MEASURING U.S. INNOVATIVE ACTIVITY

by

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Abstract

Innovation has long been credited as a leading source of economic strength and vitality in the United States because it leads to new goods and services and increases productivity, leading to better living standards. Better measures of innovative activities–activities including but not limited to innovation alone–could improve what we know about the sources of productivity and economic growth. The U.S. Census Bureau either currently collects, or has collected, data on some measures of innovative activities, such as the diffusion of innovations and technologies, human and organizational capital, entrepreneurship and other worker and firm characteristics, and the entry and exit of businesses, that research shows affect productivity and other measures of economic performance. But developing an understanding of how those effects work requires more than just measures of innovative activity. It also requires solid statistical information about core measures of the economy: that is, comprehensive coverage of all industries, including improved measures of output and sales and additional information on inputs and purchased materials at the micro (enterprise) level for the same economic unit over time (so the effects can be measured). Filling gaps in core data would allow us to rule out the possibility that a measure of innovative activity merely proxies for something that is omitted from or measured poorly in the core data, provide more information about innovative activities, and strengthen our ability to evaluate the performance of the entire economy. These gaps can be filled by better integrating existing data and by more structured collections of new data.

Keywords: Innovation, productivity, economic measurement

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1. Introduction

Innovation has long been credited as a leading source of economic strength and vitality in the United States. Innovation leads to new goods and services and increases productivity, leading to better living standards. It is not surprising, then, that policy makers want to create an environment that encourages innovative activity. Establishing such an environment requires an understanding of how innovative activities affect economic performance.

Better measures of innovative activities–activities including but not limited to innovation alone–could improve what we know about the sources of productivity and economic growth. The U.S. Census Bureau either currently collects, or has collected, data on some measures of innovative activities, such as the diffusion of innovations and technologies, human and organizational capital, entrepreneurship and other worker and firm characteristics, and the entry and exit of businesses. Research at the Center for Economic Studies of the U.S. Census Bureau and its Research Data Center system shows that these innovative activities affect productivity and other measures of economic performance. However, the existing data are not collected as part of a systematic economic measurement program on innovative activities, so there are important gaps in what is collected, for what sectors, and for which years.

Other countries' experiences with innovation surveys show that data on innovation can be collected. Research using these data shows their potential for analyzing productivity and economic growth, although the richest insights come from analyses, like those using U.S. data, that draw on data about multiple characteristics and activities of the same businesses. The experiences in countries with formal innovation surveys show that some methodological issues, particularly low response rates, remain unresolved. Collecting high-quality innovation data would require resolving these issues.

There have been calls for the U.S. to perform an innovation survey similar to those carried out in Canada and many European Union member countries. But neither a formal innovation survey nor more data on innovative activities would fill the critical and long-standing gaps in the core data needed to analyze economic performance—that is, comprehensive coverage of non-manufacturing industries, including improved measures of output and sales and additional information on inputs such as capital, labor, and purchased materials at the micro (enterprise) level for the same economic unit over time (so the effects can be measured). Without good longitudinal measures of these core data, it is hard to rule out the possibility that a measure of innovative activity merely proxies for something that is omitted from or measured poorly in the core data.

In considering how U.S. innovative activity might be better measured, reallocating additional statistical system resources for a formal innovation survey must be balanced against alternative uses, such as filling major gaps in the baseline data that the U.S. statistical system collects about businesses. Developing new measures of the effects of investment in information technology on productivity required similar assessments and tradeoffs (e.g., Atrostic, Gates, and Jarmin 2000; Mesenbourg 2001). This paper reviews existing data on innovation and innovative activities and insights gained from research analyzing these data, and identifies key gaps remaining in core U.S. data about businesses.

2. Defining Innovative Activity: Beyond Research and Development and Innovation

Internationally recognized definitions of research and development and innovation have been developed for statistical purposes to make it more likely that the data collected are internationally comparable. Research and development is defined for statistical purposes by an international effort led by the Organization for Economic Cooperation and Development (OECD) in a 1963 manual known as the "Frascati" manual – see Text Box 1. The manual has been revised, most recently in 2002 (OECD 2002). The National Science Foundation (NSF) is charged by Congress "to provide a central clearinghouse for the collection, interpretation, and analysis of data on scientific and engineering resources and to provide a source of information for policy formulation by other agencies of the Federal Government." Thus, for example, NSF has sponsored the collection of R&D data since 1953. Published U.S. research and development statistics and their underlying statistical foundation have been critically assessed periodically since data collection began. The most recent external professional review, conducted by the Committee on National Statistics for the National Research Council, was published in 2005 (see National Research Council, 2005).

Innovation is defined for statistical purposes by the 1992 "Oslo" Manual published by the OECD. The original Oslo Manual distinguished two kinds of innovation – product and process innovation – and covered only manufacturing. In the 1997 revision, coverage expanded to include services industries. Noting that innovation in services is likely to differ from manufacturing, the 2005 revision added non-technological innovations such as marketing and organizational innovation, and correspondingly modified definitions, terms, and concepts (OECD 2005) – see Text Box 1. The European Union countries, and many other countries around the world, such as Norway, Canada, and Japan, now collect a separate innovation survey based on the Oslo manual.

Innovation is one step in the dynamic process that starts with inputs to innovation (such as education, and R&D) that yield the innovation itself, to the diffusion of the innovation to businesses or consumers, and leads finally to an outcome such as increased productivity, improved energy efficiency, or new consumer goods and services. Understanding the impact of innovation on economic performance requires reliable data on the inputs and outcomes of innovative activities and not just measures of whether innovation has taken place.

A body of research shows significant relationships between productivity and a large set of factors beyond research and development expenditures and narrow measures of innovation. These other factors, which include measures of technology, human capital, organizational capability, and other intangibles, are the innovative activities whose measurement is the focus of this paper.

Text Box 1: Definitions

1. Research and Development

"Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications…." (paragraph 63);

"covers basic research, applied research, and experimental development" (paragraph 64);

Excludes "Education and training; Other related scientific and technological activities; Other industrial activities; Administration and other supporting activities" (paragraph 66).

Frascati Manual: Proposed Practice Standard for Surveys on Research and Experimental Development, (OECD 2002), http://www1.oecd.org/publications/e-book/9202081E.PDF.

2. Innovation
"The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization, or external relations."

Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data (OECD 2005), http://www.oecd.org/document/23/0,2340,en_2649_34409_35595607_1_1_1_1,00.html, p. 46.

3. U.S. Census Bureau Data Related to Innovative Activity: Data and Research Findings

The U.S. Census Bureau's microdata, largely but not exclusively from its surveys and censuses of businesses, have been used extensively to examine the determinants of productivity and other measures of economic performance. In addition, microdata from selected surveys have been used to investigate innovative activities such as the use of advanced manufacturing technologies, computer networking, electronic business processes, worker training, management practices, and exporting and importing.[1] The resulting analyses yield new insights into the structure of businesses and sources of productivity, and, in some cases, are changing the direction of economic theory (Center for Economic Studies 2006).

Brief descriptions of major U.S. Census Bureau datasets related to innovative activity, more detailed summaries of research, and links to data and research references, are given in Appendix 1. This section summarizes research findings on selected aspects of innovative activities, including the diffusion of innovations, and human and organizational capital, and notes recent and planned data enhancements.

Research Findings:

Diffusion of Innovation. Advanced manufacturing technologies, including computer networks, are widely used, but diffusion rates vary among technologies and across industries. Using these technologies is associated with higher productivity (McGuckin *et al*. 1998, Atrostic and Nguyen 2005). Plants may adopt or drop technologies over time, perhaps in response to the skills of their workers (Lewis 2005). Finally, some but not all uses of general-purpose technologies such as computer networks are associated with higher productivity (Atrostic and Nguyen 2006b).

Human and Organizational Capital. Recently developed databases allow researchers to analyze the joint behavior of businesses and their workers. Empirical evidence on the links between

[1] The U.S. Census Bureau business microdata discussed in this paper all are confidential. External researchers must apply for access through the Census Bureau's Research Data Centers – see Center for Economic Studies (2007).

business performance and workplace practices is mixed. “High-performance” workplace practices raise labor costs per employee and have a statistically weak link to improved plant-level labor productivity (Cappelli and Neumark 2001). By contrast, innovative workplace practices, the use of information technology, investments in human capital, and hiring better-educated workers, are strongly related to multi-factor productivity growth (Black and Lynch 2001, 2005).

Analyses of the transition of small and young businesses without paid employees to employer status show that these businesses are both very dynamic and volatile (Jarmin 2006). An analysis of the software industry explores the link between the riskiness of the firm’s product market – where risk derives from undertaking innovative activity – and the distribution of its workers’ earnings. It finds that firms in markets whose returns have high variance pay more to attract and retain the star workers who produce the innovative new products that yield high returns to the firm (Andersson *et al.* 2006).

Engaging in international trade may reflect a firm’s organizational capital: Firms that engage in foreign trade have higher productivity, are larger, use more capital, and stay in business longer than firms that do not. Corporate structure is important in trade, with multinational companies accounting for only 1 percent of U.S. manufacturing firms but about 20 percent of firms that trade (Bernard, Jensen, and Schott (2005a,b)). Firms that outsource – produce parts of a product in several countries – have more workers, produce more output, and are more profitable (Kurz 2006).[2]

Data enhancements. Data on investment in information technology, collected in the 1998 Annual Capital Expenditure Survey, show that such investment is less lumpy than other kinds of investment (Wilson 2004a), and that it is positively associated with productivity in both the manufacturing and non-manufacturing sectors (Wilson 2004b). Data were collected for the first time in 2003 on *all* business spending on information technology, not just spending that qualifies as investment. The share of non-capitalized spending ranged from 28 percent of information technology equipment to 50 percent of computer software (U.S. Census Bureau 2006a).

The National Science Foundation (NSF) is sponsoring several extensions to the current data on research and development (R&D) collected by the U.S. Census Bureau. A few questions are being added to the 2007 Economic Census, for selected industries. NSF and the Census Bureau are redesigning the R&D survey and are developing new and more effective questions about the cost of domestic R&D, and foreign and contracted-out R&D.

[2] The first formal project for inter-agency data sharing conducted under the Confidential Information Protection and Statistical Efficiency Act of 2002 (CIPSEA) produced a potentially rich source of information for analyzing the consequence of Foreign Direct Investment (FDI) for innovation and other economic outcomes. The interagency project involved an agreement between the Bureau of Economic Analysis (BEA) and the U.S. Census Bureau to match data from BEA’s surveys of FDI in the U.S. and U.S. Direct Investment Abroad with data from the Survey of Industrial Research and Development (SIRD) sponsored by the Division of Science Resources Statistics (SRS) of the National Science Foundation (NSF) and the U.S. Census Bureau (U.S. Census Bureau *et al*. 2005). Results from this study are summarized in Howenstine (2006).

4. **Measuring Innovative Activities in Other Countries: Data and Research Findings**

The statistical organizations of the European Union (EU) and many other countries collect innovation data through the Community Innovation Surveys (CIS).[3] This section briefly describes the CIS. It also summarizes selected research findings on the sources of productivity and economic performance that are based on the CIS or on other micro data.

CIS Data. The initial round of CIS data, collected in 1993, CIS1, was limited to the manufacturing sector. The second round, CIS2, was based on the 1997 revision of the *Oslo Manual* (OECD 1997), and expanded to include selected service sector industries, with different surveys for manufacturing and services. The scope of CIS3 expanded to include both manufacturing and the entire service sectors. CIS3 includes innovative activities such as organizational innovation that are included in the 2005 revision *Oslo Manual*, with a common questionnaire for all industries (European Commission 2004). Further details on the CIS surveys, references and links, and summary results for selected countries, are given in Appendix 2.

The share of firms that are innovative varies widely across EU countries, industries, and sectors. For example, Guellec and Pattinson (2001) report that 51 percent of EU manufacturing firms innovated in 1994-96, compared to 40 percent of services firms. The share of innovators in manufacturing ranged from 26 to 73 percent (Portugal and Ireland), and from 13 to 58 percent in services (Belgium and Ireland). The CIS3 data show similar variations (European Commission 2004).

Research Findings:

Methodology. According to Guellec and Pattinson (2001), definitional and methodological issues contribute to the wide variations in reported shares of innovative firms, over and above actual differences in innovative behaviors. The definition of "technological" itself appears to present problems. The word may have different meanings when translated into different languages. Countries did not always use the word in their questionnaires, and responses seem to be sensitive to small changes in definition.

Response rates for CIS1, CIS2, and CIS3 ranged across countries from less than 30 percent to more than 80 percent (Guellec and Pattinson (2001) and European Commission (2004)). Some of the difference in response rates may be due to differences in collection methodologies. For example, CIS3 was mandatory in five countries (Norway, Spain, France, Italy and Sweden), including two of those with the highest response rates (France and Norway), but voluntary elsewhere (Lucking 2004). Low response rates are a concern because they may affect the quality and comparability of the data, although nonresponse analysis for CIS3 finds no bias in aggregate data (Jaumotte and Pain 2005).

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[3] While Australia conducted four innovation surveys between 1993 and 2005, it decided not to conduct further separate innovation surveys. Instead, it plans to create an Integrated Business Characteristics Strategy (IBCS) that will collect information on innovation and information technology use in conjunction with its Business Characteristics Survey. Core questions on innovation and information technology will be asked each year. In alternate years, detailed questions will be asked on innovation or information technology. (ABS ITU Bulletin 14, August 2006).

Analytical Findings. The CIS microdata for many countries have been extensively analyzed. Initial analyses typically focus on innovation as an outcome. More recent studies extend the analyses to model innovation's impact on measures of the business's economic performance, such as productivity, and growth of employment or output. These studies typically link the innovation data to other sources of information about the firm. Hall and Mairesse (2006) summarize several such studies presented at a conference and note that it is hard to make cross-country and cross-study comparisons from the current econometric literature based on innovation microdata, as data sources may not be comparable across studies. Even studies using the CIS may select different variables from the survey, or estimate different empirical models. Similar observations apply to the range of studies reviewed in Jaumotte and Pain (2005). Despite these substantial methodological differences, however, most studies find positive and statistically significant relationships between innovation and productivity.

However, many other studies for the same sets of countries use other sources of microdata and find positive and statistically significant relationships between productivity and other measures of innovative activity, such as participating in foreign trade or using advanced information processing and computer technologies. For example, Dourfour, Nakaumra, and Tang (2006) analyze data on business practices and advanced technology in Canadian manufacturing, using data collected in the 1998 Survey of Advanced Technology, linked to the annual Survey of Manufacturing for 1995 and 1998. They find statistically significant relationships between productivity and the use of various business practices and computer technologies, and significant interactions between the practices and technologies. Bloom, Sadun and Van Reenen (2006) explore the joint effects of using information technology, participating in international trade, and the ownership structure of firms, for the United Kingdom. They find distinct effects and interactions among these factors. An analysis of German and Dutch firms in the services sector finds a direct impact of innovation on multi-factor productivity in both countries, as well as a joint impact of the use of information technology and technological innovation (Hempell, van Leeuwen, and van der Wiel 2006).

While the importance of innovative activity is evident, and a growing number of researchers in more and more OECD countries are assessing the CIS and related data, the conclusions are currently neither uniform nor clear. The OECD, through its Statistical Working Party of the Industry Committee (SWIC), is leading an international effort to conduct comparable econometric analyses using innovation survey micro data. Those studies are being developed, and will be presented and discussed at a series of workshops planned through 2007 and 2008.

5. Methodological Issues in Implementing "Best Practices" in Innovation Statistics

Many innovative activities – innovations themselves, organizational capital, and the use of specific kinds of business practices – fall outside the standard economic measurement model, raising questions about whether statistical organizations can measure such factors well. The National Resource Council's 2005 report on measuring research and development expenditures recommended that the United States collect innovation data. However, it also noted significant methodological problems with the innovation surveys conducted by other countries, and expected that further problems would be encountered in trying to apply measures designed for other economies to the U.S. economy (National Resource Council 2005). The review of lessons learned from U.S. data collection on innovative activities, and from other countries' experience with innovation surveys, suggests three issues to consider in assessing whether the U.S. could apply current "best practice":

1. Applicability – survey designs and questions that work well for other countries may need considerable re-thinking to apply well to the U.S. economy;
2. Response rates – typical response rates on innovation surveys are low;
3. Resources – statistical organizations need resources to prepare and conduct surveys that yield high quality data.

Applicability. The structure of the U.S. economy differs from that of most European countries, and many other OECD countries. U.S. economic activity is concentrated in large firms. In 2003, only 0.3 percent of all U.S. firms had more than 500 employees, but these large firms accounted for 49 percent of firm employment and 55 percent of firm payroll. This structure makes it hard to determine the appropriate reporting unit for surveys – the unit best able to answer specific questions. In multi-unit firms, the appropriate respondent for questions about company-wide issues such as management practices or investment may be at corporate headquarters. But the appropriate respondent for questions about specific inputs and outputs, or the use of particular techniques or processes, may be at the plant or establishment. Even within the plant, the best respondent for questions about the use of specific processes may not be the best respondent for other information, such as employment and sales (Mesenbourg 2001). Finally, the ability of statistical organizations to collect accurate information depends on the ease with which respondents can provide it. Neither the structures of businesses nor their record-keeping practices is well understood. To improve its business survey programs, the U.S. Census Bureau is soliciting proposals for research on both topics through its new dissertation fellowship program (U.S. Census Bureau 2006c).

Response rates. Response rates affect the quality and cost of surveys. The empirical evidence suggests that innovation data are difficult to collect. The response rates for innovation surveys in the U.S. and in countries using the Oslo Manual are almost always low. The response rate for the 1995 NSF / Census Bureau Pilot Innovation survey was between 45 and 53 percent, and the rate for the 2001 NSF / IBM survey was 57 percent. Response rates are similar for the CIS surveys for European Union countries. Norway's response rate was 96 percent (to a mandatory survey). Spain had the next-highest response rate, 73 percent. Response rates for the remaining countries ranged from 21 to 63 percent. Making response to these surveys mandatory does not address the data collection challenges and could erode the willingness of these respondents to cooperate on other important surveys. Statistical organizations continue to conduct research on response rates in business surveys, such as Petroni *et al.* (2004) and sources cited in it, and to request research proposals on nonresponse through U.S. Census Bureau fellowship and dissertation grants programs (U.S. Census Bureau 2006d and 2006c).

Resources. Assuring that new information collected about innovative activity would be of high quality would require statistical agencies and respondents to make significant resource commitments. Statistical agencies need computing and human resource infrastructures to accomplish survey tasks such as pre-testing, and data collection and processing. Pre-testing assesses whether respondents understand survey questions, and whether they are able to provide the requested information. Adequate lead-time assures that test results can be incorporated in the final survey design.

6. Critical Data Gaps for Measuring Innovative Activity and Its Impacts on Economic Performance

The Census Bureau either currently collects, or has collected, data on some measures of innovative activities, such as the diffusion of innovations and technologies, human and organizational capital, entrepreneurship and other worker and firm characteristics, and the entry and exit of businesses. Research at the Census Bureau Center for Economic Studies and in its Research Data Center system shows that these innovative activities do affect productivity and other measures of economic performance.

Neither a formal innovation survey nor other more systematic data on innovative activities would fill the critical and long-standing gaps in the core data needed to analyze economic performance -- that is, comprehensive coverage of service industries, improved measures of output and sales and additional information on inputs such as capital, labor, and purchased materials at the micro (enterprise) level for the same economic unit over time (so the effects can be measured). Without good longitudinal measures of these core data, it is hard to rule out the possibility that a measure of innovative activity merely proxies for something that is omitted from or measured poorly in the core data.

Considering how U.S. statistical resources might be used to better measure innovative activity therefore requires balancing that use against alternatives such as filling major gaps in the core data that the U.S. statistical system collects about businesses. Developing new measures of the role of information technology on productivity required similar assessments and tradeoffs (e.g., Atrostic, Gates, and Jarmin 2000; Mesenbourg 2001). Two basic ways of filling data gaps are to collect new data, and to leverage existing data. Some ways of filling the gaps could both provide information about innovative activity and substantially improve the information available to evaluate the performance of the economy as a whole.

The first part of this section identifies critical gaps in core data. The second part of this section outlines ways of potentially filling these critical gaps, including initiatives currently underway at the U.S. Census Bureau.

<u>Critical Data Gaps:</u>

<u>Comprehensive coverage of services industries.</u> The Census Bureau collects detailed information on inputs and outputs in the manufacturing sector. In contrast, coverage of services industries, which account for 55 percent of Gross Domestic Product, is incomplete. However, it is likely that much innovative activity takes place in this large and growing sector of the economy. Indeed, some analysts conclude that productivity growth in the services sector "fueled the post-1995 expansion of labor productivity in the United States" (Triplett and Bosworth 2005). But the data needed to test such hypotheses at the level of the business unit are far sparser

in the non-manufacturing sectors. Filling this core data gap must be our highest statistical priority.

Output data for services have been expanded in the last several years but still do not match the breadth of information available for manufacturing, nor are comprehensive data available annually for retail or wholesale trade. An example is annual product data. Product data are routinely available for manufacturing, and the 2007 Economic Census will collect product detail for the first time for all services industries, but product detail is not now collected for either retail or wholesale trade, except in the Economic Census.

The input information that is needed to help explain economic change – data on materials, energy, producer services, and other inputs – is much less complete for non-manufacturing sectors of the economy.   Data on technology diffusion, such as the use of advanced information and communication technologies, are rarely collected for the non-manufacturing sector.

Understanding the process of innovation from its inputs, to its inception, through its diffusion to businesses or consumers, and finally to its outcome in terms of productivity or long-term growth or consumer well-being, requires linking together the various data sources that measure the individual parts of the process. In the manufacturing sector, data on inputs and outputs are typically collected from the same plant, making it straightforward to measure productivity growth at the plant level and assess the effects of changes in important inputs (labor, capital, energy, and materials) to production. In service industries, however, data on inputs and outputs are collected in separate surveys that have different sampling frames and may be collected from different economic units, such as from a retail store and its corporate parent.

While in principle the internal identification information exists to make appropriate linkages among service sector data, in practice it may be difficult. For example, Doms, Jarmin, and Klimek (2004) detail specific problems they encountered in trying to link data from the Censuses of Retail Trade and the Assets and Expenditures Survey (now the Business Expenditure Survey) over the 1992 to 1997 period. More generally, when such linkages are imprecise, it is difficult to assess the impact of any technology, process, or other innovative activity for the non-manufacturing sectors, and to compare such estimates with those based on manufacturing data.

Longitudinal measures of technology development and diffusion. Many important questions about technology and its diffusion in the U.S. economy are asked only infrequently. The absence of longitudinal information on these topics reduces our ability to understand the paths through which they can affect economic outcomes such as productivity, long-term growth, or consumer well-being. For example, surveys concerning the diffusion of advanced technology have been conducted only a few times in the last 20 years. The Survey of Manufacturing Technology was conducted in 1988 and 1993 (with a one-time survey conducted in 1992 on the barriers to, and benefits and costs of, using advanced technologies), and the Computer Network Use Survey was conducted only in 1999. Both surveys were limited to the manufacturing sector. Information on specific supply chain practices was collected for manufacturing and non-manufacturing sectors in the 2002 Economic Census. Indicators on off-shoring and outsourcing are planned for the 2007 Economic Censuses of Manufacturing and Wholesaling.

Improved measures of small business performance. While large companies account for most of the economic activity in the U.S., small business contribute to innovation and job growth. The Census Bureau must rely heavily on administrative data for information on small companies. Collecting more survey information on small businesses would improve our understanding of the dynamics of the U.S. economy, but increasing the respondent burden is unattractive. Research would be valuable on how to leverage existing administrative data sources for small companies.

Linked survey data. The ability to link surveys and administrative data together and to link them over time is crucial. In order to be able to understand the process of innovation from its inputs, to its inception, through its diffusion to businesses or consumers, and finally to its outcome in terms of productivity or long-term growth or consumer well-being, it is necessary to link together the various data sources that measure the individual parts of the process. More reliable linkages can be made, and made more quickly, when potential linkages are considered in creating the survey design. The Census Bureau's re-engineering of the Survey of Income and Program Participation, for example, explicitly envisions linkages between survey responses and administrative data, and the Census Bureau plans to structure some of its questions to dovetail with selected data in administrative data files (U.S. Census Bureau 2006e). In addition, the underlying technical information showing the relationships among the businesses responding to various censuses, surveys, and administrative data sources must be kept up-to-date.

Detail on inputs. Collecting additional detailed data on inputs is also important. For example, the Annual Capital Expenditure Survey collects data on information technology, but lacks data on real capital stock, vintages of capital, or on service flows. These gaps limit the ability to understand all the sources of productivity growth, part of isolating the effect of innovation. There is a parallel need for detailed data on labor inputs. U.S. Census Bureau data collections for businesses include only total employment on March 12th in any survey year. Hours worked are collected only for production workers in manufacturing. There is no detail on the occupations, training, or other characteristics of workers. The Longitudinal Employer Household Dynamics (LEHD) project leverages existing data to synthesize such firm-level detail. However, the LEHD data products are new, are not created for all states, and are extremely complex files. Additional data on labor inputs could come from the questions on employer spending on worker health insurance and pension benefits that are planned for the 2007 Economic Census. Collecting more detailed information on inputs in the Economic Censuses of service industries would provide data for a much larger number of businesses than would adding comparable questions to annual surveys, and would provide the new input data for the same economic units as the other information collected in the Economic Censuses.

Filling Critical Data Gaps:

Collecting new data, such as new surveys of innovation, technology use, or workplace practices, provides new information going forward. However, as shown in the preceding section, statistical agencies and respondents incur costs to provide that information. Leveraging existing data by linking records about the same business can fill some critical data gaps without expending the substantial resources required to collect new data. Most of the research papers cited in this review, for example, are based on linkages among different censuses and surveys within a country.

<u>*Collecting new data.*</u> Several relevant new data collections are planned as outgrowths of the Census Bureau's on-going measurement programs. These new data collections will yield more information about the determinants of economic performance and the role of innovative activities if the data collection plans include collecting in successive periods, allowing longitudinal analyses.

Reflecting the importance of filling gaps in the frequency with which it collects data on service industries, the Census Bureau has proposed an initiative in its budget for fiscal year 2008 to provide quarterly and annual coverage of all twelve of the service sectors. This expansion would match the coverage of the quinquennial Economic Census.

Indicators of off shoring and outsourcing will be collected in the 2007 Economic Census for manufacturing and wholesale industries. Research at CES (for example, Bernard and Jensen 2005) and for other countries (for example, Bloom *et al.* 2006 for the United Kingdom) shows that participating in foreign trade or international economic activities is associated with productivity.

Corporate structure – whether a business is a single economic unit or part of a larger economic structure – may affect the unit's level or sources of innovative activity. A major expansion of questions about franchising, also planned for the 2007 Economic Census, will provide more information about this facet of corporate structure for roughly 80 industries. The industries are primarily in retail, but some, such as baking, are in manufacturing.

The 2002 Survey of Business Owners (SBO) collected information on the characteristics of businesses, including franchising, and on characteristics of business owners for 2.4 million businesses. The SBO covered both employer and non-employer businesses. The 2007 SBO will provide updated and expanded information on businesses and owners.

The Company Organization Survey will in the future collect new data in alternate years on offshoring and on research and development. Data on offshoring, of interest in their own right, will improve the frame for the BEA's survey of Foreign Direct Investment (FDI). As prior research has shown, participating in FDI may be an innovative activity that reflects a firm's organizational capital. New data on the use of the research and development tax credit will be collected to improve the survey frame for the current R&D survey.

The National Science Foundation is sponsoring several extensions to the current data on research and development collected by the U.S. Census Bureau. Questions for selected industries are being added to the 2007 Economic Census. Questions on the cost of foreign and domestic research and development are being tested as part of the NSF-Census Bureau re-design of the R&D survey.

<u>*Leveraging existing data*</u>. Researchers at CES and in the RDC system have leveraged existing data by linking many existing survey, census, and administrative data sources that can be used to

understand the determinants of economic performance and the role of innovative activities; see, for example, Center for Economic Studies 2005 and 2006. However, important research remains to be conducted with existing linkages. For example, R&D data that have been collected since 1953 are one obvious source of potential insights into these topics. While CES and RDC researchers have conducted a number of analyses of the R&D data, including many that link the R&D data with other micro data (see, for example, a number of papers by Adams on the CES web site), those analyses largely took place in the early 1990s. Not only is there nearly a decade of new R&D data, but the R&D survey during this period also expanded beyond the manufacturing sector.

In addition to more, and more thorough, analyses of existing data, a variety of new linkages would further leverage resources already expended on existing data collection and deepen and expand understanding of these topics. For example, the database on the merger and acquisitions (M&A) structure of U.S. companies that CES researchers created in the 1990s (Nguyen 1998) has been extensively used to understand the effect of changes in corporate structure on economic performance and related outcomes. However, the database ends in 1992. Analyses have just begun using both survey and administrative data on international trade. The investment in the LEHD program has produced a growing number of linked micro data products that are just beginning to become available to CES and RDC researchers. These new linkages of worker, employer, and administrative data hold the promise of filling critical data gaps, particularly gaps in what is known about the characteristics of workers, and about the joint characteristics of workers and employers.

Finally, there are many sources of external data on businesses, such as investments in specific kinds of computer hardware or other technologies, or financial characteristics (such as the foreign operations of firms operating in the United States, which are not collected by the U.S. Census Bureau), that could potentially be linked – in the secure RDC setting – with existing Census Bureau data. Analyses using such external data further leverage existing Census Bureau investments in data collection and linkages.

7. Conclusion

The potential of innovative activities to increase productivity, economic growth, and consumer-well-being generates interest in measuring those activities and improving understanding of how they affect economic performance. But understanding how innovative activity affects economic performance requires solid statistical information about core measures of the economy as well as about innovative activity. It also requires good longitudinal measures of these core data – the same core data collected repeatedly over time from the same economic units – to rule out the possibility that a measure of innovative activity merely proxies for something that is omitted from or measured poorly in the core data. In particular, gaps in critical components of the core data, particularly for the service sector, limit the ability to understand determinants of economic performance and the role of innovative activities. Filling some of these gaps could both provide more information about innovative activities and strengthen our ability to evaluate the performance of the entire economy. Filling these gaps can be accomplished by better integration of existing data as well as by more structured collections of new data.

Colleagues at the Census Bureau and at other statistical agencies, as well as data users and data providers, are invited to provide feedback, corrections, and suggestions. Please direct your comments and suggestions to the author, at the e-mail address on the title page.

Appendix 1: U.S. Census Bureau Micro Data Related to Innovative Activity

a. Annual Capital Expenditure Survey (ACES), and Information and Communication Technology Survey (ICTS) Supplement.

Data:

The Annual Capital Expenditures Survey (ACES) is a firm-level survey designed to collect industry-level data on capital investment in new and used structures and equipment. The sample consists of large employers, small employers, and non-employers. Respondents are asked to provide capital expenditures data for each industry in which they had activity and to classify these expenditures as new or used and as structures, equipment, or other. Additional firm-level information is collected on total assets, depreciation and retirements, sales/revenue, and capital lease arrangements. In certain years, firms are asked to break down their expenditures further, by type of structure (in 1992, 1994, 1998, and 2003) and type of equipment (in 1992, 1998, and 2003). In 2003, the Census Bureau fielded an ACES supplement that asked firms about specific kinds of spending on information technology. The supplement, the Information and Communication Technology Survey (ICTS), has been collected annually since 2003. The supplement expands the scope of the ACES by asking both about information and communication technology items that were treated as investment – the traditional scope of ACES – and as expenses. Expensed items were asked because of concerns that falling prices of computers and other kinds of information technology meant that an investment-based ACES concept was missing a growing and potentially large share of information and communications technology (ICT) spending.

Detail on asset type was introduced in the 1998 ACES. The 2003 and 2004 ACES and ICTS data only recently became available for research.

Lessons Learned:

Analysis of the 1998 micro data shows the importance of collecting that detail: the capital spending of a typical firm is concentrated on a few kinds of capital, with the specific kinds of capital varying substantially among firms. While previous research found that a firm's investment was typically lumpy over time, the ACES data show that computer investment is less lumpy than other kinds of investment (Wilson 2004a). Further analysis finds that investment in information technology is positively associated with productivity in both the manufacturing and non-manufacturing sectors (Wilson 2004b).

The published data from the 2003 and 2004 ACES and ICTS clearly show the importance of measuring all ICT spending, not just spending that qualifies as investment. Noncapitalized spending is an important share of all four major ICT groups: Computer and peripheral equipment; information and communication technology (ICT) equipment; electromedical and electrotherapeutic apparatus; and computer software. The share ranges from 28 percent of ICT equipment to 50 percent of computer software (U.S. Census Bureau 2006a).

b. Computer Network Use Survey: 1999.

Data:

The 1999 Computer Network Use Survey (CNUS) was designed as a supplement to the 1999 Annual Survey of Manufactures (ASM), and was collected by the U.S. Census Bureau in 2000 (U.S. Census Bureau 2002). The 1999 CNUS was one of the data collections that the U.S. Census Bureau conducted based on analysis of data needs for understanding the impact of information technology (Mesenbourg 2001; Atrostic, Gates, and Jarmin 2000). The mandatory survey – plants were required by law to respond to the CNUS as well as to the ASM – was sent to approximately 55,000 U.S. manufacturing plants. The CNUS data can be linked to the ASM and to the Census of Manufactures.

The CNUS collected information on whether the plant had a computer network, the kind of network (e.g., open technologies such as the Internet, or closed technologies, such as Electronic Data Interchange, which had been in place for some time), whether the plant engaged in e-commerce (buying and selling on-line), the value of e-commerce sales and purchases, and whether the plant used electronic enterprise-wide planning systems. The CNUS asked about more than 25 ways that plants used their computer networks, such as controlling their production processes, for inventory control, logistics, etc. The CNUS also asked about specific kinds of information that plants share over their networks with customers and suppliers.

Lessons Learned:

The Census Bureau developed the questions in close consultation with industry experts to make a close fit between the concepts measured and actual business practice and nomenclature. The CNUS was sent to the plant manager, rather than to the usual ASM contact, typically in the accounting department, because the plant manager was expected to be aware of the ways the plant used information technology (Mesenbourg 2001). The response rate for the CNUS was 83%. The importance of asking the plant manager about network use, and of having a consistent respondent, was highlighted the next year, when the standard respondent was asked to report e-commerce sales and purchases. Differences were identified in whether a plant was reported to have such activity, and in the amounts reported (U.S. Census Bureau 2000).

Research using the CNUS data finds strong empirical links between productivity and the use of computer networks (Atrostic and Nguyen 2005). The research also finds that computers and computer networks are distinct forms of capital, and that both are linked to productivity (Atrostic and Nguyen 2006a). Plant-level productivity increases with the intensity of network use – with the number of processes conducted over networks. However, not all of the uses are linked with productivity. Using networks to run sophisticated enterprise software is associated with higher productivity, as are using networks to control inventories and logistics, but other uses, such as managing core production processes, are not (Atrostic and Nguyen 2006b).

Similar data were collected for Japan in 1991 and 2000 (Motohashi 1999, 2001, 2003). Analysis of the 1991 data suggested that some uses of networks were associated with productivity but other uses were not. However, a parallel analysis of the 1999 CNUS data and the 2000 data for Japan finds strong links between the use of computer networks and productivity in both countries, but statistically significant links between productivity and specific ways of using networks, such as inventory control, only for the United States (Atrostic, Motohashi, Nguyen 2005).

c. Entrepreneurship: Characteristics of Business Owners Survey (CBO) and Integrated Longitudinal Business Database (ILBD).

Data:

Several Census Bureau data collections address different aspects of the formation and growth of small businesses. The 1987 and 1992 Characteristics of Business Owners (CBO) Survey contained detailed information about businesses and their owners. The CBO was replaced in 1997 by the Survey of Business Owners (SBO), which asks less financial information than did the CBO. However, while the 1992 CBO sampled 78,000 firms and 116,000 business owners, the 2002 SBO collected information on the characteristics of businesses, and business owners, for 2.4 million employer and non-employer businesses. A major data development project of the Center for Economic Studies is creating an Integrated Longitudinal Business Database (ILBD) including businesses with and without employees. The ILBD thus makes it possible to follow a business as it transitions from being a non-employer to an employer (Jarmin 2006). The ILBD is intended to provide rich and current data on business creation.

Lessons Learned:

Researchers prefer rich current data that allows them to explore complex questions. Most CES and RDC research on entrepreneurship and small businesses since 1988 used the CBO data. There is less recent research on this topic – only 5 CES working papers since 1999 compared to 21 in total since 1988 – and most of it used data from 1992 or earlier.

Summarizing the extensive research findings based on the CBO is difficult. Researchers have examined topics ranging from the effects of franchising on business duration to whether intergenerational links in self-employment are due to family entrepreneurial preferences, rather than the inheritance of businesses. The research can be found under *Discussion Papers* at Center for Economic Studies 2007.

The ILBD provides new facts about U.S. businesses. Non-employer businesses are a large share of all businesses but not of business revenues. About three-fourths of U.S. businesses in 2000 were non-employers, and most businesses with employees had only one establishment. Initial research finds that about three percent of non-employer businesses become employer businesses, and that businesses transitioning from non-employer to employer grow more rapidly before transiting than other non-employers. Young businesses are both very dynamic and volatile (Jarmin 2006).

d. Foreign Trade: Annual Survey of Manufactures, Longitudinal Research Database, Commodity Flows Surveys, and Foreign Direct Investment.

Data:

International trade – importing and exporting goods and services – and foreign direct investment (FDI) – acquiring subsidiaries in foreign countries – are rapidly growing economic activities. Engaging in them may be viewed as innovative activity because they require innovative and flexible corporate management to deal with diverse cultures and wide-flung production processes in an increasingly interconnected and complex world, and because they may facilitate innovative and flexible production. Until recently, however, traditional trade theory lacked both tools and data to analyze such behaviors. Newly available micro data on trade spurred the development of new theoretical tools and corresponding new empirical research on these activities (see, for example, Melitz 2003). Helpman 2006a and 2006b summarize recent research on trade, FDI, and firm organization.

Initial micro data analyses of international trade were limited to exporting activity in the manufacturing sector, using data from the Annual Survey of Manufactures and the Longitudinal Research Database (LRD) (e.g., Bernard et al. 2003). Recent research expands the sectors analyzed beyond manufacturing by using the Integrated Longitudinal Research Database (ILRD), and expands the information about trading firms. Firm-level linkages of detailed data on the type and value of imports and exports based on U.S. customs data are added, and the corporate structure of traders (e.g. whether trading firms are domestic or multinational) is linked in (see, for example, Bernard, Jensen, and Schott (2005a, 2005b)). These studies generally examine only the manufacturing sector, which accounts for more than half of the value of U.S. imports and exports. New research extends data development and analysis to retail and wholesale trade, which account for over two-thirds of the U.S. firms that engage in international trade (Bernard, Jensen, and Schott 2005b).

Another line of trade research examines the relationship between productivity and the domestic and international distances that plants ship their products (Holmes and Stevens 2006). The analysis uses information about the goods that manufacturing plants ship, based on the Commodity Flows Surveys (CFS) conducted by the U.S. Census Bureau. The CFS contains detailed information on the product, origin and domestic destinations, value, modes of transport, and whether the product was exported, and includes manufacturing, mining, wholesale trade, and selected retail industries. Holmes and Stevens (2006) find that large plants are more likely to be exporters, and to ship longer distances domestically. One hypothesis is that productive plants undertake innovative activities such as investing in the kinds of infrastructure needed to facilitate and monitor long-distance transactions.

The first formal project for inter-agency data sharing conducted under the Confidential Information Protection and Statistical Efficiency Act of 2002 (CIPSEA) produced a potentially rich source of information for analyzing the consequence of Foreign Direct Investment (FDI) for innovation and other economic outcomes. The interagency project involved an agreement between the Bureau of Economic Analysis (BEA) and the U.S. Census Bureau to match data from BEA's surveys of Foreign Direct Investment in the U.S. and U.S. Direct Investment Abroad with data from the Survey of Industrial Research and Development (SIRD) sponsored by the Division of Science Resources Statistics (SRS) of the National Science Foundation (NSF) and the U.S. Census Bureau (U.S. Census Bureau *et al*. 2005). See Howenstine 2006.

Lessons Learned:

Research on foreign trade using U.S. Census Bureau micro data introduced new stylized facts about the characteristics of U.S. firms that engage in international trade. Such firms have higher productivity, are larger, use more capital, and stay in business longer than firms that do not. These new stylized facts, in turn, are sparking new developments in trade theory and trade policy – see a summary of citations in Krizan and Riggs 2006. Recent research finds that import and export flows at U.S. firms, and employment at U.S. firms that trade, are dominated by firms that both export to and import from related parties (Bernard, Jensen, and Schott (2005a)). Corporate structure is important in trade, with multinational companies accounting for only 1 percent of U.S. manufacturing firms but about 20 percent of firms that trade (Bernard, Jensen, and Schott (2005a,b)). Firms that outsource – produce parts of a product in several countries – have more workers, produce more output, and are more profitable (Kurz 2006).

e. **National Employer Surveys: 1994, 1996, 1997, 1998, 2000.**

Data:

The National Employer Survey (NES) collects information on worker education, employer training and employer business characteristics, including business productivity, in all sectors of the U.S. economy. The first survey sampled about 4,000 establishments and collected data in 1994 and 1996. A second sample of about 5,500 establishments (including 900 that participated in the first survey, and an over sample of states involved in particular education reforms) was surveyed in 1997 and 1998. Information on the use of information technology was conducted in 2000. The National Center on the Educational Quality of the Workforce (EQW), a nonprofit research group, fully funded the survey, which was collected by the U.S. Census Bureau. The NES was a voluntary survey: employers were not required by law to respond. The surveys are designed to be linked to Census Bureau employer data series, allowing estimates of the relationship between workplace practices and business outcomes. Cappelli (2001) describes the core NES data.

Lessons Learned:

Response rates ranged from 60% to 94%, depending on year, sector, and employer size. These response rates are roughly comparable to those for other Census Bureau surveys of businesses. However, achieving these response rates required extensive and costly follow-up activities.

Analyses of NES data suggest links between business performance and some of the workplace practices surveyed. Cappelli and Neumark (2001) find that “high-performance” workplace practices raise labor costs per employee and have a statistically weak link to improved plant-level productivity, raising output per dollar spent on labor. Black and Lynch, in a series of articles (e.g., 2001, 2005), find that workplace practices and the use of information technology are strongly related to multi-factor productivity growth, as are investments in human capital and hiring better-educated workers.

f. Survey of Manufacturing Technologies.

<u>Data:</u>

The Survey of Manufacturing Technologies (SMT) was collected in 1988 and 1993. A one-time survey was conducted in 1992 on the barriers, benefits, and costs of advanced technologies. Information was collected only from plants in the five manufacturing industries thought to be primary users of such technologies: Fabricated metal products (SIC 34), Industrial machinery and equipment (SIC 35), Electronic and other electric equipment (SIC 36), Transportation equipment (SIC 37), and Instruments and related products (SIC 38). Plants were asked about their use of 17 advanced technologies.

Researchers interested in understanding the diffusion of advanced technologies and their contributions to business performance have analyzed the SMT data extensively. The data collections were structured to provide two cross-sections but also linkages between plants surveyed in 1988 and 1993, allowing researchers to test causality – whether high-performing plants invest in advanced technologies, or investment in advanced technologies leads to high performance.

<u>Lessons Learned:</u>

While advanced technologies are widely used, diffusion rates vary among specific technologies and across industries. More productive plants are likely to adopt these technologies. However, older plants are no less likely to adopt than newer plants, and adoption is likely to be *because* a plant is productive, rather than to increase its productivity.

McGuckin *et al*. (1998) uses SMT data from 1988 and 1993 to examine the relationship among the use of all the advanced technologies, and labor productivity and its growth rates in the five manufacturing industries. They find that industry diffusion differs across the surveyed technologies, and that plants may drop, as well as adopt, technologies over time. Productivity is higher at plants using advanced technologies, even after controlling for multiple economic characteristics of the plant. The relationship between productivity and advanced technology use holds both in terms of the number of technologies used and in the intensity of that use. But the use of advanced technologies does not necessarily cause higher productivity. In particular, McGuckin *et al.* conclude that the positive relationship between average productivity and the use of advanced technologies arises because operations that are performing well are more likely to use advanced technologies than poorly performing operations.

Dunne (1994) examined how the use of advanced technologies varies by plant and firm characteristics. Technology adoption was more likely in larger plants, and in plants that are part of firms with high ratios of R&D to sales. Although it often is suggested that newer plants are more likely to use new technologies because they can open with the latest technologies rather than face replacement costs and perhaps costs of reorganizing production, this study finds only a weak relationship between the age of a plant and the likelihood that it uses these technologies.

Lewis (2005) uses the SMT and decennial census micro data to examine the relationship between the skill level of workers living near plants and the plants' use of advanced technologies. Lewis concludes that plants may respond to worker skill level by altering their mix of technologies. Plants in areas with less-skilled workers may shift to less-advanced technologies that do not require as high a level of skill from their workers.

g. Worker and Firm Characteristics: Longitudinal Employer-Household Dynamics (LEHD).

<u>Data:</u>

The Longitudinal Employer-Household Dynamics (LEHD) project at the U.S. Census Bureau uses modern statistical and computing techniques to combine federal and state administrative data on employers and employees with core Census Bureau censuses and surveys while protecting the confidentiality of people and firms that provide the data.

<u>Lessons learned</u>:

Creating the LEHD data is a major undertaking. The LEHD program produces published statistical series showing the dynamics of labor markets at the state level (LEHD 2006). LEHD datasets are just beginning to be used by CES and RDC researchers. Andersson *et al.* (2006) use LEHD data for the software industry to explore the link between the riskiness of the firm's product market – where risk derives from undertaking innovative activity – and the distribution of its workers' earnings. Software firms in markets whose returns have high variance pay more to attract and retain the star workers who produce the innovative new products that yield high returns to the firm.

Appendix 2: The Community Innovation Survey and Other Innovation Surveys

Countries conducted the CIS firm-level surveys of innovation in three rounds. All rounds are based on the appropriate version of the *Oslo Manual.* With each round, the scope of the surveys expanded, and the number of participating countries increased. The first round, CIS1, conducted in 1993, covered innovative activities for 1990 through 1992. CIS1 was limited to the manufacturing sector. The second round, CIS2, conducted in 1997, covered activities for 1994 through 1996. CIS2 was based on the 1997 revision of the *Oslo Manual* (OECD 1997), and its scope was expanded to include selected service sector industries. Different surveys were used for manufacturing and services industries. The third and most recent round, CIS3, conducted in 2001, covered activities for 1998 through 2000. The scope of CIS3 expanded to include both manufacturing and the entire service sectors. CIS3 goes beyond the scope of the 1997 *Oslo Manual* to include innovative activities such as organizational innovation that are included in the 2005 revision (European Commission 2004). A common questionnaire was used for all industries.

The CIS collect information on a number of dimensions of innovations, including the number of firms that innovate by introducing new or improved products or new or improved processes within the firm, and the number of firms that introduce at least one innovation. The CIS distinguishes among innovations that are new to the firm, new to its industry, and new to the world. Expenditures on innovation include R&D, capital investment, training, and marketing costs. Costs of protecting innovations through formal methods such as patents and copyrights, as well as informal methods such as complex designs, also are collected.

The CIS2 and CIS3 differed in a number of important ways. These differences are detailed in European Commission 2004. Because countries were not required to implement CIS3, there is no single questionnaire or collection methodology. The conceptual and methodological differences make it hard to compare results among countries for CIS3, or between CIS3 and CIS1 or CIS2 within a country.

a. Lessons Learned: Cross-Country Comparisons

<u>Core Statistics.</u> The CIS2 data show wide variations across EU countries, industries, and sectors in the share of innovative firms (Guellec and Pattinson 2001). Just over half of EU manufacturing firms innovated in 1994-96 (51 percent), compared to 40 percent of services firms. The share of innovators in manufacturing ranged from 26 to 73 percent (Portugal and Ireland), and from 13 to 58 percent in services (Belgium and Ireland).

The broad range of statistics that can be produced from CIS3 is presented for the EU, Iceland, and Norway, in European Commission 2004. Statistics for the EU alone show that 44 percent of enterprises had innovative activity between 1998 and 2000. More businesses innovated in manufacturing ("industry") than in services, 47 percent vs. 40 percent.

Roughly 40 percent of enterprises in 16 countries had innovative activities, ranging from a low of 28 percent in Greece to a high of 51 percent in Germany (Lucking 2005).[4] As with CIS2, countries display substantial heterogeneity in all CIS innovation metrics.

Strategic and organization changes, measured for the first time in CIS3, are found more often in businesses with innovative activity than in businesses without such activity. For example, 46 percent of businesses with innovation activities reported that they made important strategic changes, compared with 17 percent of businesses that did not report innovation activity. Similar differences hold for other kinds of organization changes, in both manufacturing and services (European Commission 2004).

Lessons Learned. Guellec and Pattinson (2001) assess CIS1 and CIS2 for OECD countries. Definitional and methodological issues may contribute to the wide variations in reported shares of innovative firms, over and above actual differences in innovative behaviors. They note that such non-technological innovations as organizational change are widespread and likely linked to technological innovations, particularly in the services, but were not measured in CIS2. The definition of "technological" itself appeared to present problems. The word may have different meanings when translated into different languages, and countries did not always use the word in their questionnaires. Limited experimental evidence suggests that responses are sensitive to small changes in definition. Guellec and Pattinson (2001) express concern that response rates ranging from less than 30 percent to more than 80 percent may affect the quality and comparability of the data.

Response rates for CIS3 also ranged from 20 to 30 percent (for Belgium, Denmark, and Germany) to more than 80 percent (for France and Norway) (European Commission 2004). Some of the difference in response rates may be due to differences in collection methodologies. For example, CIS3 was mandatory in five countries (Norway, Spain, France, Italy and Sweden), including two of those with the highest response rates (France and Norway), but voluntary elsewhere (Lucking 2004). Nonresponse analysis for CIS3 finds differences between responders and non-responders for some countries, but no bias in aggregate data (Jaumotte and Pain 2005).

b. Lessons Learned: Selected Country Experiences

Canada. Canada has conducted a series of surveys of innovation and technologies since the early 1990s (Statistics Canada 2006a). The 1993 Survey of Innovation and Advanced Technology surveyed manufacturing firms. The Survey of Innovation 1996 covered the communications, financial services and technical business services industries. The 1999 Survey of Innovation, Advanced Technologies and practices covered Construction and Related Industries. The Survey of Innovation 1999 covered manufacturing and selected natural resource industries for the reference period 1997-1999. The Survey of Innovation 2003 covered information and communication technology industries, selected professional, scientific and technical services industries, selected natural resource support service industries, and selected transportation industries. The Survey of Innovation 2005 surveyed manufacturing and logging industries for the

[4] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

reference period 2002-2004. The surveys were based on the relevant version of the *Oslo Manual*. Response to the surveys is mandatory for Canadian businesses (National Research Council 2005). The response rate for the 2005 survey was 72 percent (Statistics Canada 2006a).

Australia. Australia conducted four innovation surveys between 1993 and 2005 (ABS 8158.0, March 8 2006 (reissue)). The 1993-1994 survey collected data for a number of sectors. The 1996-1997 survey collected more detailed data but only for the manufacturing and mining sectors. The 2003 survey covered more industries, excluded businesses with fewer than 5 employees, and was mailed to a stratified random sample of businesses. The 2003 survey was based on the 1997 *Oslo Manual* (ABS 8158.0, March 8 2006 (reissue)), making it comparable with the CIS surveys. Australia expanded the scope of its 2003 survey by adding questions on non-technological innovation. Results from the 2005 survey are expected to be released in late 2006 (ABS ITU Bulletin 14, August 2006).

Australia decided not to conduct further separate innovation surveys. Instead, it plans to create an Integrated Business Characteristics Strategy (IBCS). The IBCS will collect information on innovation and information technology use in conjunction with its Business Characteristics Survey. This strategy will reduce the total number of businesses surveyed because information on basic characteristics, innovation, and information technology will be asked of the same sample. Core questions on innovation and information technology will be asked each year. In alternate years, detailed questions will be asked on innovation or information technology. Because the revised strategy directly collects data on innovation and technology and basic business characteristics for the same businesses, researchers will have business-level micro data to model complex relationships among these variables and productivity and economic growth. In time, longitudinal analyses will become possible as the BCS contribute data to the longitudinal business database Australia is developing (ABS ITU Bulletin 14, August 2006).

United Kingdom. The United Kingdom conducted innovation surveys as part of the wider Community Innovation Survey. All UK surveys were mailed, voluntary, surveys of enterprises with more than 10 employees. Most sectors of the economy were covered in all the UK innovation surveys, but industry coverage varied somewhat among them (see, for example, Thomas and Jones 1998 for CIS2 and Stones 2002 for CIS3). CIS2 was conducted in 1997 and 1998 and collected data for 1994 through 1996. The CIS3, conducted in 2001, covered innovative activities for 1998 through 2000, and had a response rate of 42 percent (Stones 2002). The 2005 round added some services sectors. It was a mailed, voluntary survey, and had a response rate of 58 percent (Robson and Ortmans 2006).

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