Investigating the Economic Value of Selected NESDIS Products

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CENTREC
Consulting Group, LLC

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A Report to the
National Environmental Satellite, Data, and Information Service

NOAA Satellite and Information Services
National Environmental Satellite, Data, and Information Service

An Agency within the
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Executive Summary

The purpose of the study described in this report is to provide information that will be useful to NESDIS leaders regarding the types of applications that generate value for society, including explicit monetary values. Three types of activities were conducted to achieve that purpose:

- Visit the five NESDIS operational units and develop a searchable database of a subset of NESDIS customers,
- Complete an intensive case study with a private sector firm that makes use of NESDIS information, and
- Conduct brainstorming sessions with NESDIS personnel regarding prospective analyses employing NESDIS data and information services.

As part of the study's analysis, three key economic concepts were investigated and applied to NESDIS data and information services:

- NESDIS information products are generally considered public goods and are non-rival and non-exclusionary in nature, as opposed to private. In such settings, private markets have difficulty in arriving at optimal quantities and prices. The market failures, which often result when products with such characteristics are offered as private sector goods, cause inefficiencies to accrue to the users of those goods.
- Cost of producing the first unit of information products is extremely high whereas subsequent units are very low cost to reproduce. In these instances, it is likely that a market structure characterized by dominance of one firm will emerge. The NESDIS pricing policy of providing data with minimal charges is consistent with the relatively low reproduction costs associated with information products.
- Emergence of a dominant firm market structure tends to lower consumer benefits due to monopolistic pricing behavior relative to competitive market pricing. Public sector provision of such information, such as through NESDIS, offsets the "natural" tendency for a dominant firm market structure to emerge.

These concepts provide general guidance as to the market dynamics that result as information-based goods and services, such as those provided by NESDIS, are produced and delivered. In particular, these dynamics underscore the benefits of public sector provision of these goods and services.

In Phase 1 of the project, it was discovered that the move to distribution of NESDIS data and information services via the Internet has significantly enhanced the availability of those resources to the public. At the same time, this development has made it more difficult for NESDIS personnel to have operational knowledge of the uses to which the data and services are being applied. Analysis of information provided by personnel at the National Climate Data Center led to the development of a template which contains a classification system based upon the North American Industrial Classification Systems. This template may provide an approach that can be employed with the currently used Customer Order Management Processing System (COMPS) to provide enhanced service to the public through increased understanding of NESDIS customers and their use of NESDIS informational products. COMPS is the primary NESDIS order management system that tracks customer orders and financial transactions.

In Phase 2 of the project, an extensive case study analysis was conducted with a major energy company. The analysis provides an extremely detailed report of the energy company's use of NCDC resources and the application to which those resources were applied. (To preserve the confidentiality of the case study company, the participating firm is referred to as the Energy Company throughout the report.) The absence of such information would curtail its effective operations. Indeed because of the existing regulatory needs, the Energy Company and firms like it in the industry would need to secure other means to obtain that information if it were not available from NESDIS. These resources are made available to the Energy Company through NCDC at a cost of slightly more than $5,000 per year. An exploratory economic analysis was conducted to provide estimates of the costs that would be required to provide the information resources now provided by NESDIS. Using relationships based upon the Energy Company's cost of data acquisition and the Energy Company's relative market share, a cost-benefit ratio of 495 was determined. (For every $1 that the Energy Company spends in acquiring data, they are receiving a potential benefit from not having to spend $495 to acquire that data on its own.) When extended to the entire industry, the potential benefits are approximately $65 million per year. It should be noted that for purposes of this study the definition of the energy industry relates only to electricity and natural gas providers and not the entire energy industry as broadly defined.

In Phase 3 of the project, brainstorming was conducted to engage NESDIS personnel to consider proactive means of addressing economic and social changes occurring in areas across the U.S. that are vulnerable to environmental events. Three instances were identified where it appears that analysis employing NESDIS information resources might be useful to societal decision-makers:

- Understanding risk management in modern society by collaborative efforts with the insurance industry to identify where environmental data and analysis would provide an enhanced basis for understanding future risk potentials and associated liabilities.
- Exploring emerging activities at the National Coastal Data Development Center (NCDDC) by considering decision experiment analyses to determine how best to attract additional resources to these development efforts as well as guide decision-making about allocation of existing resources.
- Understanding coral reef resources in the South China Sea that are likely to be particularly challenged by future economic growth in Asia. Prospective analysis could define more forward looking policies relative to the coral reef resources and their future.

Finally, three recommendations from this study are to:

1. Implement enhanced user and use codes within the COMPS system to enable better customer support. Analysis of this information could assist in the development of improved NESDIS data and information services.
2. Continue additional investigation using case study analysis techniques to understand the benefits other industries achieve in utilizing NESDIS information and services. A sample list includes:
    - Agribusiness
    - Insurance industry
    - Transportation industry
    - Energy industry

- Airline industry
- Aquaculture

3. Engage in prospective analyses which explore potential effects on the interaction of social and demographic forces and environmental events. The analysis could assist both societal and NESDIS decision-makers in planning, preparing, reacting and avoiding calamitous impacts from natural disasters.

Introduction

The mission of the National Environmental Satellite, Data, and Information Service (NESDIS) is described on its web site as:

> "…to provide and ensure timely access to global environmental data from satellites and other sources to promote, protect, and enhance the Nation's economy, security, environment, and quality of life. To fulfill its responsibilities, NESDIS acquires and manages the Nation's operational environmental satellites, provides data and information services, and conducts related research" (U.S. Department of Commerce, 2002).

The scope of the project described in this report does not extend across the entire range of NESDIS activities noted in that mission statement. Instead, this project concentrates on economic implications associated with the "providing data and information services" component of that mission.

Although oftentimes not well understood, in today's technological and global circumstances providing data and information services is a complex multi-function task. Functions that are included within a comprehensive data management system include:

- Plan
- Collect (or rescue)
- Ingest
- Metadata and cataloguing
- Calibrate and validate
- Store
- Access
- Migrate

Specific explanations of these functions in the NESDIS context are provided in *The Nation's Environmental Data: Treasures at Risk* (U.S. Department of Commerce, 2001a). The magnitude of data managed by NESDIS currently is immense, 760 terabytes of data in 1999 (U.S. Department of Commerce, 2001a). But the current data needs are expected to be dwarfed in the very near future because of society's increasing recognition of the importance of the environment and the need for long term records of high quality climate data to improve decision-making about the environment, coupled with advances in information technology capability. The data that NESDIS needs to manage is expected to expand fivefold by 2005 and to explode by almost 20 times in the next 15 years (U.S. Department of Commerce, 2001a).

Although data storage is necessary, society is interested in access and retrieval of the environmental data to inform decision-making. NESDIS provides data and information services in support of a diverse and economically important set of activities including (U.S. Department of Commerce, 2001b):

- Commercial Remote Sensing: Licensing and Advocacy
- Coping with Daily Weather Conditions
- Planning for Climate Variations

- Ensuring Effective Multiple Uses of the Nation's Coasts
- Supporting Maritime Industry and Exploration
- Reducing the Impact of Natural Disasters

The massive amounts of data made available currently and in the future by NESDIS require careful investment of considerable financial resources. The preceding list of affected economic activities highlights the involvement of NESDIS data and services in critically important elements of the nation's economy and society. However, this necessarily broad level of assessment doesn't provide detail as to specifically how decision-makers are using NESDIS data and services and what the economic benefits are of those specific uses. Investigating some of those specific uses is the topic of the study described in this report. In addition to analyzing certain specific use situations, the study identified additional types of activities that could be conducted to enhance society's understanding of the value of NESDIS information and services to society.

Project Objectives

The purpose of the project is to provide information that will be useful to NESDIS leaders regarding the types of applications that generate value for society, including explicit monetary values. Three principal objectives of this project are to:

- Give NESDIS leaders information useful in demonstrating to others the value of NESDIS resources and infrastructure,
- Define areas where NESDIS products could be improved or new ones generated to better serve users as identified through assessment of the inventory of NESDIS products, and
- Identify potential new users of NESDIS products based on the parameters of the study and through interaction with NESDIS personnel.

Activities Conducted Within Project

The project was organized into three major phases. The specific activities conducted for each phase are discussed briefly below. More detail of activities by phase is included in later sections.

Phase 1

There are two primary activities included in Phase 1. The first activity involved visiting the five "data" centers that comprise NESDIS, specifically:

- National Climatic Data Center (NCDC) in Asheville, NC
- National Oceanic Data Center (NODC) in Silver Spring, MD
- National Geophysical Data Center (NGDC) in Boulder, CO
- Office of Satellite Data Processing Division (OSDPD) in Suitland, MD
- Office of Research and Applications (ORA) in Camp Springs, MD

The site visits included discussions about product development and delivery as well as customer usage of data and data products. These meetings generally were conducted with middle and upper-level managers and, when possible, with those personnel who actually interact with users. Records of product usage and payments were obtained during the NCDC site visit as that center distributes the largest number of information products to users. The company to be investigated during Phase 2 was identified during the site visit to NCDC.

The second activity involved developing a database to provide specific descriptions of key data users and products. Existing NCDC information was employed as the data source for this activity. Nearly 1,100 records referred to as "Unusual Service Requests" were evaluated. The deliverable for this phase of the project is a database which contains detailed user and use information regarding NESDIS data, many of which have economic value.

Phase 2

Phase 2 of the effort was designed to evaluate and provide economic estimates for one application of NCDC services. The specific application was identified during the Phase 1 activity in collaboration with NCDC personnel.

NESDIS provides information-based services (generally in the form of data) to a wide range of clientele. A powerful means of documenting economic impacts is through the use of decision case analysis. To document the value of such an effort within NESDIS, we planned to conduct a specific decision case analysis for an NCDC product or service. The goal was to determine the appropriate economic value from an instance where a private firm, government agency, or other organization created documentable value through the use of NCDC services (and associated infrastructure).

One critical dimension in selecting the case study for analysis is that the situation be consistent with the NESDIS intent of providing information services through which users create value. In addition, identifying one best situation for NCDC considered the following factors:

- The potential for significant economic value
- Operating versus planning applications (as operating decisions tend to have higher demonstrable value)
- Likely interest and engagement of the information user
- Most efficient use of project resources

As will be described in more detail later in the report, in-depth discussions with representatives of the case firm disclosed that the decision case method was not well suited to the specific applications of NESDIS information used by that firm. Therefore, an alternative cost approach was defined and employed to successfully accomplish the Phase 2 goals.

Phase 3

Phase 3 explores a concept that emerged from prior Centrec work with NESDIS. That concept involved framing economic evaluation of NESDIS services within the larger context of potential benefits within a dynamically changing society. Although the potential value of NESDIS services in this context is considerable, resources were not available in this study to conduct the type of analyses that would be necessary to document this potential.

Instead, interaction with NESDIS personnel at each of the five "data" centers that occurred during the Phase 1 and 2 efforts was used to further refine and develop this framework. Specific opportunities and an evaluation approach will be described in the Phase 3 section of the report.

Relevant Economic Concepts

Economic analysis is a well-developed process with concepts that can aid decision-making, even without empirical application. In this section of the report, three conceptual discussions will be provided as a framework to enhance our understanding of the issues involved in the evaluation of NESDIS information services. An overriding purpose of this study focused on enhancing the understanding of the economic role of NESDIS information to the economy and to society. Although a specific case examination is detailed later in the report, it is important that the general determinants of the benefits of the NESDIS provision of information also be addressed in the study. This section of the report describes important concepts from basic economics and from the rapidly emerging field of information economics. These concepts should inform public decision-makers and the public at large as to the appropriate contexts within which to consider the role of NESDIS and its products and services.

Key findings from this analysis include:

- NESDIS information products are generally considered public goods and are non-rival and non-exclusionary in nature, as opposed to private. In such settings, private markets have difficulty in arriving at optimal quantities and prices. The market failures, which often result when products with such characteristics are offered as private sector goods, cause inefficiencies to accrue to the users of those goods.
- Cost of producing the first unit of information products is extremely high whereas subsequent units are very low cost to reproduce. In these instances, it is likely that a market structure characterized by dominance of one firm will emerge. The NESDIS pricing policy of providing data with minimal charges is consistent with the relatively low reproduction costs associated with information products.
- Emergence of a dominant firm market structure tends to lower consumer benefits due to monopolistic pricing behavior relative to competitive market pricing. Public sector provision of this information, such as through NESDIS, offsets the "natural" tendency for a dominant firm market structure to emerge.

These concepts provide general guidance as to the market dynamics that result as information-based goods and services, such as those provided by NESDIS, are produced and delivered. In particular, these dynamics underscore the benefits of public sector provision of these goods and services.

The remainder of this section of the report describes the concepts and procedures employed to derive the findings just described. Readers who are familiar with these concepts may want to skip this discussion of economic concepts and move directly to the section entitled, "Results of Phase 1 Activity" on page 15.

Key Economic Characteristics of NESDIS Data Systems

The most commonly understood aspects of economic analysis relate to private goods traded in the market place. Common examples include purchasing food in a grocery store or consumer electronic items in a retail store. The information that NESDIS makes available for its users is fundamentally different from these common examples in terms of, at least, three key characteristics. First, the information that NESDIS provides is not traded in the market place (although charges to recover some costs are made).

A second key characteristic of NESDIS information is that such information is in the form of public rather than private goods. A public good is characterized as being both non-rival and non-exclusionary in nature. These features are described later in this discussion.

The production and marketing of information has blossomed as an important economic undertaking over the last decade. Although the collapse of the "Internet bubble" has cooled speculator interest in information marketing, this issue is important in the evolving knowledge economy. Thus, a third distinguishing characteristic of NESDIS information relates to the likely market structure impacts that are associated with the production and sale of information in the marketplace. These arise from the cost structure typical for information and information systems and also will be described in this section.

Information as a Public Good

Most goods that we purchase have the characteristic of being rival in consumption. When one person purchases a can of vegetables, that can of vegetables is no longer available for others to consume. Public goods, in contrast are characterized as being non-rival in consumption (Pindyck and Rubinfeld). When a public good is consumed by one individual, it is still available to be consumed by others. Consider, for example, the services of a lighthouse. Just because the captain of one boat observes the light, sailors on other boats also can benefit from the same service.

Typically the provider of a good or service can restrict the use of that good or service. If a customer doesn't purchase the good or service, that customer can't enjoy the associated benefits of consumption. The providers of public goods, however, cannot prevent certain people from consuming the good. The information that NESDIS provides, therefore, fits the definition of being a nonexclusive good, the second dimension of a public good. National defense is the classic example of a nonexclusive good. Or if a local government unit expends resources to control an agricultural pest, the benefits of doing so are available to all farmers in the area.

Most goods exist on a spectrum (or range) across the non-rival and nonexclusive characteristics. Most goods are neither completely non-rival nor rival in consumption, nor are they completely excludable or non-excludable. For example, because NESDIS charges a minimal fee to recover a portion of the costs of some information, those information items have some of the elements of being an exclusive good. However, those charges are small relative to total costs. Further, once one customer has specific information items, it is virtually impossible to restrict that user from making the information available to others. (As data produced by the Federal Government, NESDIS information is not copyrighted.).

As the name indicates, traditionally it was expected that public goods would be provided by public entities rather than by firms in the private sector. With advances in technology, the capability for private sector firms to provide formerly public goods has increased. Some technologies now allow providers to more effectively exclude customers from what were formerly non-exclusionary goods. Therefore, the boundary line between the public and private good categories has become less distinct. The classic arguments for public sector provision of non-rival and nonexclusive goods include (Savas):

- Positive Externalities—When a public good is provided, those who did not pay for it still enjoy its benefits. An example is clean air—when a factory spends money to produce less pollution, everyone benefits from the cleaner air.
- Low contracting costs—Because there is usually only one supplier of a public good, the government, costs to build and negotiate a contract are low

- Less vulnerable to strikes, slowdowns—As the supplier of the public good is the government, strikes and slowdowns occur less often.
- Economies of scale easily achieved—Again because there usually is one supplier, the government, the benefits of scale economies are more likely to be achieved.
- Private firms do not become too powerful in the political sphere—With private goods the threat of monopolistic power emerging, which can exert influence into political dealings, is a possibility.

Conversely the disadvantages of public sector provision include (Savas):

- Free-rider problem—Because of positive externalities, individuals can benefit from a public good without contributing to funding the costs required to bring the good into existence.
- Low levels of voluntary contributions—Individuals may see the presence of free-riders and conclude that the public good is under funded, and therefore not worth contributing resources to.

Although the basic rules of economics haven't changed (Shapiro and Varian), new technologies and changing market forces have caused many to call for reexamination of the best means to provide goods and services that traditionally were provided by the public sector. Such reexamination often is useful to inform public sector decision-makers and the public, even if it doesn't lead to total or even partial privatization of activities. The advantages of public sector provision of services which are non-rival and non-exclusionary in nature need to be recognized and quantified for effective analysis and decision-making to occur.

Cost Structures of Information Systems

As the role of knowledge and information has grown in the modern economy, the attention devoted to understanding information production and marketing has grown. As a valued good, information is costly to produce. (In this discussion, the term "information" is defined very broadly—essentially anything that can be digitized as a stream of electronic bits.) "Information is costly to produce but cheap to reproduce" (Shapiro and Varian, p. 3). This is a key distinguishing feature of information as an economic good. Figure 1 illustrates this notion. A very high cost is associated with producing the first unit of information (U_1) in Figure 1. This high cost is depicted by the relatively tall cost bar shown for U_1. The relatively low costs associated with reproduction are indicated by the low bars associated with units U_2 to U_7 in Figure 1.

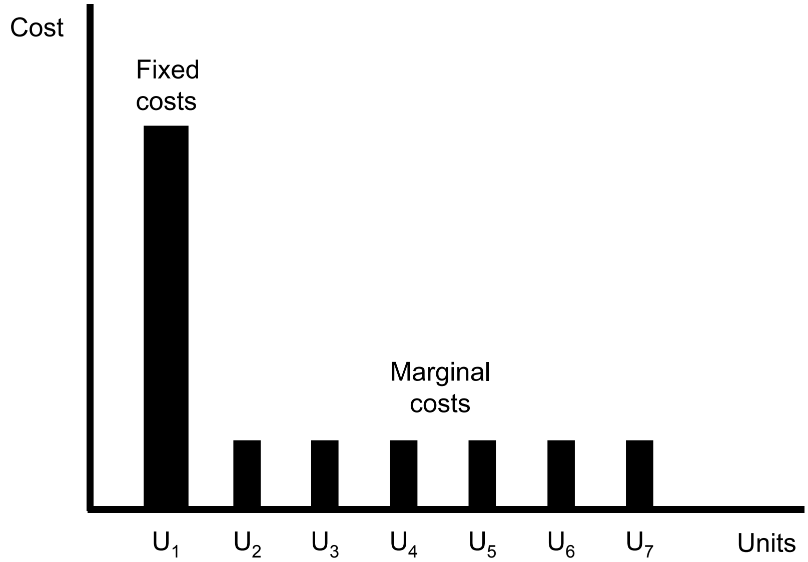

Figure 1. The Typical Cost Structure of Producing Information

Relative to NESDIS, the cost levels indicated by the bar U_1 are indicative of the entire set of costs associated with ingesting, archiving, quality control, data set development, and making available its data resources. The much lower bars for additional units (U_2…. U_7) represent the very low costs of data reproduction. The benefits of these very low costs are then experienced by users of NESDIS information in terms of the low charges associated with accessing NESDIS information.

Anyone who has downloaded a file over the Internet or paid a dime to copy a page of a legal document that originally cost thousands of dollars to produce has experienced the cost dynamics depicted in Figure 1. These dynamics exist for making a single copy of that document but they extend across the decisions of investing in and maintaining entire information systems. Such systems tend to have relatively large investment costs while the variable costs of operating the system tend to be relatively small. Often, however, users can experience substantial switching costs when moving from one information system to an alternative system. For example, consumers who wanted to enjoy an enhanced musical experience by using CDs instead of tapes found each CD to be relatively inexpensive per unit of music stored on the device. However, the user had to expend a more substantial amount of funds to purchase the new device needed to play CDs.

Because of this cost structure, providers of information strive to create lock-in effects to encourage their customers to procure all the information in a category from that provider. The likely market structure to result in this setting is that of the dominant firm. The initial firm to effectively provide the information resource in question will strive to keep competitors out of this market. Firms contemplating entry into the market will anticipate that the existing firm will vigorously discipline the market through various means to create lock-in, including temporarily lowering prices in those areas where the entering firm is competing. Because of the relatively high initial system costs, entering firms are discouraged from investing to enter further establishing the dominant firm market structure. The implications of that structure for customers and society are described in the following section.

Welfare Effects of Alternative Market Structures

The preceding discussion identified that the market structure likely to result because of the cost dynamics of information provision is that of the dominant firm model. Much is known regarding the consumer welfare effects associated with different market structures. This section will provide a brief overview of those implications, paying particular attention to the specific NESDIS setting as a provider of environmental information. A number of these economic concepts also will be employed in the analysis of NESDIS information described later in the text.

Figure 2 provides the classic depiction of the long run price and quantity equilibrium in a perfectly competitive market (Pindyck and Rubinfeld). Price is graphed along the vertical axis and quantity along the horizontal axis. The line marked D represents the market demand curve. This curve has a downward slope indicating that if only a small quantity is available, the unit price will be high. Conversely, if an abundant quantity is available, the per unit price will be low. The upward sloping curve (S) represents the industry supply curve. This market supply curve originates from the marginal cost curves of individual firms in the industry.

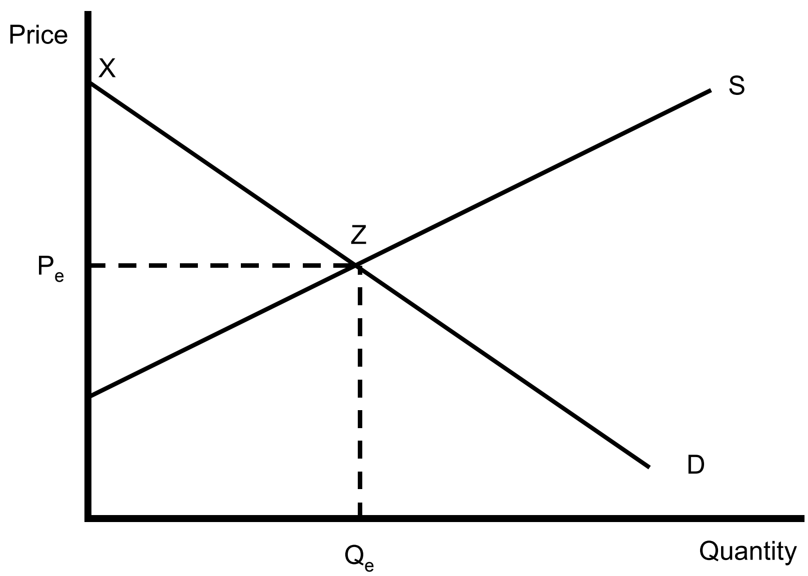

Figure 2. Long-run Competitive Equilibrium

The market is said to be in equilibrium at the price and quantity levels where the demand and supply curves intersect. In Figure 2, equilibrium would occur at points P_e and Q_e. In a perfectly competitive market, each unit sold in the market receives the same price, P_e. The downward sloping demand curve indicates that some consumers would have paid more than that price, if less of the product had been available. The result is that many consumers in the market are able to purchase the product at a price which is lower than what they would have been willing to pay, if forced to, for the product. This notion is called consumer surplus. In the setting described in Figure 2, the amount of consumer surplus is given by the area enclosed in the triangle formed by the points P_e, Z, and X.

The Shapiro and Varian based analysis in the preceding section noted that the dominant market structure is likely to occur in a market where the product is characterized by the cost dynamics of information systems. In a dominant market, one firm's product holds the preponderance of the market. Further, that firm has sufficient market power to effectively constrain the market price to a level that the firm finds most profitable. A market with a single, monopolist firm represents the extreme case of a dominant firm market structure.

Figure 3 depicts the equilibrium price and quantity in a market where a monopoly exists (Pindyck and Rubinfeld). The demand and supply curves in Figure 3 are identical to those in Figure 2. In the competitive setting shown in Figure 2, each unit was sold at the same price, P_e. In Figure 3, a second downward sloping line is shown to the left of line D. This line is labeled MR for marginal revenue. The concept of marginal revenue refers to the additional revenue a firm receives by providing one more unit of a product. In a perfectly competitive market, as depicted in Figure 2, the marginal revenue is equal to P_e for all units provided. In a market with a monopolist, however, the monopolist could sell just one unit at a very high price. Although the price would be at its maximum, firm profits might not be. To sell the second unit, the firm has to lower the market price that will be charged on both units sold. Therefore, the marginal revenue for the second unit has to reflect the reduction in price associated with unit 1. The MR line reflects this notion for each of the unit levels of Figure 3.

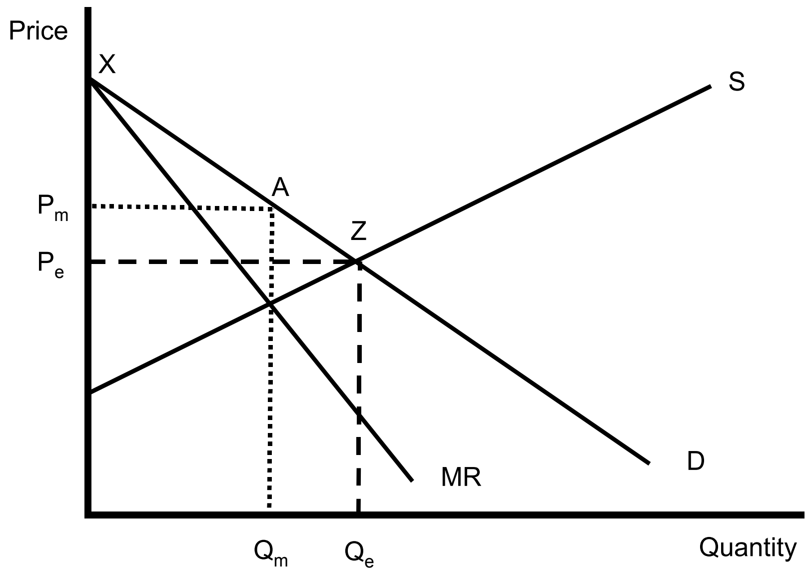

Figure 3. Long-run Monopolist Behavior

Profit maximization for a monopolist occurs when the marginal revenue line intersects the supply curve. (As in Figure 2, the supply curve also is the marginal cost curve.) In Figure 3, this equilibrium point occurs at Q_m. At that quantity, the monopolist can charge the price P_m. Note that the quantity available in the market is lower and the price charged is higher in the case of a monopoly than was the case in perfect competition (Figure 2). Consumer well-being, therefore, is lower in the case of a monopoly. In geometric terms, consumer surplus is reduced by the four-sided area defined by the points P_e, Z, A, and P_m.

With advanced information technology it is becoming increasingly possible to provide the market differing versions of essentially the same information product. For example, many firms and individuals are interested in the price movements that occur during each day's trading on stock and futures exchanges. But some individuals desire to know that information the moment it occurs. Others are satisfied to know those movements 10, 20 or 30 minutes after the trade occurs. The firm that provides these price quotes can charge differing prices to those customers who receive "real-time" information versus those who are satisfied with receiving the information after some time delay.

A monopolist providing information products/services would be very interested in the versioning concept. That firm would attempt to provide a different version of the product that corresponded with the demand curve facing the firm. Optimally, for the monopolist, a specific version could be provided to those customers who were willing to pay relatively high prices if only a few units of the product were available to the market. Other versions, which didn't satisfy the needs of the highest paying group, would be offered to customers willing to pay less for the product. This setting is referred to as perfect price discrimination. The term "perfect" reflects the view of the monopolist firm as the firm's welfare is at a high level and consumer surplus is minimal.

Although the dominant firm market structure is a typical result of the cost dynamics of information and information systems, competition has been intense in many software and information technology markets in the past few years. Rapid technological change often is the factor that mitigates the monopoly price and quantity effects of the dominant firm structure. While the dominant firm may have power within a specific market niche, that power may not provide excess returns if the entire product market is supplanted by offerings in new product markets. Further, the potential for technological change acts to discipline the dominant firm from extracting excessive profits from consumers. Excessive profits will attract competition from firms with potential new technologies that can lead to new product markets being developed.

This section has presented a conceptual analysis of the likely market structure if the types of information now provided by NESDIS were provided in the private sector. The section has outlined two reasons why the dominant firm market structure could be expected. First the cost structure of information systems tends to encourage "winner take all" outcomes because users desire one standard and the relatively high initial investment costs can act to reduce the attractiveness of markets to potential new entrants. Second, because the information resources provided are both non-rival and non-exclusionary in nature, firms will be hesitant to make investments unless they have a major share of the market. As previously outlined, the dominant firm market structure, when extended to the monopolist setting, results in reduced consumer well-being.

Results of Phase 1 Activity

Phase 1 of this project is comprised of site visits and development of an interactive "database." The site visits were done to better understand NESDIS customers and data products as well as gather information necessary for the development of a simple, searchable database constructed from a subset of users. In conducting Phase 1, a better understanding of operations, customers, and products allow us to make recommendations for capturing new or different informational items or suggestions for new implementations. This section of the report discusses briefly the five site visits, but focuses primarily on the understanding gained by the development of the searchable database of NESDIS customers.

Intent of this Phase

The intent of Phase 1 was to better understand the customers and data products within NESDIS data centers. This involved two components: site visits to five different NESDIS agencies and investigation and analysis of customer order records and eventual processing into a searchable database format. While valuable information was obtained at the site visits, a description of those activities is not presented, but rather the findings and recommendations that resulted from these visits are woven throughout the report. The second component, understanding users and data products through the development of a searchable database, is discussed in detail in this section of the report.

The intent of the database activity was to provide a framework for user and use classification of all the NCDC products ordered on-line and off-line. The purpose for classifying the users and use of NCDC's products is to permit the agency to better understand its customers and the manner in which its products are being used. This will ultimately lead to NESDIS having a greater ability to target its products to its users and the manner in which the data are being used.

Site Visits

The first portion of this phase involved site visits to the agencies listed below, with the primary focus on the three data centers (the first three agencies listed).

Table 1. NESDIS Agencies Visited

NESDIS Agency	Location	Date of Visit
National Climatic Data Center (NCDC)	Asheville, NC	April 10-12
National Geophysical Data Center (NGDC)	Boulder, CO	August 19-20
National Oceanic Data Center (NODC)	Silver Spring, MD	September 3-4
Office of Satellite Data Processing Division (OSDPD)	Suitland, MD	September 5
Office of Research and Applications (ORA)	Camp Springs, MD	September 6

The site visits were instrumental in understanding the innerworkings of NESDIS as well as providing valuable insight into customers, data products, operations, etc. Most importantly, the site visits allowed us to identify key customers and primary data users who have a vested interest in NESDIS data. Some examples of industries that appear to have realized economic benefit from using NESDIS data are listed below. Note that this is a partial listing of industries with the potential of obtaining economic benefit from utilizing NESDIS data. Further, no attempt to quantify the potential magnitude or significance of the economic benefit is implied.

- Agribusiness—particularly sensitive to climatic events.
- Insurance industry—this is a unique industry in that it utilizes data from all three data centers (NCDC, NGDC, and NODC)

- Transportation industry—depending on the locations served, this may include all data centers.
- Energy industry—while the current report focuses on the energy industry's use of NCDC data, the energy industry is able to operate more efficiently by responding to space weather forecasts, data that comes from NGDC.
- Airline industry—use of NGDC data for airport design, planning for operations during severe weather events, and to generate more accurate topography maps that can aid in better navigation over uneven terrain.
- Aquaculture—NODC data used for forecasting and helping operate the best growing conditions, etc. for the fisheries industry.

Finally, during some of the site visits we focused on discussion related to Phase 3 of this project. The outcomes from these discussions are included in the Phase 3 section of this report.

Development of Database

The section discusses the existing customer tracking system housed within NCDC (and also used by NGDC and NODC) and describes the procedures followed in developing methods for capturing additional customer information when customers place orders for NESDIS products.

Existing System

The COMPS system, currently used by NESDIS for customer tracking, is used to track both on-line and off-line orders from the three data centers: NCDC, NGDC, and NODC. This is a proprietary system that undergoes periodic maintenance and is currently undergoing significant enhancements. During the NCDC visit, we witnessed the system in action and performed queries to view prior orders and customer information. As changes are made to the system, the suggestions contained herein can be added at the discretion of the NESDIS personnel.

In FY 2002 there were over 104,000 paid orders for data among the three data centers. OSDPD and ORA are not considered "data centers" and do not sell products to external customers. The current system captures customer categories as shown in Table 2. The customer categories are listed in descending order of sales volume. Figure 4 illustrates the sales volume ($) and number of orders placed by the various customer categories presented in Table 2.

Table 2. Customer Categories

Lawyer/Legal	Insurance	Library
Consultant	Foreign Research	Manufacturer
Consulting Meteorologist	State/Local Government	Regional Climate Center
Business	Contractor	US Media
Other Federal Government	Department of Defense	Education K-12
University	Utilities	State Climatologist
Engineer	Foreign Other	Transportation
NWS	Foreign Government	Mining
Individual	Foreign University	World Organization
Noaa (Non-NWS)	Agriculture	Member of Congress
Research (U.S.)	Non-Profit Organization	World Data Centers

NESDIS maintains over 800 data products. Some of these products are available free, while others are priced based on government formulas for data recovery costs, which do not reflect the value of the data, but rather only a portion of the cost for providing access to data. Because some of the NESDIS data products are more expensive than others, the two series in Figure 4 do not align (e.g., consultants spend the second highest amount of dollars with NESDIS, but are the fourth largest in terms of number of orders). While government and academic use of NESDIS data is common, the majority of NESDIS customers come from the private sector.

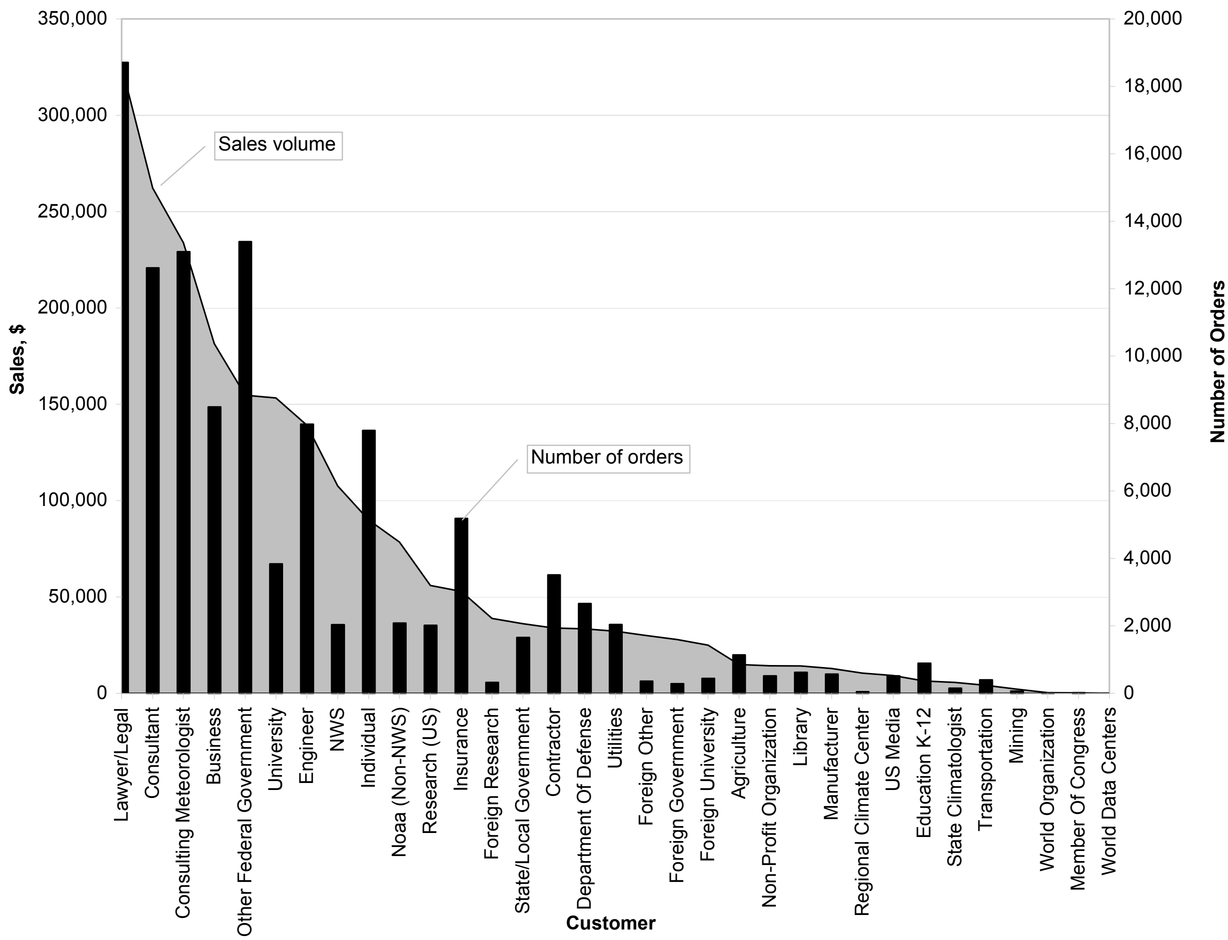

Figure 4. NESDIS Data Center Sales Volume and Number of Order, FY 2002

The purpose of reviewing the output from the COMPS system is not to provide suggestions for system enhancements, but rather to understand NESDIS customers and determine if there were any additional informational items that could be gathered during the order process that would benefit future product development, allow the data centers to better understand their customers, and improve customer service. Presently, no data is captured on the intended use of NESDIS data by its customers. Trying to ascertain customer intent by studying previous orders in the COMPS system is impossible currently. Therefore, to try and understand the types of customers and their uses of NESDIS data, we relied on a subset of customer orders that were written in narrative form by the NCDC staff as a way to determine the types of uses of data by their customers. The next section describes this process in detail.

Subset of Data Analyzed

During the April site visit in Asheville, NC, NCDC personnel identified the Unusual Service Requests (USR) database as containing unique and potentially relevant information for this project. USRs are narratives written by NCDC personnel for two to five data product orders per week. USRs from January 1997 through April 2002 were obtained from NCDC and consisted of a total of 1,091 entries. In earlier years, four or even five USRs were written each week. However, in more recent years, only about two USRs were written per week.

The USRs are distributed within NCDC/NESDIS to provide feedback on the types of data requested. These USRs are in addition to the monthly reporting, which consists of tables and charts reporting total orders (both on-line and off-line), products ordered, etc.

The USRs were obtained from NCDC in the form of text documents. These descriptions consisted of a title of the request assigned by the NCDC employee handling the request, a written description of the request, and the name and contact information of the employee handling the request.

After receiving the USR information, we transferred that information into an Excel spreadsheet. As the requests were imported into Excel, NCDC's titles for the requests were extracted from the description. The descriptions also included the entity making the request, purpose of the request and the data or data products requested. Two primary factors were defined as relevant in understanding the value of NCDC's products. These factors are:

1. NCDC's customers—who uses the products, and
2. The manner in which the data are to be used.

The users and their intended use for each request were identified based on the description in each USR. The initial categorization then provided a foundation for formulating more refined user and use lists.

Note on USR Subset

The classification and categorization process used in this project resulted in a sample database with a user and use coding system applied to the NCDC product requests defined as unusual. The information subset used in developing the database is not representative of the entire NESDIS customer base, even though it represents a diverse sample of NCDC's clientele. The criteria used for determining if an order is included in the USR (i.e., a narrative write-up occurs) is dependent on many factors, but the intent is to describe unique (not unreasonable) requests. Therefore, when viewing the accompanying Excel database (a compilation of the USRs) the user must not draw conclusions from the subset and apply them to all NESDIS customers.

Refined User Codes

The government has recently instituted the North American Industrial Classification Systems (NAICS) for classifying operating entities. Since this new classification code will be widely used by both governmental agencies and private parties, it appears to be an appropriate classification system on which to base the user categories for the NCDC database. Using the NAICS system as the foundation, and reviewing the initial user classification, a refined user code was devised to capture the breadth of the users of the NCDC products described as USR. Actually, a two-tiered user system was used to simplify the selection process. Tier I user codes are listed in Table 3.

Table 3. Tier I User Codes and Descriptions Based on NAICS

User Code	User Description
11	Agriculture, Forestry, Fishing and Hunting
21	Mining
22	Utilities
23	Construction
31	Manufacturing
42	Wholesale Trade
44	Retail Trade
48	Transportation and warehousing
51	Media and Information
52	Finance and Insurance
53	Real estate, rental and leasing
54	Services (Professional, scientific, technical)
55	Management of companies and enterprises (holding companies, corporate, managing offices)
56	Services (administrative, support, waste management, remediation)
61	Education
62	Health care and social assistance
71	Arts, entertainment and recreation
72	Accommodation and food services
81	Other services (Repairs, maintenance, personal, laundry)
813	Non-profit, non-government organizations (religious, grantmaking, social advocacy, civic, professional, etc)
814	Individuals and Personal households
921	Local Government
922	State Government
923	Federal Government
1000	Non-U.S.

Note that the codes listed are only a portion of the actual NAICS codes. The combined Tier I and II user codes appear in Appendix A. Their final coding includes a total of 25 Tier I and 61 Tier II user codes. Combining the user codes into a final listing results in 74 user codes.

New Use Codes

The use codes suggested here resulted from completion of two tasks. One involved a literature review of the manner in which weather and climate data are used. The second is based on interpretation of the information provided in the USR. Based on these two tasks, a refined fourteen category use code was defined and implemented in the database. The final list appears in Table 4.

Table 4. Use Codes and Descriptions

Use Code	Use Description
1	Assess
2	Attend/Visit
3	Create/Design
4	Forecast/Predict
5	Host
6	Install/Update
7	Investigate
8	Monitor
9	Plan/Prepare
10	Present/Report
11	Research
12	Review
13	Train
20	Other

Methodology

Figure 5 shows the iterative process undertaken for defining the user and use codes. For each USR record, category codes for user and use were extracted initially. Following a review by Centrec project members, a revised classification system was devised—one that captured the diversity of the users and application of the NCDC products, yet allowed for more concise evaluation. An iterative process was used in developing the final codes by narrowing and combining the user and use codes until an acceptable number of codes were selected.

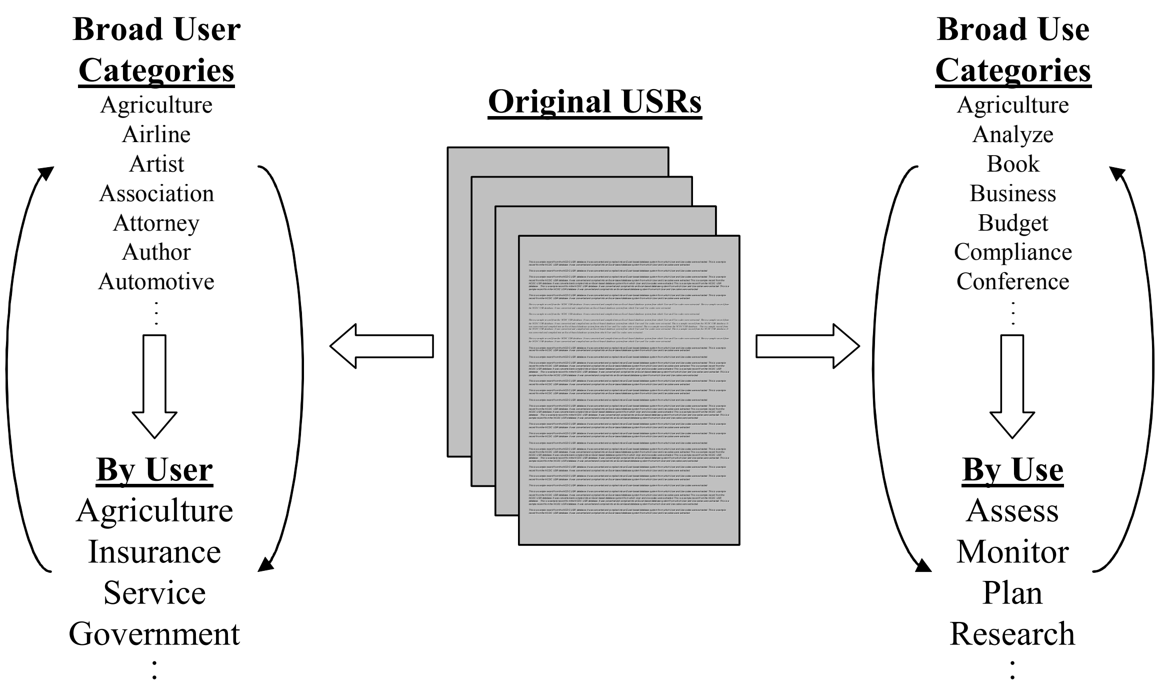

Figure 5. Iterative Classification Process Used with USR Database for "User Codes" and "Use Codes"

A sample of how the user and his or her use of one of the NCDC products were presented in the original USR files is presented in Table 5. The America Red Cross (ARC) frequently prepares information packets for their volunteers. Included in their packets are weather and climate information about the area to which the volunteer is going. A chapter of the ARC requested information about a particular location, and acquired the Local Climatological Data Annual Summary with Comparative Data.

Table 5. Sample of Original USR Description

NCDC'S SUPPORT TO THE AMERICAN RED CROSS: The American Red Cross (ARC) frequently recruits volunteers from various regions across the U.S. to provide relief in disaster situations. For example, in the aftermath of Hurricane Andrew, many people came from North Carolina to help with the repair of structures and to clean up the debris. The Harrisburg, Pennsylvania, chapter of the ARC is compiling a location familiarization package to include climatological information for its potential volunteers. NCDC provided the Normals, Means and Extremes table from the publication Local Climatological Data Annual Summary with Comparative Data for inclusion in their information packet. The temperature, wind, and humidity data in the Harrisburg climate summary should be beneficial to these Red Cross workers.

Table 6 presents the record as it was transformed in the database. The ARC was classified as a "Health Care and Social Assistance" organization, and the purpose for the climate information was classified as to "plan/prepare".

Table 6. Database with "User" and "Use" Classification

Mon	Week	Year	USR Description	Name	User Code	User Description	Use Code	Use Description
Jan	4	1997	The American Red Cross (ARC) frequently recruits volunteers from various regions across the U.S. to provide relief in disaster situations. For example, in the aftermath of Hurricane Andrew, many people came from North Carolina to help with the repair of structures and to clean up the debris. The Harrisburg, Pennsylvania, chapter of the ARC is compiling a location familiarization package to include climatological information for its potential volunteers. NCDC provided the Normals, Means and Extremes table from the publication Local Climatological Data Annual Summary with Comparative Data for inclusion in their information packet. The temperature, wind, and humidity data in the Harrisburg climate summary should be beneficial to these Red Cross workers.	American Red Cross (ARC)	62	Health care and social assistance	9	Plan/Prepare

"Stories" within Sectors

An example of the additional benefit of capturing more detail user information and use codes is illustrated in Table 7, where USR information (after processing into a database) is presented for two different companies.

Table 7 reflects the use of Local Climatological Data (LCD) by two companies in the health care industry. The most interesting aspect is that the use of the data is entirely different between the two companies. One entity is using LCD for research purposes to understand the impact of weather on asthma, while the other company is using LCD to present a report to a supervisor as justification for a capital expenditure.

Table 7. Comparison of Uses by Similar Users in the Health Care Industry

Mon	Week	Year	USR Description	User Code	User Description	Use Code	Use Description
Jan	2	2001	[A] Medical Center in Dallas, Texas, recently contacted NCDC to obtain climatological data to assist in their research of factors contributing to the effect of how weather relates to asthmatic children the Dallas area. NCDC supplied the Medical Center with the monthly issues of the Dallas Local Climatological Data publication for this past year.	62	Health care and social assistance	11	Research
Dec	2	2001	A pharmaceutical salesperson requested snow data from NCDC for eastern North Dakota and western Minnesota to justify a request to her employer for a four wheel drive vehicle to use on deliveries. The specific requirement is to show that there is a 100 inch annual average of snowfall for this area. The annual issues of the Local Climatological Data publication for several stations in the area were provided for the last 10 years to substantiate her request.	62	Health care and social assistance	10	Present/ Report

Another example of the additional benefit of capturing more detailed user information and use codes is illustrated in Table 8. This example reflects the use of Hourly Surface Weather Observations by two professional service firms. Again, while the data is similar (different locations), and both instances recount weather–related fire, one is used as part of the investigation for support in a lawsuit, while the other is used as part of a research report.

Table 8. Comparison of Uses by Similar Users in the Professional Services Industry

Mon	Week	Year	USR Description	User Code	User Description	Use Code	Use Description
Jun	1	1998	An attorney representing a farmer contacted NCDC in order to obtain meteorological data which will be used in a case involving an auto accident in California. Apparently a farmer started a fire to clear brush and the wind abruptly shifted almost 180 degrees causing the smoke to blow over a nearby secondary road. Immediately after the wind shift, a passing motorist slammed on her brakes due to extremely low visibility, whereupon she was struck by an automobile directly behind her. The farmer is being sued by each of the accident victims. NCDC provided the attorney hourly surface weather observations from two specific locations in California as of the date of the fire.	54	Services (Professional, scientific, technical)	7	Investigate
Sep	1	1997	A consultant contacted NCDC to obtain hourly meteorological data which will be used in a wildfire study. Apparently, a farmer was harvesting a hay crop when his combine stalled and while trying to restart the machine several hay bails ignited. The local fire department came to the rescue and apparently thought they had extinguished the fire but the cinders re-ignited after the fire brigade left the area. The same day several miles away a neighboring fire department was conducting a controlled burn, when winds began to gust, causing the controlled burn to jump the fire suppression line and merge with the smoldering hay fire. The end result of this raging inferno was a total of 20,000 acres of land seared. NCDC provided hourly surface weather observations for areas in Washington for the period in question.	54	Services (Professional, scientific, technical)	11	Research

Table 7 and Table 8 illustrate the notion that without capturing additional user information and use information, much detail about each transaction is forever lost. By implementing these new codes, NCDC will be able to better understand its user base, respond to inquiries, and engage in more focused product development.

Value to NESDIS/NCDC

As stated previously in this section of the report, the USR records that were analyzed are not a representative sample of all NESDIS data users. The USRs were chosen because they were readily available and contained information that allowed past analysis of the data uses (the main order system does not capture enough information to allow the type of analysis conducted in this project). However, it is anticipated that the user and use codes developed from the sample USR records can be applied to all data orders in the future. By capturing this additional information, NESDIS will be able to better understand its users and how its data is being used.

Government agencies are prohibited from asking certain private/confidential questions of their constituents. As such, NCDC is limited in the amount of information it can collect on the users and use of NESDIS data. One alternative is to attempt to obtain additional information through optional feedback forms. For instance, NCDC may not be able to explicitly ask, "How will you use the data you acquire from NCDC?" But they can provide an optional form where all users can be invited to describe the use of the data. Until additional detailed information is obtained regarding users and how data is used, it will be difficult for NESDIS to more effectively target products to certain groups of users.

Finally, as we have looked at some of the on-line web statistics, a large number of the accesses of the NESDIS and NOAA web site come from users in the .com domain. Although some of these may in fact be individuals or non-business entities, it is likely that a substantial proportion represent commercial interests. A target analysis of more detailed web logs could provide insights as to the types of commercial users now taking advantage of NOAA resources. More thoroughly understanding these users would be another way for NESDIS to find out more information about their customer base.

Results of Phase 2 Activity

Originally, Phase 2 was planned as conducting a decision experiment with a firm(s) who uses NESDIS data on a regular basis as part of their decision-making. Project resource constraints made it infeasible to search across all NESDIS data centers to identify a candidate firm. Because NCDC is the largest data center and has the largest customer database, NCDC was chosen as the initial data center with which to conduct such an analysis.

This section of the report discusses the decision process used to select a company for further study and analysis. It also provides a brief industry overview for the company's primary activities and computes the benefits of using NCDC data products.

Intent of this Phase

The intent of Phase 2 is to quantity the benefits obtained from a commercial entity relying on NCDC data for decision-making as part of their ongoing operating activities (i.e., used for daily or frequent planning, budgeting, reporting, etc.). By quantifying the value to a commercial entity for using climatic data, NESDIS is better positioned to:

- Apply scarce resources to the most relevant and popular products
- Conduct more tangible data product development
- Enhance existing data products
- Improve servicing of existing customers

Methodology

The first activity in this phase was to select a company for study. After identification of the company, meetings and interviews were set up to discuss their use of NCDC data. Next, through interaction with company personnel, a list of applications that NCDC data is used for was assembled. Once the data uses of the company were understood, we worked with NCDC personnel to understand the cost of providing the data. From there we were able to determine the benefits provided by NCDC to the company selected.

Selection of Company

To capture the economic importance of providing climate and weather data to the public, an analysis of a particular industry's utilization of NCDC's products is conducted as part of this project. It is important to select an industry that plays an important role in the U.S. economy and in which climate and weather data plays an integral part.

After discussions with NCDC personnel, the energy industry was selected. A large U.S.-based company that provides energy in multiple sectors of the energy industry was identified as a candidate for this project's case study. The selected firm was contacted to determine its willingness to participate in the study, and the company subsequently agreed to participate. To preserve the confidentiality of the case study company, the participating firm is referred to as the Energy Company throughout the report.

Energy Industry Overview

To gain perspective as to the Energy Company's role in the energy industry and the economic significance of the energy industry, a brief overview of the industry is provided. In 2000, the U.S. energy industry produced 71.90 quadrillion Btu of energy; the largest sources of domestic energy were coal, natural gas, crude oil and nuclear energy (Figure 6). The Energy Company is involved in providing electricity from power plants fueled by coal, nuclear energy and hydroelectric power, and is involved in multiple facets of the natural gas industry. It also markets electricity and natural gas.

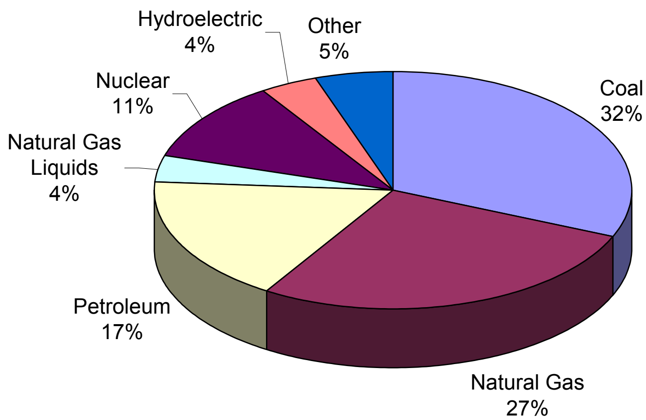

Figure 6. Sources of U.S. Energy, 2000

Source: Energy Information Administration Annual Energy Review 2000

The electricity industry is undergoing significant changes due to deregulation. While the sources of electricity have not changed substantially over the past decade, the manner in which electricity is marketed has undergone a dramatic shift. The largest source of electricity is coal-powered plants, followed by nuclear power plants. Providers of electricity are categorized as being either an electric utility or a nonutility power producer. These two sources provided 79% and 21% of the electricity in 2000, respectively (Energy Information Administration *Annual Energy Review 2000*). The Energy Company is considered an investor-owned electricity utility. In 2000, electric utility companies disposed of 8,384,442,308 million kilowatt hours[1], earning total revenues of $474,071,102[2] (Energy Information Administration *2000 Annual Electric Utility Data*).

The Energy Company is also involved in the natural gas industry, an industry even more dynamic than the electricity industry in recent years. There are multiple players in the natural gas industry, and firms involved in the natural gas industry can perform any number of the following services within the industry:

1. Extract natural gas from the ground;
2. Gather natural gas;
3. Process natural gas and extract the liquids, resulting in dry natural gas and natural gas liquids;
4. Transport dry gas;
5. Market dry gas;

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[1] Disposition represents sales to consumers and for resale, electricity furnished without charge, electricity used by electricity department and energy losses.
[2] Total revenue includes retail and resale revenue, revenue adjustments and other revenue.

6. Store dry gas; and/or
7. Market dry gas to other marketers, end-users, or local distribution companies.

Due to the number of sectors within the industry and the fact that natural gas is traded multiple times, the size of the natural gas industry is problematical to quantify. No industry statistics indicating the industry size for natural gas revenues were found during the research stage of this project. Therefore, industry size had to be estimated as described later in this section. The Energy Company is involved in multiple sectors of the natural gas industry: gathering, processing, transporting, storing, and marketing dry natural gas and natural gas liquids.

Misfit of Decision Experiment Approach

As stated previously, the original project plan was to use a decision experiment approach to estimate value for a specific case study application. As we gained input from NCDC personnel and especially from the Energy Company, two significant impediments to the use of that approach were discovered.

The first impediment relates to the relevance of the decision experiment approach within the energy industry. The decision experiment approach requires that estimates of firm performance be available both with and without the climate information of relevance. In most of the important energy applications, however, the managers at the Energy Company felt that a "without information" scenario would not be credible. For example, climate information needed to obtain permits or to conform with regulations is not optional in modern regulatory systems.

The second disadvantage is that it may be very difficult to "scale up" a decision experiment result to be relevant to an entire industry. The strength of a decision experiment analysis is that it is very specific. However, that specificity typically makes it difficult to credibly expand the analysis results to an entire industry.

Description of Alternative Cost Approach to Understanding Value

After consultation with Energy Company managers, and subsequent project team meetings, we identified an alternative approach that we feel is preferable to a decision experiment in these circumstances—the "Alternative Cost Approach to Understanding Value." Its goal is to document the value of NCDC's activities by assessing the cost the Energy Company pays to obtain climate information from NCDC versus an estimate of the costs required for the Energy Company to perform those functions on its own. In general terms, there are four steps in this process:

1. Identify and categorize significant uses of NCDC data within the Energy Company.
2. Estimate the typical annual data acquisition costs for the information currently received from NCDC.
3. Develop, in consultation with NCDC staff, a general estimate of the costs of establishing and operating a system which would provide the Energy Company the same information.
4. The computed ratio (the benefit estimate in Step 3 divided by the cost identification in Step 2) is extended to an industry scale level based upon the relative share of the national energy market that the Energy Company comprises.

The Alternative Cost Approach employed here is a derivative of the opportunity cost concept, one of the most basic concepts in economics. A typical definition of opportunity cost is, "the cost associated with opportunities that are foregone when a firm's resources are not put to their highest-value use" (Pindyck and Rubinfeld, p. 204). In this context, highest value refers to the lowest cost means of acquiring high quality and essential information. By using the lowest cost data resource, firms forego the need to expend the additional resources required in acquiring the needed data from an alternative source.

Identification of Key Uses of NCDC Products by Energy Company

To identify the key applications of NCDC data by Energy Company, the manner in which the products are utilized by a sub-sample of Energy Company personnel were evaluated. The following steps were employed:

1. Key personnel within the Energy Company organization who use climate data were identified.
2. Centrec Consulting Group personnel visited with three Energy Company personnel in June 2002. An additional person participated via a separate phone conference call. The discussion objectives were to understand the manner in which the personnel use climate data.
3. A list of the NCDC products purchased by Energy Company for the past 3 ½ years was acquired from NCDC.
4. A preliminary categorization of the data products and how they are used by the four Energy Company employees was devised.
5. The categorization was presented to the Energy Company employees, and they offered suggestions on how the categorization could be revised to convey their utilization more accurately.
6. The categorizations were revised and submitted to the Energy Company personnel a second time. The Energy Company employees offered their input for a final revision.
7. Based on the feedback of the Energy Company personnel, a final categorization of products used by the employees and the manner in which the data is used was prepared[3].

NCDC Products Purchased by Energy Company

Table 9 lists the NCDC products purchased by Energy Company during 1999 through May 2002. The Energy Company purchased a wide array of products in various media forms such as reports, publications, CD-ROMs, electronic ASCII data files, and on-line subscriptions. Average annual purchases during this period were a little over $5,000. Based on the discussions with the Energy Company personnel, some of the products are purchased on a regular basis while other products are purchased when certain data are needed for special reports and analyses. Energy Company's purchases contain some of NCDC's most popular products.

[3] After in-depth discussions with the personnel, it was determined that real-time data provided by the National Weather Service are also used for some of their analyses. The categorization focused on the NCDC products used by the Energy Company.

Table 9. List of NCDC Products Purchased by Energy Company During 1999–2002

NCDC Product
Annual Climatological Summary (ACS)
Climate Atlas of the Contiguous United States
Climatography of the US #81–Monthly Normals of Temp, Precip, HDD, & CDD
Climatological Data
CLIVUE
Combined On-line Subscription
COOP Data/Record of Climatological Observations (RCO) Form
Engineering Weather Data
Global Climate Normals 1961–1990
Global Daily Summary
Historical Climatology Series
International Station Meteorological Climate Summary Ver. 4.0
International Surface Weather Observations (SWO)
Local Climatological Data
National Climate Information Disc–Vol. 1
NCDC Cooperative Station Data
TD 3220–US Monthly Surface Data
TD 3280–Airways Surface Observations
TD 6301–U. S. Rawinsonde (AIRS)
TD 9956–DATSAV3 Surface
TD Summary of the Day
TD6305–CARDS
U.S. Divisional and Station Climatic Data and Normals Vol. 1.0
United States Snow Climatology

Application of NCDC Products by Energy Company

The utilization of NCDC products depends on the form and frequency in which the data are received and the data's intended uses. The various forms and frequency of publishing the data define the data's applications in the following manner:

- An Energy Company employee obtains NCDC data via the ASCII electronic files and inputs the data into a database that she maintains on an ongoing basis. The data points within the database are used for a variety of applications by members of her engineering group and by other groups within Energy Company for purposes related to marketing and operations. The database is updated when the new data are received. The Energy Company employee acts as a gatekeeper for the data, and provides additional analytical assistance as needed.
- Other data are obtained through the on-line subscription and then input into electronic data files. These files are used to update the forecasting models in which the historical data are used. The models are refreshed when new data are received.
- For special analyses, Energy Company personnel either access climate data provided by one of the NCDC products already in house, or they contact NCDC to determine which product(s) is (are) most appropriate for their needs and then purchase the product(s).

Table 10 presents the categorization of the applications of the NCDC products used by the Energy Company personnel interviewed for this project. The NCDC products used for the application, the data used from the products, the manner in which the data are used, the analytical output and purpose, and the frequency of use of the data or output were captured in this process. For example, the ongoing database previously mentioned consists of data from the TD 3280, TD 9956 and TD 6301 products. From this database, climatology analysis, analysis for EPA regulation compliance, and analysis for operations and maintenance are conducted. Another Energy Company employee uses the on-line subscription to obtain data for long-range forecasting models for energy demand. In addition, the on-line subscription is used to obtain local climatological data to verify weather outcomes, determine load demand, and for new plant design. Specific special reports often require different data products from NCDC.

The scope of disciplines in which NCDC products are used is wide. The products are used for analytical purposes in engineering and regulatory compliance, operations and maintenance, finance, and energy trading and marketing (gas and electric).

Within the sample of the Energy Company personnel interviewed as part of this project, it was ascertained that their key applications of NCDC data products focus on the following:

- Validation of actual weather events;
- Climatological analysis;
- EPA regulation compliance;
- Energy plant design, operations and maintenance;
- Market analysis; and
- Long-term energy demand forecasting.

Energy Company's data needs, while not unique, focus on one aspect of the broad array of products NCDC offers. Energy Company uses some CD-ROM products and the more summarized data provided on the CD-ROMs. However, their fundamental needs lie in the raw data arena. They utilize raw data for forecasting, modeling and climatological analysis. Their geographical needs span the continental United States, and they employ data points that extend from hourly observations to monthly averages.

The Energy Company personnel participating in this study believe the NCDC products are invaluable and that NCDC has been innovative in the manner in which its products are provided. Timeliness of the data is important, and the quicker they can obtain final quality controlled data the better for their analyses. One person commented that it would be helpful for on-line subscribers to receive an e-mail notifying them when updated data have been put on-line.

Table 10. Summary of a Sampling of an Energy Company's Use and Application of NCDC Products

Product Description	Data Used	How Data are Used	Analytical Output	Analytical Purpose	Frequency of Use of Data/Output
TD 3280—Airways Surface Observations and TD 9956—DATSAV3 Surface	Surface observations from 6 NWS stations; cloud information; hourly observations; historical data; temperature, rainfall, dew points, and rainfall intensity data	Hourly surface observations are data input for ongoing database	Climatology analysis; Summary statistics of extreme values for temperature	Engineering and compliance aspect of operations and maintenance; special studies are requested and summary statistics are used for analysis; studies could be to understand potential extreme temperatures and to revise processes for equipment design	Database is accessed as needed; for water quality issues, about 1-2 times/year; for climatology issues, about 4-5 times/year
TD 3280; TD 9956; and TD 6301—U.S. Rawinsonde (AIRS)	Surface observations from 6 NWS stations; cloud information; hourly observations; historical data; upper air data (balloon observations); temperature, rainfall, dew points, and rainfall intensity data	Reformat data from above described database for inputs into models that estimate levels of potential pollutants; models are approved by EPA	Estimated levels of pollutants in worst case scenarios	EPA regulation compliance, permit renewal; and application for new permits for either new plants or altered plants; also for compliance and permits for other facilities such as garages and painting facilities	After data have been archived, about once a year
LCD summaries (Local Climatological Data)	Monthly summaries of rainfall data from same 6 weather stations; variables include temperature, dew point, wind	Summary statistics of particular data points	Climatology analysis; Summary statistics of extreme values for temperature, rainfalls	Special studies requested by Energy Company personnel; Energy Company analysts employ NCDC data to provide summary statistics to requesting personnel	As needed; maybe 4-5 times a year
TD 3280 and TD 9956	Hourly data for dew points, temperature, winds and cloud cover from database	Computes heat rate calculations, lake temperature equilibriums and exchange rates	Measure water loss from lake (for hydroelectric purposes); verify worst case conditions for discharge temperature limits	Operations and maintenance—water permits; Used by fossil fuel, hydroelectric and nuclear plants to evaluate efficiency of plants' operations; used to help people understand unusual events; basis for negotiation with other water users	Sporadic; last time this application was used was 5 years ago
Several NCDC products	Data such as high wind, icing, tornado frequency	Used in NUREG equations to calculate probability of blackout	Evaluate the probability of station blackouts at nuclear power plants	Engineering design basis and risk management	Very rare
TD 3280	Historical (about 20 years) data; temperature and dew point	Heating and cooling degree days calculated from data; then input, along with other variables, into annual forecast model; linear regression models	Forecasted electric energy consumption annual from year 4 up to year 20	Operations—planning purposes for long-term power purchases, new plant construction and additional plant purchases	Twice a year
TD 3280	Historical (about 20 years) data; temperature and dew point	Heating and cooling degree days calculated from data; then input, along with other variables, into annual forecast model; linear regression models	Forecasted electric energy consumption annual from year 4 up to year 20s	Finance—sales and revenue projections; expectations of earnings for budgets	Twice a year

Table 10. Summary of a Sampling of an Energy Company's Use and Application of NCDC Products (Continued)

Product Description	Data Used	How Data are Used	Analytical Output	Analytical Purpose	Frequency of Use of Data/Output
Combined On-line Subscription	Local Climatological Data of Daily summaries—Actual temperature data; RCO, LCD and SWO are used; RCO are preferred when available; LCD or SWO are used for preliminary calculations	Summarize actual outcome of daily temperatures for appropriate region	Summary statistics of actual outcome of weather	Wholesale energy trading and marketing—settlement of options	As needed for contract
Combined On-line Subscription	Local Climatological Data of Daily summaries (RCO)—Actual temperature data dating back to 1950	Historical temperature and precipitation data are used as input into long range statistical analogue forecasting models (16-180 days)	Expected demand for weekly energy use (heating or cooling demand; depends on season)	Wholesale energy trading and marketing—pricing of options/derivatives	As needed for contract; refresh model when new data are received, about once a month
Combined On-line Subscription	Local Climatological Data of Daily summaries (RCO)—Actual temperature data dating back to 1950	Historical temperature and precipitation data are used as input into long range statistical analogue forecasting models (16-180 days)	Expected demand for weekly energy use (heating or cooling demand; depends on season)	Wholesale energy trading and marketing—project energy usage/demand	Refresh model when new data are received, about once a month
Combined On-line Subscription	Local Climatological Data of Daily summaries (RCO)—Actual temperature data dating back to 1950	Historical temperature and precipitation data are used as input into long range statistical analogue forecasting models (16-180 days)	Expected demand for weekly energy use (heating or cooling demand; depends on season)	Operations—merchant plant operations; determine load demand	Refresh model when new data are received, about once a month
Combined On-line Subscription	Daily summaries of temperature, precipitation, number of days with snowfall; Use historical data back to the 1960s; Use ACS and RCO	Use data to calculate summary statistics	Statistical calculations of monthly snowfall and other weather statistics	Operations—new plant design and nominal range of operations	6 to 7 times a year up to about a year ago; currently, new plants aren't being built
Combined On-line Subscription	Daily summaries of temperature, precipitation, windchill, number of days with snowfall; use RCO and SWO	Forecasting models or summarization of data such as correlation analysis of energy commodity price with weather	On-demand forecasts or analysis of historical data	Trading and marketing and operations—ad hoc market analysis	As requested; about 20 to 30 times a year

Estimation of Costs of an Alternative System

As mentioned above, the energy company we analyzed spends approximately $5,000 per year on acquisition of climate data. This amount is considered to be the actual cost component in our analysis. To arrive at the benefits for an alternative system (a system similar to NCDC), we worked with NCDC personnel to derive a conservative estimate of the cost to replicate the essential NCDC departments/activities that would be necessary to deliver the type of data products to the Energy Company that NCDC currently provides.

Calculation of Benefit Ratio

NCDC has a FY2002 budget of $44.8 million. Working with NCDC personnel we derived that the basic functionality required in NCDC to be able to provide Energy Company with the breadth of data products costs about $2.48 million per year (or 5.5% of the entire budget). The following table indicates the components of the NCDC budget required to staff and maintain all necessary divisions in order to provide the level of service and data products that NCDC currently provides.

Table 11. Annual NCDC Costs to Provide Climate In-Situ Products and Data to Energy Company, FY02

Work Breakdown Structure (WBS) of NCDC's budget	NESDIS Base Funds[1]	Regional Climate Centers[2]	Climate Data Modernization Program[3]	GOES Active Archive[2]	ESDIM[4]	National Virtual Data System[5]	Climate Reference Network[2]	Other NOAA[2]	Non-NOAA Cost Recovery[6]	Manage-ment[7]	Total
Total budget, millions	$11.90	$2.90	$15.50	$1.90	$1.40	$0.60	$3.50	$1.60	$3.50	$2.00	$44.80
Allocation of total budget											
End-to-End Data Management											
Planning										0.15	0.15
Collect or Rescue			0.00								0.00
Ingest, Calibrate, and Validate	1.43										1.43
Archive, Metadata, and Cataloging	0.60										0.60
Access						0.06			0.20		0.26
Migrate					0.05						0.05
Total, millions	$2.02	$0.00	$0.00	$0.00	$0.05	$0.06	$0.00	$0.00	$0.20	$0.15	$2.48
Percent of Total Budget	17.0%	0.0%	0.0%	0.0%	3.3%	10.0%	0.0%	0.0%	5.7%	7.5%	5.5%

1 Use of near real-time and historic climate in-situ data. Ingest, calibrate, and validate activities cost about $1.78 million for all NCDC data streams. Climate in-situ products require 80% of this cost or $1.43 million (validation of products is labor intensive). Archive, metadata, and cataloging activities cost $1.19 million for all NCDC data streams. Climate in-situ products require 50% of this cost or $0.6 million.
2 No funds used from this WBS.
3 No funds directly assignable. But, energy company uses products rescued from this program.
4 Use of climate in-situ data migrated to new media. Migrating accounts for 66% of ESDIM funds or $0.92 million. Climate in-situ is 5% of total archive and would require 5% of $0.92 million or $.05 million to perform migration.
5 Even though the energy company uses all aspects of E-Gov systems for most orders, we only allocated 10% of the system cost (the energy company orders an estimated 10% of the products in the entire E-Gov system).
6 Offline order processes include technical advice, order placing, gathering products & shipping (1-FTE data consultant and 1.5-FTE order fulfillment).
7 Planning/consulting with climate in-situ network managers on end-to-end data management principles for current climate in-situ networks (1.5-FTE).

Dividing the cost to maintain a portion of the NCDC data center ($2.48 million) by the annual data cost of the Energy Company ($5,000), results in a cost-benefit ratio of 495.8. Implying that for every $1 the Energy Company spends in acquiring data, they are receiving the potential benefit of not spending about $495. Stated in a different fashion, the savings to the Energy Company in this context comes to nearly $2.5 million dollars annually.

This is a relatively large cost-benefit ratio, but not uncommon when measuring the economic benefit from information management and distribution. With such a significant benefit in obtaining independent, unbiased information, it probably would not be prudent for the Energy Company to engage in data collection and maintenance on its own.

Calculation of Sector Level Benefits

For purposes of this report, the "energy sector" refers to electricity and natural gas providers—the primary focus of the Energy Company. According to the 2000 Annual Electric Utility Data (Energy Information Administration), over $474 billion was attributed to total electricity revenue in the U.S. The Energy Company earned about $7.3 billion (or 1.5% of the total $474 billion) in total electricity revenue in 2000 (2000 Annual Electric Utility Data).

Since no revenue statistics for the natural gas industry are available from secondary sources, it is more difficult to measure the Energy Company's market share of the natural gas industry. The Energy Information Administration's *Natural Gas Annual 2000* provides summary statistics on U.S. natural gas production, supply, disposition, and consumption, in addition to average prices to each consumer segment receiving natural gas. Around 20 trillion cubic feet of natural gas was delivered to consumers in 2000 (Table 12). Using the weighted average price of $5.58 per cubic feet, an estimated industry revenue for the natural gas industry is $115 billion. The Energy Company's Annual Report presents the amount of natural gas the company handled and marketed on a daily basis in 2000. Using these volume numbers, an estimate of the Energy Company's revenue from natural gas transactions is calculated. The resulting proxies for the Energy Company's revenue and market share in the natural gas industry are about $15.07 billion and 13%, respectively.

Table 12. U.S. Consumption and Average Price of Natural Gas, 2000 (Cubic Feet)

Consumer Category	Average Price ($ per thousand CF)	Volume of Natural Gas (Million CF)	Estimated Revenue (Thousands)
Residential	7.76	4,991,678	$ 38,735,421
Commercial	6.59	3,217,674	21,204,472
Industrial	4.48	9,511,565	42,611,811
Vehicle Fuel	5.54	8,281	45,877
Electric Utilities	4.38	3,043,094	13,328,752
Total		20,772,292	$ 115,926,333

Source: Energy Information Administration *Natural Gas Annual 2000*

The combined size of electricity and natural gas revenues estimated for the Energy Company is about 3.8% of the total estimated revenues for electricity and natural gas. Assuming the Energy Company is representative of other energy companies, total expenditures by all energy companies for climatological data are computed as $5,000 ÷ 3.8% = $131,578. These results imply that the entire energy industry (as narrowly defined here) spends nearly $132,000 annually on climatological data for the purposes of:

- Estimating demand for products
- Planning/budgeting and investing decisions
- Regulatory compliance

Multiplying the annual climate data expenditure of $131,578 by the cost-benefit ratio of 495.8 calculated previously yields potential industry benefit of slightly more than $65 million.

In FY 2001, COMPS data indicate that utilities expended approximately $41,000 to acquire data (and over $32,000 in FY 2002). Applying the same relationships as just described results in an estimated industry benefit of $20,327,800 (and almost $16 million in FY 2002). It is likely that considerable data is provided to utility companies by consultants and through other means, which would understate the actual use of NCDC data in the energy industry.

Interpreting the Phase 2 Findings

Valuation of the use of an existing information system often is difficult. Ideally the value of the system could be determined by comparing the difference in performance of the relevant economic agents when they used the information system versus their performance when the services of the information system were not available. However, in the case of the energy industry's use of NESDIS information, we only are able to observe performance in the "with information" case. Further, in this study, detailed information is available for only one firm in the industry.

There are several conclusions that can be drawn from this analysis:

- The extensive use of NESDIS products described in Table 10 provides a detailed assessment of the impact of NESDIS information and services to the Energy Company. Clearly the absence of such information would curtail its effective operations. Indeed because of the existing regulatory needs, it is likely that the Energy Company and firms similar to it in the industry would need to secure other means to obtain that information if it were not available from NESDIS.
- The calculated firm cost-benefit ratio of 495.8 undoubtedly represents an aggressive estimate of the relevant relationship. Therefore, the $65 million amount calculated at the industry level also is an aggressive benefit estimate.
- Another alternative means of securing the necessary data and information services would be for a private sector firm to perform the range of functions now provided by NESDIS. The discussion of economic concepts provided earlier in the text provides some insights on the likely outcomes of this alternative. The cost structure of information systems clearly is a factor in this analysis. It is likely that the natural tendency would be to gravitate towards a dominant firm market structure. As outlined previously, it is likely that this structure would provide a lesser amount of data and information services at a higher price than would exist if cost-recovery pricing is employed.
- If would be desirable, of course, to have a more precise set of estimates than have been provided. But, the nature of goods produced by information systems makes precision difficult. The non-rival and non-exclusive nature of these goods provides strong incentive for public sector provision.

Results of Phase 3 Activity

It seems that society is experiencing increasingly calamitous natural events, such as hurricanes, earthquakes, and droughts, whose impact in human and economic terms are more substantial than expected. Analysis after the event generally discovers that changes in demographic factors (such as population and wealth in the region) contributed to the surprisingly large effects.

Figure 7 and Figure 8 describe the types of wealth and population changes that have occurred across the United States over the last century. Although the figures are necessarily at an aggregate level they illustrate the dynamics that economic and social changes bring to geographic areas. For example, the population/wealth pressures that exist today in the Southeast are significantly different than the pressures that existed for most of the 1900s. These pressures exist on the coasts but in the last 20 years have expanded to include inland and rural areas as well.

Such shifts can lead to much greater than expected economic and human losses when natural events occur in those regions. The information resources of NESDIS, coupled with powerful modeling and visualization technologies, should play a critically important role in assisting both public and private decision-makers to make more informed choices either in planning for or in responding to crisis events.

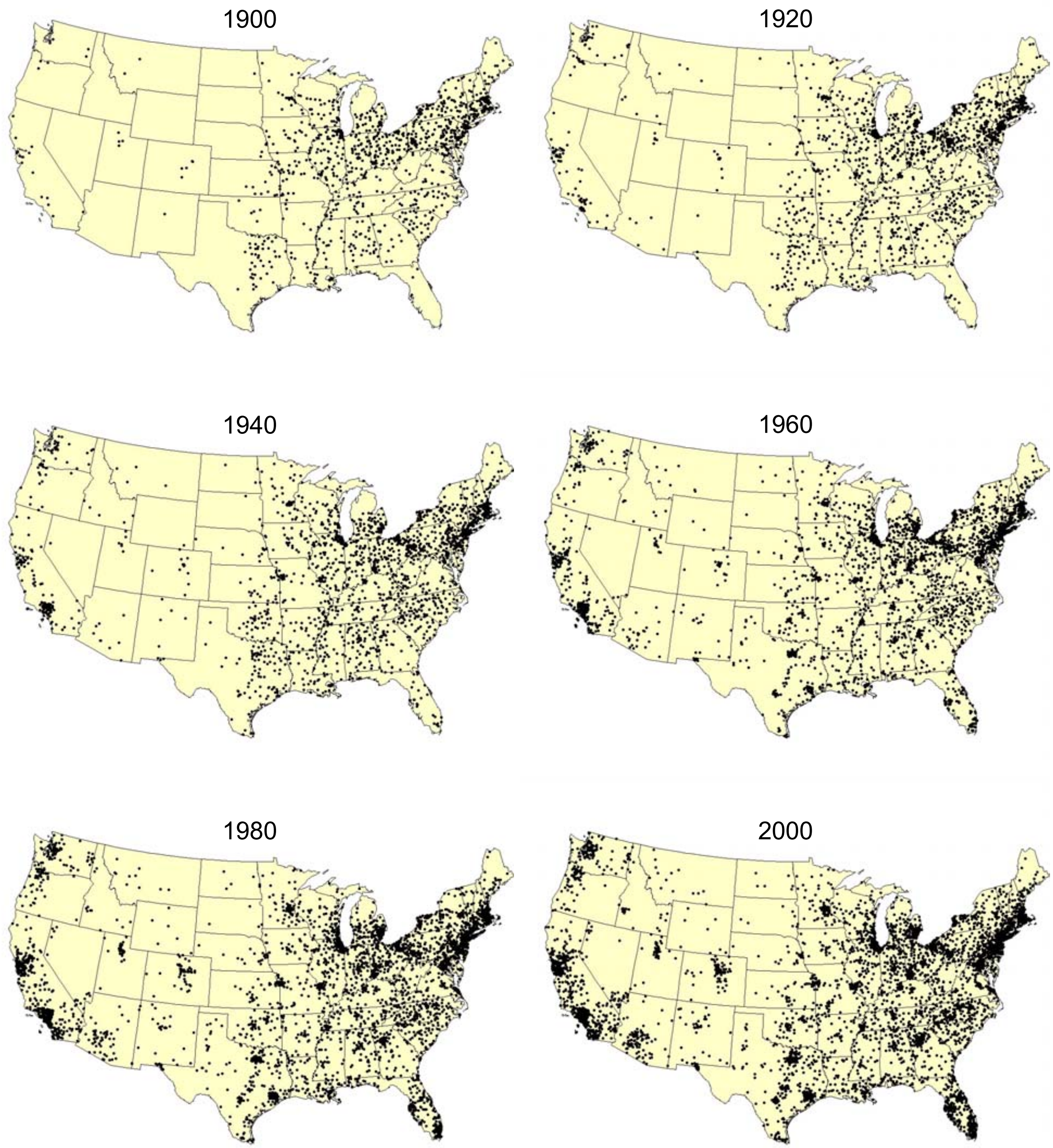
Intent of this Phase

The purpose of this segment of the study is to identify instances where demographic changes could interact with environmental dynamics to produce unexpected societal consequences. Conceived as a preliminary, exploratory analysis, the primary means of addressing the issue was to conduct informal brainstorming sessions with NESDIS personnel during the site visits conducted to support the Phase 1 effort. Three particularly intriguing instances are noted as "attractive targets" below.

As the study proceeded, discussions with NESDIS personnel led to the realization that a more appropriate economic analysis framework should be considered as a means to evaluate society's investment in the NESDIS information-providing capabilities. That approach is real options analysis. Data and information maintained and provided by the centers to assist economic decision-making today also can provide society the option to evaluate important economic and social issues tomorrow. Adapting new tools from the world of corporate finance, a real options framework could be used to provide the appropriate conceptual foundation for justification of investments in the data centers. An explanation of this concept and discussion of its application also are provided later in this section.

Identification and Discussion of Attractive Targets

The following discussion identifies three instances where it appears that proactive analysis employing NESDIS information resources in concert with dynamic analysis of economic and social forces might particularly inform decision-makers. Only three of numerous potential instances that could be articulated are discussed here.



1 dot = 50,000 people

Figure 7. U.S. Population by County Every 20 Years between 1900 and 2000

Source: Decennial U.S. Census, U.S. Department of Commerce.

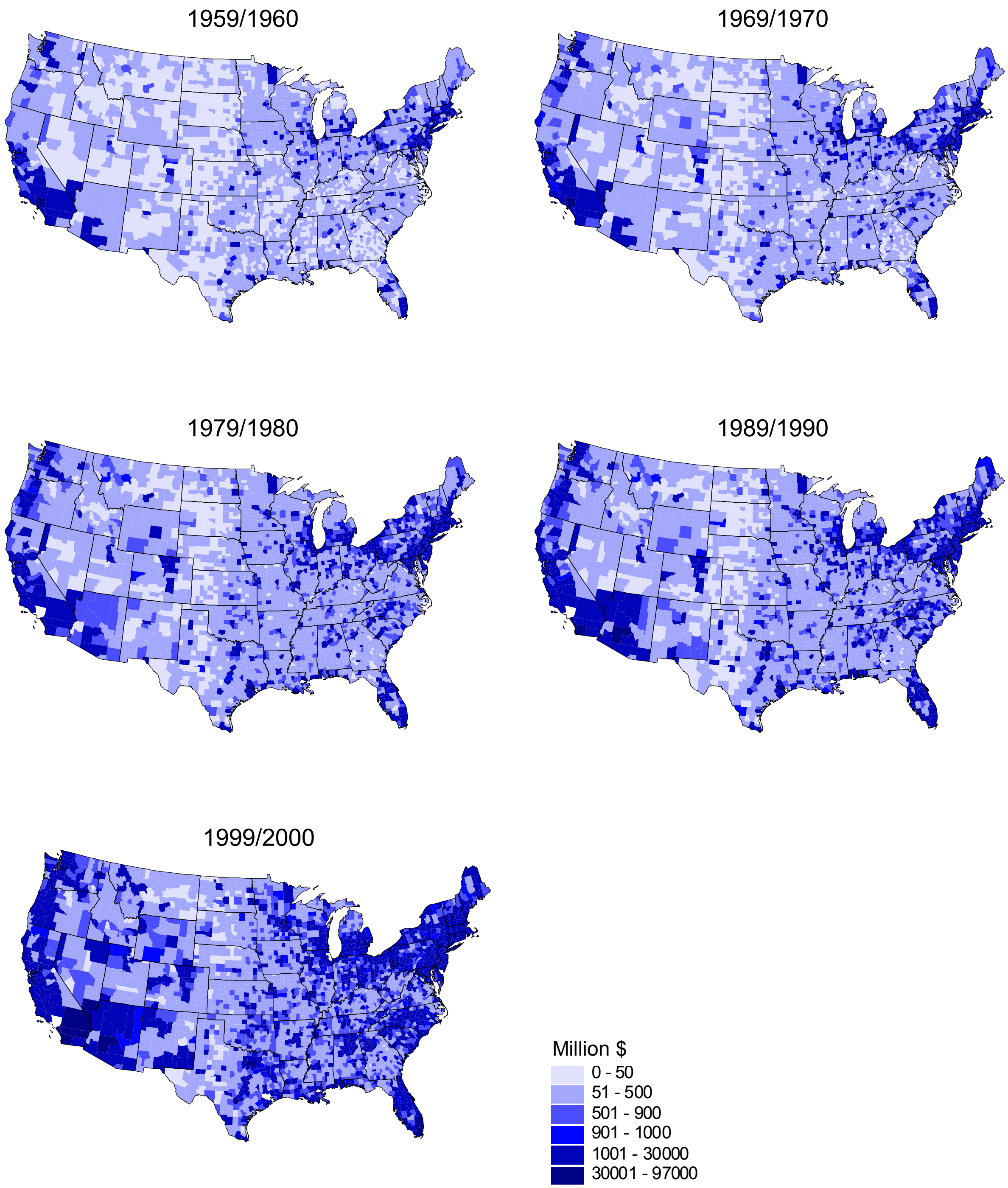


Figure 8. U.S. Wealth by County Every 10 Years between 1959/1960 and 1999/2000

Note: Wealth data by county is unadjusted and reported in nominal dollars.
Source: Bureau of Economic Analysis, U.S. Department of Commerce.

Risk Management

Modern economic and social activities increasingly rely upon sophisticated risk management tools. The availability of affordable insurance is essential to decision-makers as they contemplate investing in new building projects or committing to new economic ventures. Intriguingly for NESDIS many events for which insurance is necessary relate to geophysical, ocean and/or climate occurrences that extend across the domains of the NESDIS information-providing efforts.

As a competitive industry (with regulatory oversight), firms in the insurance industry continually strive to achieve the optimum trade-off between sufficiently low rates to attract customers and sufficiently high rates to generate enough reserves to cover their customers' losses. Actual loss experience in a region is a critically important factor in the rate setting process. However, the actual losses at any point in time are the product of the occurrence of events and the type and magnitude of societal activity in the region. Massive climatic events do not occur frequently and routinely in a locale, however, societal growth tends to occur on an ongoing basis. When major climatic events do occur, the economic and social impacts often are more profound than anticipated because our expectations are implicitly calibrated by the magnitude of prior climate events.

A potentially useful analysis, therefore, would involve a collaborative effort with the insurance industry to identify where environmental data and analysis based upon NESDIS information would provide an enhanced basis for understanding future risk potentials and associated liabilities. A prospective analysis could document existing insurance industry practices and the potential for value contribution by use of NESDIS information resources.

Coastal Resources

The National Coastal Data Development Center (NCDDC), located at the Stennis Space Center, in Mississippi, and a part of the National Ocean Data Center, is undertaking several efforts that offer the potential for economic benefits to specific user groups. Efforts focused on hypoxia in the Gulf of Mexico, harmful algae blooms, and the Coastal Risk Atlas are just a few examples.

These efforts are likely to be more amenable to analysis employing the decision experiment methodology than was the energy sector analysis conducted as Phase 2 of the current study. First, the capabilities are more targeted to specific economic and social uses, therefore, analysis of potential application is likely to be more straightforward. Second, because these are new capabilities, they will provide advantage to early adopting organizations and are not likely already to be industry standards or norms dictated by regulation.

Decision experiment analysis conducted with staff of NCDDC in collaboration with key likely user organizations would indicate the extent of the potential gain as well as impediments to achieving those gains. The results of such analyses could be used to attract additional resources to these development efforts as well as guide decision-making about allocation of existing developmental resources.

Coral Reef Resources

Coral reef resources are vitally important to ocean ecosystems but they are being environmentally challenged by economic activities conducted in close proximity to those resources. As part of the global effort to respond to these concerns, the NOAA Coral Reef Information System (CoRIS) is being implemented with the National Ocean Data Center having significant responsibility for the success of that effort.

One intriguing product of CoRIS is its map of global coral reef intensity. This shows that a substantial portion of the world's coral reef reserves are located in the South China Sea and other ocean areas south and east of Asia. Interestingly, economic analyses show that if the world's economy is to experience attractive growth rates in the future, the major increases in growth have to occur in the nations bordering these same ocean resources.

Annual economic growth in China, South Asia and East Asia averaged 10.6, 5.6, and 7.0 percent, respectively, over the period 1984 to 1996 (Fisher). Looking over the next two decades and assuming a continuation of economic growth and reasonable population growth, total gross domestic product could increase more than sixfold in China, more than threefold in East Asia, and more than double in South Asia. This growth in economic activity could significantly strain the coral reef resources of the oceans in this area.

Such commerce will require greater use of ocean freight in this region. For many people in these regions, an attractive use of additional income would be to consume greater amounts of fish. Both these activities (and probably others) are likely to intensify stresses on coral reefs. Analysis could more effectively link these factors to define more forward-looking policies relative to the coral reef resources and their future.

Real Options to Value Investments

A key issue for which economic analysis is relevant is determining the worth of a firm or an investment alternative. Society's ongoing investment in NESDIS activities represents a substantial commitment of resources. Cost accounting techniques can provide an analysis of a firm's or project's opportunity cost. However, the purpose of investment is to earn benefits that exceed costs. But even in a simple investment, capital expenditures tend to occur immediately while returns (net of operating expenses) occur over a period of time. Discounted cash flow (DCF) analysis (also called net present value analysis) is a commonly accepted means of converting those return flows into a single value. It tracks the time pattern of investment expenditures and net cash returns expected for the investment and then weights (discounts) that pattern of cash flows recognizing that each dollar of return in the future has less value than a dollar today. The result of that summation is the net present value of the investment.

However, in certain settings, DCF doesn't capture the entire potential value of the investment. Boer refers to the result of DCF analysis as the economic value of the investment. He contrasts this with the investment's total value, where the difference between total and economic value is the investment's strategic value. This strategic value, if it exists, results because some investment alternatives provide future potential opportunities beyond the specific initial purposes of the investment or where, because of uncertainty, the known initial purposes are not likely to fully account for the entire range of purposes that could exist in the future. Because of this uncertainty, for example, NESDIS information provision services are better characterized as "platform activities" that serve as an infrastructure base for additional efforts. Generally, platform activities have strategic value that significantly exceeds their economic value.

In settings where strategic value exists, discounted cash flow analysis will undervalue an investment (Glantz). Dixit and Pindyck are credited with recognizing that strategic value could be estimated in a fashion similar to that used to value a financial option. Financial options exist for numerous commodity futures and for stocks.

An option is the right, but not the obligation, to buy or sell a specified asset at a pre-specified price on a pre-specified date. Financial options are for financial investments such as stocks while real options are related to real (non-financial) assets. Table 13 identifies key dimensions that underpin the analogy between financial and real options.

Table 13. Comparison of Financial and Real Options

Financial Call Option	Real Option
Exercise Price	Present Value of Expenditure to Acquire the Assets
Stock Price	Present Value of the Assets to be Acquired
Time to Expiration	Length of Time Decision Can be Deferred
Variance of Stock Returns	Variance of Expected Returns
Risk-free Rate	Risk-free Rate
Dividend Yield	Cost of Delay

The notion underlying the real option concept is that certain types of investments provide options that may or may not be exercised. These real options typically result from learning that occurs over time. That learning may be the result of operations of the firm, from scientific innovation, or from activities in the marketplace. DCF analysis, however, assumes that the information available at the time of the investment is the totality of the information available. Therefore, within a DCF analysis, the investor's decision is constrained to either invest or not to invest at the time of the investment. Real options analysis, however, explicitly recognizes that certain investments are associated with multiple decision points over time. Recognition of this decision flexibility and the value that it provides the investor is a key factor that underlies real options analysis.

Recognition that there is a strategic value by which an investment's total value can exceed its economic value is important but would not be practically useful if a means didn't exist to estimate that strategic value. The compelling feature of real options analysis for decision-makers is that this approach provides a means to compute such estimates.

If the investment alternative involves a simple real option with a single source of variability and a single future decision point, the Black-Scholes formula is appropriate. The Black-Scholes model uses a partial differential equation that equates the change in option value with the change in the value of the tracking portfolio (Amran and Kulatilaka). The value of the option depends on five variables: (1) the value of the underlying asset, S; (2) the option's exercise price, X: (3) the time to an option's maturity, T; (4) the variance in the price of the asset on which an option is written, V; and (5) the risk-free rate of interest, R. These variables combine to determine an option's value through the following formula:

$$C = S\ N\ (D1) – [Xe\text{-}RT\ \ N(D2)]$$

where

C = the value of this option,

$D_1 = [\ \{ \{\ln (S/X) + RT\} / VT^{0.5}\}+ 1/2\ VT^{0.5}]$

$D_2 = D_2 – VT^{0.5}$

N (D_1) and N(D_2) are the cumulative area of (D_1) and (D_2), respectively, in a normal distribution

S, X, T, V and R are as defined previously.

Two other methods are employed to price real options. The dynamic programming approach lays out possible future outcomes and calculates the best set of actions to determine the value of the optimal future strategy. This approach uses a binomial model to calculate the option value. Both the Black-Scholes equation and the binomial model can be implemented on a spreadsheet. The binomial option method has greater flexibility than the Black-Scholes equation and can be used for a wide range of applications. The Black-Scholes approach is appropriate for fewer real world applications, but when appropriate, it provides a simple solution and a quick answer (Amran and Kulatilaka).

The third method for calculating real options value is the simulation approach. It averages the value of the optimal strategy at the decision date for thousands of possible outcomes. This technique employs Monte Carlo simulation and can handle many aspects of real world applications, including complicated decision rules and complex relationships between the option value and the underlying asset.

Real options valuation of investment alternatives is a relatively recent development for financial scholars and analysts in general. There are many references on application of real options for corporate businesses, including Amran and Kulatalaka and Trigeorgis. However, the application of real options to government services, especially to information provision services has not been accomplished to our knowledge.

The information managed and made available by NESDIS provides important options to society. Society, through the actions of individual decision-makers, can exercise the option to use that information to assist in evaluating current problems. Further the availability of NESDIS information resources provides another type of option. Issues and opportunities are likely to arise in the future which are unknown today. In those instances involving natural resources, evaluation to identify the preferred decision is likely to be informed by the types of data now maintained within NESDIS. Of course, unless the data is captured and maintained on an ongoing basis, historic data will not be available at the time that the decision is needed.

Application of Real Options Analysis

This discussion will describe the steps that would be undertaken to conduct an analysis using a real options framework. Three specific questions could be pursued to establish the technical and analytical feasibility of the proposed approach.

1. What types of uses of NESDIS information have the fundamental characteristics necessary to justify application of the real options approach to valuation?
2. What are the resource requirements associated with obtaining data and conducting a real options analysis for such application and what are the relative differences in estimated value compared to DCF that result from its application?
3. The real options approach is much less familiar to analysts than are alternative methods and its application requires conceptual care and use of relatively complex mathematical tools. Application of the technique will be limited if tools are not available to facilitate analysis. Is it feasible to construct a decision support system (DSS) that can: (a) accurately assess strategic value, and (b) incorporate sufficient guidance so that the tool can be readily applied?

Component 1: Categorization of NESDIS Information Uses

Both scholars and analysts believe that the critical step in successful application of the real options approach is identification and specification of the options that a specific investment alternative offers (Amran and Kulatilaka; Boer). Therefore the first component of the project work plan is to examine, in a relatively broad fashion, a sample of uses of NESDIS information so as to categorize those uses relative to the likely applicability of real options analysis. Investment alternatives that are most likely to warrant analysis with real options have three main characteristics (Dixit and Pindyck):

1. They are at least partially irreversible,
2. There are significant sources of ongoing uncertainty, and
3. The timing of the investment is at the discretion of the firm.

Amran and Kulatilaka suggest that real options analysis is likely to be warranted when:

1. There is a contingent investment decision,
2. Uncertainty is large enough to warrant waiting for additional information,
3. A substantial share of the value seems to be captured in possibilities for future growth,
4. Uncertainty is large enough to make flexibility a consideration, and
5. There will be project updates and mid-course strategy corrections.

Both Barney, and Amran and Kulatilaka provide general typologies of the types of option potentials that investment options should exhibit to most likely benefit from real options analysis. Barney identifies six options that an investment option may present. The options are to:

1. Defer
2. Grow
3. Contract
4. Shut down and restart
5. Abandon
6. Expand

Amran and Kulatilaka depict alternative settings for use of real options analysis in the following terms:

1. Valuing and investing in a startup,
2. Investing to acquire information (exploring for oil or developing drugs),
3. Investing in infrastructure,
4. Valuing vacant land,
5. Buying flexibility,
6. Combining real and financial flexibility, and
7. Investing to preempt competitors.

The prior categorization approaches will be integrated and targeted to the specific needs of NESDIS information users in a final categorization scheme.

Another type of category relates to whether the investment setting associated with each use of NESDIS information is simple or complex in nature. A simple real option would have a single source of uncertainty and one timing decision (Benninga, and Czaczkes; Amran and Kulatilaka). A complex real options setting conversely would have multiple sources of uncertainty and/or multiple decision times. This distinction will be particularly important in determining the conduct of the case study analyses and in DSS design.

Component 2: Conduct of In-Depth Case Study Analyses

The second component of the study would investigate in detail the application of real options analysis to actual instances of NESDIS information use. This component will be comprised of two steps. The first step is the selection of candidate situations for case study analysis. These are likely to come from the types of activities identified in Phase 3 of the current project. The second step involves application of the real options approach. Although computerized analysis will be employed in these analyses, the focus will be on use of these tools to address a single application rather than considering how to create tools for more general application.

The second task of Component 2 is conduct of a real options analysis for each of the case study settings selected. A number of specifications of the real options method have been provided (Dixit and Pindyck; Amran and Kulatilaka). Because of its strategic (rather than financial) orientation, the approach detailed by Barney will be adapted and presented here. That approach has five steps:

1. Recognize the real option(s) inherent in the case situation.
2. Describe the real option using financial option parameters.
3. Establish a benchmark value using net present value to estimate economic value.
4. Calculate real option values, employing the Black-Scholes method if the case involves a simple real option or a more mathematically sophisticated method (dynamic programming of the binomial model or Monte Carlo simulations) if the case provides a complex option setting.
5. Compare the total value estimated with real options with the benchmark value.

Step 4 is dependent upon the nature of the option, either simple or complex. In the case of a complex option, the Black-Scholes formula is not appropriate. Amran and Kulatilaka identify two alternatives that can be employed. One is the use of dynamic programming to evaluate a binomial model formulation of the option. The second option is Monte Carlo simulation. These alternatives are discussed in more detail in a previous section of this report.

This five-step approach will be adapted to the specific case study settings of this study. The details of application will be dependent upon the characteristics of those settings.

Component 3: Specification of the Conceptual Design, Development, and Testing of a Preliminary Prototype of the Eventual DSS

The three tasks that comprise the third analysis component are defined within the title of the component: (1) conceptual design; (2) development; and (3) testing. Application of real options analysis, except in trivial cases, requires the aid of computerized tools because of the mathematical calculations required. Certainly, in the case of complex real options, dynamic programming and/or simulation are calculation intensive. Numerous modeling tools can be and have been employed to assist in these calculations. Therefore, there is relatively little uncertainty regarding the feasibility of computerized analysis of real option questions.

The focus, therefore, of this third component of the study will be on the issue of developing a Decision Support System (DSS) that assists decision-makers who are not already experienced in real options analysis as well as completing mathematical calculations. This tool then would be available for NESDIS staff and potentially NESDIS information users. In addition to acquiring data from users, the DSS will need to inform users as to key concepts and steps associated with real options analysis.

The DSS conceptualization will be significantly informed by the results of earlier elements of this study. The categorization defined in the study's first component will provide considerable assistance in this step. Further the five-step process noted in the second component contributes to the definition of the DSS framework. A key feature of the conceptual design phase of this component is the need to design decision-maker intelligence on real options analysis into the DSS.

Development of a preliminary prototype will focus on the case study analyses of the study's second component. It is expected that standard spreadsheet and simulation modeling tools will be sufficient. Testing of this type of DSS extends beyond the traditional model verification and validation steps. These steps ensure that the developed model performs the calculations expected in a reliable and accurate fashion. In addition, the DSS developed for this study needs to have characteristics that allow it to inform non-expert users of the benefits and procedures of real options analysis.

Summary and Recommendations

Summary

The purpose of the study described in this report is to provide information that will be useful to NESDIS leaders regarding the types of applications that generate value for society, including explicit monetary values. Three types of activities were conducted to achieve that purpose. These included site visits to the five NESDIS operational units, conduct of an intensive case study with a private sector firm that makes use of NESDIS information, and brainstorming sessions with NESDIS personnel regarding prospective analyses employing NESDIS data and information services.

As part of the study's analysis, three key economic concepts were investigated and applied to NESDIS data and information services. NESDIS information products are generally considered public goods and are non-rival and non-exclusionary in nature, as opposed to private. In such settings, private markets have difficulty in arriving at optimal quantities and prices. The market failures, which often result when products with such characteristics are offered as private sector goods, cause inefficiencies to accrue to the users of those goods. The cost of producing the first unit of information products is extremely high whereas subsequent units are very low cost to reproduce. In these instances, it is likely that a market structure characterized by dominance of one firm will emerge. The NESDIS pricing policy of providing data with minimal charges is consistent with the relatively low reproduction costs associated with information products. Emergence of a dominant firm market structure tends to lower consumer benefits due to monopolistic pricing behavior relative to competitive market pricing. Public sector provision of such information, such as through NESDIS, offsets the "natural" tendency for a dominant firm market structure to emerge.

The move to distribution of NESDIS data and information services via the Internet has significantly enhanced the availability of those resources to the public. At the same time, this development has made it more difficult for NESDIS personnel to have operational knowledge of the uses to which the data and services are being applied. However, discussions with personnel at the National Climate Data Center alerted the study team to a unique data set called Unusual Service Requests (USRs). In addition to information about the entity making a data request, the USRs contain narrative descriptions of the planned use for the data. Analysis of this information provided a template, which contains a classification system based upon the North American Industrial Classification Systems (NAICS). This template may provide an approach that can be employed with the currently used COMPS system to provide enhanced service to the public.

An extensive case study analysis was conducted as a major component of the project. In collaboration with NCDC personnel, a major energy company was identified and agreed to participate in the effort. The analysis provides an extremely detailed report of the Energy Company's use of NCDC resources and the application to which those resources were applied (Table 10). The absence of such information would curtail its effective operations. Indeed because of the existing regulatory needs, the Energy Company and firms like it in the industry would need to secure other means to obtain that information if it were not available from NESDIS. These resources are made available to the Energy Company through NCDC at a cost of slightly more than $5,000 per year. An exploratory economic analysis was conducted to provide estimates of the costs that would be required to provide the information resources now provided by NESDIS. Using relationships based upon the Energy Company's cost of data acquisition and the Energy Company's relative market share, a cost-benefit ratio of 495 was determined. (For every $1 that the Energy Company spends in acquiring data, they are receiving a potential benefit from not having to spend $495 to acquire that data on its own.) When extended to the entire industry, the potential benefits are approximately $65 million per year. It should be noted that for purposes of this study the definition of the energy industry relates only to electricity and natural gas providers and not the entire energy industry as broadly defined.

As economic and social changes occur in an area, the region's vulnerability to environmental events can be significantly altered as well. In collaboration with NESDIS personnel, three instances were identified where it appears that proactive analysis employing NESDIS information resources might be useful to societal decision-makers.

- Recognizing the important role of risk management in modern society, one area of analysis would involve a collaborative effort with the insurance industry to identify where environmental data and analysis based upon NESDIS information would provide an enhanced basis for understanding future risk potentials and associated liabilities.
- The emerging activities at the National Coastal Data Development Center provide an opportunity to explore the potential value of NESDIS data and information services in the context of a more targeted set of users. Decision experiment analysis conducted with staff of NCDDC, in collaboration with key likely user organizations, could indicate the extent of the potential gain as well as impediments to achieving those gains. The results of such analyses could be used to attract additional resources to these development efforts as well as guide decision-making about allocation of existing resources.
- Coral reef resources are vitally important to ocean ecosystems but they are being environmentally challenged by economic activities conducted in close proximity to those resources. The vast coral reefs in the South China Sea are likely to be particularly challenged by future economic growth in Asia. Prospective analysis could define more forward-looking policies relative to the coral reef resources and their future.

Recommendations

Below are some specific recommendations for next steps based upon the analysis conducted in this study:

1. Investigate the implementation enhanced user and use codes within the COMPS system to enable better customer support. In addition, offering the capability for users to <u>voluntarily</u> indicate the intent for which the data was being sought would aid in understanding how NESDIS resources are being used. Analysis of this information could assist in the development of improved data and information services.
2. The case study analysis provided valuable detailed insight into the actual application of NESDIS resources in a significant energy company setting. Continued investigation using case study analysis techniques will add significantly to the knowledge created in this study. Results of multiple case study analyses can then be compared and contrasted leading to significant advances in understanding. Examples of additional industries in which case studies could be conducted include:
    - Agribusiness—particularly sensitive to climate events.
    - Insurance industry—it is unique in that it utilizes data from all three data centers (NCDC, NODC, and NGDC).

- Transportation industry—depending on the locations served, this may include all data centers.
- Energy industry—while the current report focuses on NCDC data, the energy industry is able to operate more efficiently when responding appropriately to space weather forecasts, data that comes from NGDC.
- Airline industry—use of NGDC data to generate more accurate topography maps that can aid in better navigation over uneven terrain.
- Aquaculture—use of NODC data for forecasting and help operate the best growing conditions, etc. for the fisheries industry.

3. The preceding recommendation referred to existing uses of NESDIS data and information services. But the future effects of environmental events will be conditioned by economic and social changes in the areas where those events occur. Therefore prospective analysis which explores potential effects including the interaction of social forces and environmental events could be instructive to societal as well as NESDIS decision-makers. Three examples where such efforts could have a major payoff include risk management within the insurance industry, activities emerging at the National Coastal Data Development Center, and analysis of emerging pressures on coral reef resources, especially economic development in Asia relative to the South China Sea. Use of real options analytical techniques should more appropriately model the value that NESDIS resources can provide in these instances.

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Appendix A
Combined Tier I and Tier II User Codes

User Code	User Description	User Code	User Description
111	Ag: Crop production	5416	Services: Consulting
112	Ag: Animal production	5417	Services: Research & development
113	Ag: Forestry, logging	5418	Services: Advertising
114	Ag: Fishing, hunting, trapping	5419	Services: Other
115	Ag: Other	55	Management of companies and enterprises
21	Mining	56	Services (admin, support, other)
22	Utilities	6111	Edu: Elementary & secondary
23	Construction	6112	Edu: Junior colleges
311	Manuf: Food, fiber	6113	Edu: Colleges, universities & professional schools
312	Manuf: Wood, petroleum, chemical	6114	Edu: Business, computer, management, technical, trade, other
313	Manuf: Metal, electronic, machinery, other	6117	Edu: Support services
42	Wholesale Trade	62	Health care and social assistance
441	Retail: Durable goods	71	Arts, entertainment and recreation
442	Retail: Non-durable goods	72	Accommodation and food services
481	Trans./Ware.: Air	81	Other services (Repairs, maintenance, personal, laundry)
482	Trans./Ware.: Land	813	Non-profit, non-government organizations
483	Trans./Ware.: Water	814	Individuals & Personal households
491	Trans./Ware.: Delivery	9211	Local Gov: Executive, legislative
493	Trans./Ware.: Warehousing, storage	9212	Local Gov: Justice, public order, safety
494	Trans./Ware.: Other	9213	Local Gov: Environment, economic development
511	Media: Publishing industries	9221	State Gov: Executive, legislative
512	Media: Motion Picture, Sound Recording Industries	9222	State Gov: Justice, public order, safety
5151	Media: Broadcasting—Radio	9223	State Gov: Environment, economic development
5152	Media: Broadcasting—Television	9224	State Gov: State Climatologist
5153	Media: Broadcasting—Cable and other	9231	Federal Gov: Executive, legislative
516	Media: Internet Publishing & Broadcasting	9232	Federal Gov: Justice, public order, safety
517	Media: Telecommunications	9233	Federal Gov: Environment, Forest Service, USDA
518	Media: IPSs, Web Portals, Data Processing	9234	Federal Gov: Housing and economic programs
519	Media: Other Information Services	9235	Federal Gov: Space research and technology
521	Finance and Insurance: Financial institutions	9236	Federal Gov: National security and international affairs
522	Finance and Insurance: Insurance carriers	9237	Federal Gov: Regional climate center
53	Real estate, rental and leasing	9238	Federal Gov: NWS
5411	Services: Legal	9239	Federal Gov: NOAA (Non-NWS)
5412	Services: Accounting	10001	Non-US: Foreign government
5413	Services: Architectural & Engineering	10002	Non-US: Multi-government agencies
5414	Services: Specialized design services	10003	Non-US: World data centers
5415	Services: Computer systems	10004	Non-US: Other