able to have the expertise available to look "beyond the numbers" when making decisions, especially since different factors, particularly qualitative ones, often need to be weighted arbitrarily. A related issue is whether it is possible to assess the cost-effectiveness of an option before it is fully implemented (Sullivan 1998).

6. Statistical agencies need to be concerned not only with the cost-effectiveness of their IT investments but also with addressing system wide issues that affect agency performance, such as the Year 2000 (Y2K) compliance problem, i.e., making sure computers recognize the new date. Also, agencies that rely heavily on information technology to gather, enter, and disseminate data must make sure the data is secure, both from outside tampering and to safeguard the confidentiality of the data. As information technology is highly interactive and interconnected, maintaining confidentiality becomes even more challenging.

7. Recent federal policy developments reflect the challenges associated with implementing IT cost effectively and successfully. These developments are described below.

I. LEGISLATIVE ENVIRONMENT

8. During this decade, the United States federal government has passed several important laws that have changed the way agencies plan and measure their future operations. In 1993, Congress passed the Government Performance and Results Act (GPRA), mandating that federal agencies prepare mission statements and strategic plans as well as performance measures to demonstrate progress towards stated goals and objectives. In addition, the law required that budget requests and outlays reflect goals, objectives, and progress towards results.

9. The GPRA also provided the foundation for legislation that addressed information technology investments more directly (May R. 1998). For example, in 1994 Congress passed the Federal Acquisition Streamlining Act, which requires agencies to define cost, schedule, and performance goals for information technology acquisition, and to monitor investments to ensure they deliver the expected return.

10. In 1996, Congress followed with the Information Technology Management Reform Act (ITMRA), which gave agencies additional orders to ensure wise IT investments. While the Act delegated IT procurement to individual agencies, it also stipulated that each agency designate a Chief Information Officer to manage IT investments. Moreover, agencies were also required to assess the risk, costs, and benefits associated with any major IT investment alternative.

11. To assist agencies in carrying out the ITMRA requirements, Franklin Raines, former director of the Office of Management and Budget (OMB), drafted guidelines for IT investments. According to the "Raines' Rules", federal government IT investments must meet certain criteria. They must support the core functions of the agency, and must demonstrably simplify work, reduce costs, and improve effectiveness. In addition, IT investment alternatives must be compared to determine which IT investments will yield the best return (i.e., return on investment (ROI)) to support mission requirements. In addition, IT investments must be consistent with the information architecture throughout the federal government. Furthermore, those who acquire information technology resources must make efforts to reduce risk, and to allocate risks between the government and contractors. To these ends, agencies are directed to implement IT changes in stages, and federal agencies should only pay contractors who carry out their work as defined in the contract.

12. The Census Bureau developed several organizational structures to ensure these laws and guidelines were carried out. For example, the Census Bureau designated a Chief Information Officer to provide IT leadership for the entire agency. The Census Bureau also organized an Information Technology Review Board (ITRB), composed of information technology staff and senior bureau management, to guide IT investment strategy. As part of its strategy, the board selects, manages, and evaluates the portfolio of IT investments for the bureau, and requires a business case analysis for new IT investments. The ITRB also ensures that new investments conform to the existing information

architecture and makes the final funding decisions for all IT investments. Finally, within each program area, information technology reviews are conducted to harmonize IT decisions across different levels of management.

13. Taken together, these acts, guidelines, and managerial structures provide a framework from which agencies can measure the cost-effectiveness and efficiencies of their IT investments. This framework is necessary because the idea of measuring the effectiveness of information technology investments is relatively new. To begin to assess the cost-effectiveness of IT investments, this paper identifies the costs, benefits, and outcomes in three areas of bureau activities.

II. CASE 1: SWITCHING FROM PAPER AND PENCIL INTERVIEWING TO COMPUTER-ASSISTED PERSONAL INTERVIEWING

14. The switch from Paper and Pencil Interviewing (PAPI) to Computer Assisted Personal Interviewing (CAPI) in the Census Bureau's demographic surveys was expected to improve the quality of demographic survey data and to gather and process data more efficiently.

15. The Census Bureau has been using Computer Assisted Interviewing (CAI) since 1987, and Computer Assisted Personal Interviewing (CAPI) since 1992. Prior to CAPI, surveyors went from door to door with printed survey instruments, filling them out by hand, and shipping them to the bureau for processing. With CAPI, the bureau enters survey instruments into laptop computers. Then interviewers carry these computers with them door-to-door to interview respondents, entering answers directly into the computers.

16. While the laptop computer surveys clearly represent a technical innovation over paper surveys, this change involves both tangible and intangible costs and benefits. The change also affects financial and personnel management, as well as changes in the quality and timeliness of collected data.

17. Compared with PAPI, CAPI offers several tangible improvements. With CAPI, the bureau no longer needs to print or ship questionnaires, thus saving money. In addition, CAPI expedites data processing, as interviewers can transmit survey data more quickly electronically than paper instruments via postal mail. Furthermore, since interviewers can transmit data directly from their laptops into central databases at the bureau, it is unnecessary to enter data manually from printed instruments. Electronic transmission reduces the need for manual clerical editing as well.

18. On the other hand, compared with PAPI, CAPI exacts additional tangible (i.e., monetary) costs. Given the complexity of designing and implementing laptop surveys, CAPI requires more training, not only for field representatives but also for staff at headquarters. In addition, CAPI instruments require much more time to develop and test, at considerable cost.

19. Compared with PAPI, CAPI requires a bigger investment not only in staff

but also in materials. CAPI requires more personal computers, software, and more intricate infrastructure systems. With CAPI, survey managers must also be prepared for more hardware failures and software problems. In addition, interviewing with laptops carries an increased security risk: If surveyors carry laptops, it is possible they may be damaged, lost, or stolen during the interview process.

20. The change from PAPI to CAPI is also associated with intangible benefits and costs. Regarding benefits, CAPI surveys can enhance the quality of the data received. Since the surveys are programmed into the laptops, surveyors cannot jump from question to question freely, a practice that taints data quality. In addition, laptops allow for more complex surveys to be prepared and administered. Another intangible benefit concerns the increase in prestige that laptop technology brings to demographic surveys. Interviewers reportedly appear more impressive to respondents when they arrive with laptops, possibly helping the response rate of the Census Bureau surveys.

21. While CAPI improves the quality of data in some ways, it also poses some challenges to data quality. While the move to CAPI limits the ability of survey managers to change instruments frivolously, it also requires more time to plan and implemented changes when they are needed.

22. Given concerns about the flexibility and ease of use of the laptop surveys, it is difficult to ensure data quality. In addition, presently there are no well-developed measures to assess how well the computer surveys or systems are operating.

23. The change from PAPI to CAPI has also reordered financial priorities. Developing human resources to support this change has required more money. At the same time, shipping and printing costs have decreased.

24. Human resource needs have changed as well. The Demographic Surveys Division and field offices require more technical staff. Overall, more staff is needed to carry out surveys and support field interviewers, filling jobs and functions that did not exist before.

25. In addition, the new approaches to managing work were developed in order to accommodate the change in staff and technology. A related challenge concerns the need to maintain both paper surveys and computerized surveys during the transition from PAPI to CAPI.

26. When measuring the cost-effectiveness of information technology investments such as CAPI, the costs, human resource, and financial management changes must be taken into account. If these factors are examined, it is possible to compare the cost-effectiveness of different alternatives.

27. A recent study (Longini et al. 1994) includes the type of quantitative analysis described above. The study examines the impact of the switch from PAPI to CAPI for the Current Population Survey (CPS). The Current Population Survey is the Census Bureau's largest household survey, providing information

about national unemployment and poverty rates.

28. A review of the role of laptop computers in data collection indicates laptops offered several measurable improvements in data quality and work processes. For example, CAPI decreased the nonresponse rate to a supplemental survey from between ten to twelve percent to eight percent. It is believed this improvement occurred because automation allowed the supplement to be integrated into the regular survey. In addition, CAPI allowed survey analysts to match all common CPS records between adjacent months. In contrast, with PAPI, analysts were only able to match 95% of records. Moreover, detailed examination of CPS receipts indicated that CAPI expedited the return of surveys; as a result, CPS data could be delivered to the survey sponsor, the Bureau of Labor Statistics, more quickly. Finally, although complete cost information was not available, the analysis estimated several potential cost savings due to CAPI. The study estimated that CAPI would reduce yearly paper and printing costs by a half a million dollars, would reduce shipping costs by a million dollars, and reduce yearly clerical coding costs by half a million dollars.

III. CASE 2: STANDARDIZING INFORMATION TECHNOLOGY [TOOLS] ACROSS DEMOGRAPHIC AND ECONOMIC PROGRAMS

29. The Census Bureau looks to information technology not only to increase cost-effectiveness within specific surveys but also across program areas. Thus the bureau tries as much as possible to standardize information technology tools utilized across demographic and economic programs. Demographic programs inquire about social and demographic characteristics of households and individuals, while economic programs inquire about business and industrial characteristics.

30. Standardizing information technology tools is part of the Information Technology Strategic Plan for the Bureau. The goal of standardization is to collect, record, and disseminate data more easily and less expensively throughout the Bureau; in other words, to increase the cost-effectiveness of data processes.

31. To move towards standardized IT, the Census Bureau is building upon its existing IT infrastructure. This technology includes several hardware investments and software programs. Programs to be used across demographic and economic program lines include one that links addresses to regions, optical character recognition programs, and the use of administrative records as data sources. Other possibilities include standardized programs that craft surveys.

32. It is difficult to integrate data gathering and processing across economic and demographic programs because they gather information in different ways about different audiences. Demographic surveys collect information about households and household members, using computer assisted interviewing, in person or over the telephone. In contrast, economic programs collect data about business and industry, and often collect data electronically.

Businesses often vary in size and structure, and require IT that can effectively capture and enter data about diverse organizations (Mesenbourg 1998).

33. In addition, demographic and economic programs employ different information technology for different activities. For example, the Economic Directorate uses paper surveys for their quinquennial censuses, but uses electronic reporting methods for monthly surveys. For these surveys, the economic program directorate--and the business community--prefer electronic reporting because it reduces the reporting burden of respondents, thus increasing the likelihood of survey participation.

34. Although more complete integration of economic and demographic data processing may present some challenges, the first steps towards implementing similar IT have already yielded some benefits. Because economic and demographic programs are starting to use similar IT resources, they are collaborating more closely in all aspects of survey management. Moreover, it has been observed that, with the increased use of IT, directorates are beginning to look beyond their own specific technology needs towards bureau-wide needs (Bowie 1998).

35. To measure the net efficiency gains associated with the move towards more integrated data processing IT, the Census Bureau looks at both efficiencies gained in the data processes and outcomes. The data process analysis takes into account the savings--and costs--of time, money, and investments associated with moving towards centralized standardized IT in the directorates. It is important to measure savings and costs over time, as the efficiencies might accrue as technology becomes more advanced, and processes are streamlined. Conversely, efficiencies might decline if standardization impedes data gathering.

36. The outcome analysis compares the quality, quantity, and timeliness of data in the different program areas before and after IT implementation. Cost-effectiveness might only be measured feasibly for a predetermined cluster of surveys, if an agency conducts many surveys with overlapping time frames.

IV. CASE 3: A COMPUTERIZED DATA ACCESS AND DISSEMINATION SYSTEM FOR THE DECENNIAL CENSUS

37. The Census Bureau is developing the Data Access and Dissemination System (DADS) to facilitate the access and dissemination of demographic and economic data. DADS is an interactive electronic system designed to allow efficient and cost-effective access to data and products produced by the next decennial census (Census 2000) and the 1997 Economic Censuses. DADS provides a coordinated corporate approach to data access and dissemination.

38. DADS will provide users (e.g., government and non-profit agencies, businesses and researchers, and the public at large) with access to a wide range of official statistics quickly and easily from Census Bureau databases.

The data will include information from the 2000 Decennial Census as well as the 1997 Economic Census and the American Community Survey (whose objective is to routinely assess demographic and economic aspects of American communities between censuses).

39. Before DADS development began, the Census Bureau prepared a business case analysis to compare cost-benefit ratios for DADS with the existing data dissemination method, termed "tabulation and publication" (TAB/PUB). To compare alternatives, the business case reviewed all costs associated with TAB/PUB and DADS, both in the preparation and implementation phases, relying on budget estimates from program managers. The analysis compared costs for capital investments, program development, staffing, training, and overhead on a yearly basis. The case concluded that DADS yielded higher benefit-cost ratios than TAB/PUB, even factoring in a margin of error for personnel needs (Advanced Resource Technologies Inc. 1997).

40. The case also identified qualitative benefits for each alternative. Identified intangible benefits of TABS/PUBS included its familiarity both to the Census Bureau and to some users. Identified intangible benefits of DADS included ease of finding data and customizing data to user needs; enhancement of data quality and products; integration of data from all bureau sources; and enhancement of the Census Bureau's image. While intangible benefits are hard to quantify directly, they should be factored in, however crudely, into cost-effectiveness analysis.

41. To measure the cost-effectiveness of this change, it will be necessary to compare costs using the TAB/PUB method versus using DADS, taking into account the quality, quantity and timeliness of data disseminated through each method. (Data quality is not assessed or improved by DADS, merely maintained.) Such an analysis will build upon the information gathered in the business case. Quantity of data could be measured per units of data generated. Timeliness of data could be measured looking at the amount of time between program formulation and data dissemination.

42. DADS presents even further opportunities to measure cost-effectiveness. A main impetus for DADS is that end users will be able to obtain more information more quickly and to customize their own data products. To compare the cost-effectiveness of ease of data access, it would be helpful to look at the time allocations of end-users before and after the implementation of DADS. That is, how much time did end users have to spend looking for data before DADS and after? How much money were end users able to save or to earn as a result of being able to access data more quickly? Bureau costs for assisting users, creating special tabulations, and sending them to users must be considered as well.

43. The following example illustrates this approach: A program manager at the Department of Housing and Urban Development reviews Census data to decide which regions should receive community development block grants based on poverty rates and other eligibility criteria. In the past, such an activity required 150 hours per fiscal year. Using the DADS program, such an activity

only requires 100 hours a year. This timesaving could be reflected in lower staff overtime or more time to devote to program development or technical assistance, with resultant benefits or savings to society.

44. Looking at data availability, it might be useful to look at particular regions and sectors of American society in order to assign, however crudely, the monetary or other efficiency benefit to more voluminous or rapid data access. More precisely, the objective of analysis would be to determine whether DADS was able to improve the "fit" between perceived and real community needs. For public services, research could examine the change in match between public services and community needs. For business planning, research would need to examine the match between business development and community economic needs. For entitlement programs, research would need to examine the match between funding allocations and the number of eligible participants in a region.

V. CONCLUSIONS

45. It is commonly believed that computers have greatly increased the quantity, quality, and timeliness of data statistical agencies can gather, enter, and disseminate. The hope is that investments in technology will help statistical agencies such as the Census Bureau to prepare its data products more cost-effectively as well. Although quantifying the cost-effectiveness of IT is difficult, at least the benefits and costs can be estimated with some degree of accuracy (Gregory 1998). Even crude financial analysis is better than no analysis or comparison of IT choices.

46. While implementing IT cost-effectively offers challenges, it also offers organizational opportunities. With new tools for doing its work, the Census Bureau can develop standards for training and competency for employees in many areas of bureau activity. Moreover, the need to develop standard training programs for IT personnel can drive the need to standardize information technology, a change that should increase cost-effectiveness of investments. Finally, IT can provide career paths in new and challenging areas (Sullivan 1998).

47. Since IT offers tremendous opportunities for data collection, entry, processing and dissemination, it has become a fundamental component of the business of the Census Bureau. The challenge is to manage investments wisely to achieve economies across the bureau. Furthermore, it must be remembered that cost-effectiveness and cost-benefit analyses are tools to guide IT investments, and that programmatic requirements must ultimately determine what investments are made (Mesenbourg 1998).

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