the productivity gains from the electrification of manufacturing were not large at first but became quite substantial several decades after the opening of the first central power station. Box 2-1 examines the hypothesis that rising productivity follows major technical innovations with a considerable lag, and considers whether productivity patterns in the information age are likely to mirror those that followed the widespread adoption of electrical power.

MACROECONOMIC IMPLICATIONS OF THE Y2K PROBLEM

It is now less than a year until the widely anticipated arrival of the year 2000 problem, called Y2K for short (or, more colorfully, the "millennium bug" or "millennium bomb"). Many older computer programs, including those running on microprocessors embedded in other electronic products, encode the current year using only the last two digits. Thus, when January 1, 2000, arrives, they may fail to recognize "00" as

Box 2-1.—The Electrical Revolution, the Computer Revolution, and Productivity

Although the electric dynamo was invented well before the turn of the century, it did not seem to fuel large gains in productivity until many years later. One economic historian reports that U.S. productivity grew more slowly between 1890 and 1913 than previously, but it increased rapidly between 1919 and 1929, and he attributes half of the acceleration in manufacturing productivity relative to the preceding decade to growth in electric motor capacity. Drawing a parallel between this episode and the spread of computing technology in our own time, he argues that an extended process of technological diffusion may now be under way, which may yield large productivity gains in the future. Others have noted similar lagged productivity effects following the introduction of steam power and the development of the automobile.

The slow diffusion of electric power may be explained primarily by the need to build new factories and redesign manufacturing processes in order to take full advantage of the new technology. Many manufacturers would have gained little from simply replacing a large steam power unit with a large electric power unit in the same factory. Substantial cost savings *were* available over time from building new factories: electric-powered factories could be single-story and less sturdy, machinery could be reconfigured more easily, and the flexibility of wiring meant that portions of plants could be shut down individually. However, new construction was generally unprofitable until existing plants had the year 2000, mistaking it instead for 1900. The result could be incorrect output or total system failure. Although it sounds to many at first like a trivial matter, of interest only to computer engineers and programmers, in fact the Y2K problem is potentially extremely serious, given the central role that computer technology has taken in our lives. Problems caused by the Y2K bug in one company, industry, or sector may have widespread consequences in others.

There are many conceivable Y2K disaster scenarios. Most involve disruptions to some critical infrastructure that links the rest of the economy together, such as transportation systems, power distribution grids, or telecommunications or financial networks. Such disruptions would likely have effects that are more than proportionate to the size of the sector directly affected. Some observers warn that in January 2000 planes may stop flying, telephone traffic may be disconnected, financial transactions may not go through, power grids may shut down, and so on. Others have worried that Social Security recipients might not receive their checks (although, as Box 2-2 notes, the Social

Box 2-1.—*continued*

depreciated. In addition, a relatively loose industrial labor market at the turn of the century kept the price of labor low and discouraged manufacturers from substituting capital for labor. Real wages in the United States did not rise enough to motivate significant expansion of the capital stock until immigration from Europe was curtailed during World War I. Lastly, implementing the new processes throughout the economy required a considerable supply of specialized talent—electrical engineers and factory architects experienced in the new designs—which developed only slowly.

Whether productivity in the information age will follow the path of productivity in the electric age remains to be seen. The introduction of computer technology is similar in many ways to the transition to electric power. Integrating computers into the work environment is not a straightforward matter: firms are clearly still adapting the organization of work to take maximum advantage of the new technology. At the same time, the diffusion of computers differs from the spread of electricity in important ways. For example, computers have already spread through the economy much faster than electric power did, at least in part because of their plunging prices. The historical analogy is intriguing and has appealing implications, but even its main proponent warns against taking it too literally. It is simply too soon to know whether the computer revolution will generate a surge in productivity growth ahead.

Box 2-2.—Preparing Federal Systems for the Year 2000

The Federal Government is a sufficiently large player in the economy that a failure of its own operations due to the Y2K problem would cause great inconvenience and hardship to many Americans, even if it did not impact the macroeconomy. The Federal Government operates some of the largest, most complex computer systems in the world, which provide services to millions of Americans. At the Social Security Administration (SSA) alone, information systems track annual earnings for more than 125 million workers, take 6 million applications for benefits each year, and make monthly benefit payments to 48 million Americans. The Federal Government also exchanges vast amounts of information with the States, which administer key Federal programs such as the food stamp program, Medicaid, and unemployment insurance.

Preparing Federal systems for the year 2000 is an enormous challenge, and agencies have mounted aggressive efforts to ensure that their critical services will not be disrupted. SSA was the first agency to begin work on the Y2K problem, as long ago as 1989. By 1995 several agencies had Y2K projects under way and were sharing information with each other about their efforts. In 1995 the Office of Management and Budget (OMB) formed an interagency committee, which it asked the SSA to chair, to coordinate the various Federal efforts. In 1996 the Chief Information Officers Council was assigned the responsibility of building on and overseeing the committee's work.

Since early 1997 the OMB has produced quarterly reports on agencies' progress in assessing, remediating, testing, and implementing critical systems. The Administration has established a goal of having all critical systems compliant by March 1999. As of November 15, 1998, 61 percent were already compliant, up from 27 percent a year earlier. A small percentage of critical systems

Security Administration is already Y2K-compliant) and even that hospital life-support systems might shut down.

Huge efforts to address the Y2K problem have been under way for some time, especially in large corporations and financial markets and in the U.S. Government (see Box 2-2 on Federal Y2K efforts; see also Box 5-3 in Chapter 5, on the Administration's initiative to encourage Y2K information sharing among companies). The American economy is large, diverse, and resilient, and people will find ways around those disruptions that, despite everyone's best efforts, will inevitably occur. But it is essential to guard against complacency. Some, in particular some smaller companies and some State and local governments, have not yet gotten the message.

Box 2-2.—*continued*

are not expected to meet the March goal, and their agencies have been instructed to produce specific benchmarks showing how they will complete work on these systems before January 1, 2000, and to create contingency plans where necessary.

Federal payment systems are of particular concern to the public and the economy. Social Security and veterans' benefits systems are already compliant, and the Internal Revenue Service appears well on its way to being able to collect and process tax returns and issue refunds in a timely manner. For Medicare, which continues to face major system challenges, the Health Care Financing Administration is developing contingency plans to ensure that health care funding is not disrupted. State-run systems for administering Federal benefit programs play a critical role in distributing a wide range of benefits, and a few States are receiving increased attention from Federal agencies.

The OMB also works with agencies to ensure that they have adequate financial resources to address the problem. In the fall of 1998 the Congress provided a $3.35 billion emergency fund to ensure that unanticipated Y2K funding needs are met and that no system will fail for lack of financial resources.

In February 1998 the President's Council on Year 2000 Conversion was created to coordinate the Federal Government's Y2K efforts. The council works with the OMB to ensure that agencies are making the most effective use of their financial and human resources to prepare their systems. The council is also concerned with reaching out beyond the Federal Government to promote action on the problem and to offer support to Y2K efforts in the private sector, by State, local, and tribal governments, and by international entities.

Some foreign countries have only recently gotten the message as well. Thus concern has shifted recently to the international dimension. Y2K problems can be transmitted not just from one company to another, but also from one country to another. Australia and Canada are classed with the United States among those countries relatively far along in their remedial efforts. But some European countries have been diverted by another large information processing task, namely, that of converting their information systems to deal with the new European currency, the euro, which came into existence in January 1999. In many countries, preparations are not as far along as they should be. The reassuring notion that developing countries are not yet as dependent on computers as are many industrial countries is outweighed by the fact that their equipment is likely to be older and therefore may contain more of the old two-digit coding.

Those companies and countries that only began to address the Y2K problem in 1998 now find themselves in a race against time. And any that have still not begun to deal with the problem will probably find their efforts have come too late. In such cases, business continuity planning to minimize probable disruptions is particularly necessary.

A few Wall Street forecasters have assigned high odds to the likelihood that the Y2K problem will lead to a serious global recession. Such forecasts seem excessively dire. Even if disruptions turn out to be more serious than most analysts expect, they will most likely show up primarily as inconveniences and losses in certain sectors. It is less likely that they would manifest themselves as the sort of economy-wide macroeconomic disturbances that can lead to a recession. In other words, aggregate economic statistics such as GDP and employment will probably not reflect Y2K effects to any noticeable extent. However, it would be unwise to state categorically that a Y2K recession is not in the cards. Computer technology is so pervasive in our lives that it is difficult to predict all the possible sources of danger.

Some effects on the demand side of the economy can reasonably be predicted—indeed, they are already upon us. First, the need to address the Y2K problem is already boosting demand for computer hardware and software, both to retrofit older machines and programs and to purchase new equipment that is Y2K-compliant. From a review of quarterly 10-K reports filed by Fortune 500 firms, the Federal Reserve Board has estimated that these large companies will spend a total of $50 billion on Y2K fixes. Indeed, this spending probably helps explain why real investment in computers and peripheral equipment in late 1998 was running more than 60 percent above its level a year earlier. Sometime later in 1999, it is likely that a tendency for firms to freeze their systems, so as not to be caught in midstream when January 1, 2000, arrives, will work to moderate Y2K spending. Thereafter a second burst of pent-up computer spending may occur, especially if new Y2K-related problems are revealed.

The Y2K problem is also increasing demand for the services of computer programmers. This effect should reverse after 2000, if all goes well, but it is likely to persist for some time after January 1. Not only may unanticipated glitches be discovered and need to be fixed, but companies are also likely to face a backlog of upgrade tasks that they had postponed in order to divert programming resources to Y2K issues. Economists at the Federal Reserve Board have pointed out that the increased demand for computer goods and services may not be showing up in GDP, to the extent that it takes the form of firms reallocating their own computer support services to work on the problem. To the contrary, they point to a negative effect on productivity resulting from the diversion of resources from what would otherwise be investment in new productive capacity, and they estimate a loss to U.S. productivity due to such diversion of 0.1 to 0.2 percent per year in 1998 and 1999.

Uncertainty over the performance of information and delivery systems might lead firms to stockpile inventories in the runup to January 2000. Uncertainty has a positive effect on the demand for inventories at every stage of production, from raw materials such as oil and other mineral and agricultural products to retailers' inventories of consumer goods. The Y2K inventory effect should provide a clear boost to GDP in the fourth quarter of 1999, offset by a corresponding negative effect in early 2000. But this possibility implies no particular distortion of economic activity and calls for no particular policy response. Given the intrinsic uncertainty created by Y2K, it is rational and sensible, even optimal, for companies to take the precaution of adding a bit to inventories ahead of time. There is no reason to presume that this tendency to stockpile will be greater, or that it will be less, than what is appropriate.

Disturbances in the financial sector are also possible. The demand for cash balances, like the demand for inventories, is affected by uncertainty. Risk-averse people may withdraw more than the usual amount of money from automatic teller machines on the way to their New Year's Eve parties this year. As any macroeconomic textbook shows, an increase in the demand for cash without an increase in its supply can have a contractionary effect on the economy. Unlike the other factors, however, this one is easily accommodated. The Federal Reserve has already made arrangements to ensure that banks have the currency they need to satisfy a surge in demand. Thus, an increased demand for cash is one part of the macroeconomic equation that need not be a source of concern.

Effects on the supply side—notably in the infrastructure sectors mentioned above—are the source of the more alarming scenarios and are much harder to predict. It is here that the greatest risks lie. There is no way to evaluate, for example, whether the prospect of Y2K glitches in the financial sector will stoke irrational end-of-millennium unease to the point of provoking self-confirming volatility in securities markets. Banks have reported that Y2K compliance is already an important factor in their decisions to extend credit in certain foreign countries, particularly in Asia and Eastern Europe, where countries are thought to be among the least well prepared for the Y2K problem. A tightening of bank lending in these regions could accentuate the capital scarcity arising from the recent flight to quality.

There is no way of knowing the odds that the Y2K problem will lead to a recession. Even those who issue pessimistic forecasts admit freely that they are purely subjective judgments. This is not the sort of problem that lends itself to formal modeling; macroeconomic models simply are not built to address one-time scenarios such as a Y2K debacle. Moreover, if one knew enough about all the potential problems to construct an accurate forecasting model, one would also know enough to go out and fix them. But as always, the unpredictable problems are the hardest to predict.

One can look to historical precedent—past disruptions of transportation or power systems due to strikes, weather events, or technological failures, for example—to see if anything can be learned about the macroeconomic spillover effects. Such an analysis is encouraging. Table 2-2 reports over 20 major disasters that occurred in the United States between 1971 and 1995, most of them weather-related, together with estimates of their monetary damages. The adverse impacts on buildings and property, even leaving aside the tremendous human toll, were often large: over 1 percent of GDP each in the cases of Hurricane Andrew in 1992 and the Northridge, California, earthquake in 1994. In economic terms these damages represent a loss in future consumption; resources must be diverted to replace or repair the capital stock that

TABLE 2-2.—*Disaster Damage: National Income and Product Accounts Estimates of Value of Structures and Equipment Destroyed*

Disaster	Area affected	Impact on NIPAs	
		Period	Value destroyed (billions of 1992 dollars at annual rates)[1]
Earthquake	California	1971: I	1.7
Hurricane Agnes	Middle Atlantic	1972: II	20.2
Flood	Mississippi	1973: II	6.3
Tornadoes	Alabama, Indiana, Kentucky, Ohio, Tennessee	1974: II	1.9
Flood, dam collapse	Idaho	1976: II	1.4
Windstorms, flood	Kentucky, Virginia, West Virginia	1977: II	2.8
Floods	Alabama, Mississippi, North Dakota	1979: II	} 3.0
Tornadoes	Arkansas, Texas	1979: II	
Hurricanes David and Frederick	Alabama, Mississippi	1979: III	4.6
Mudslides	California	1980: I	1.5
Riots	Miami (Florida)	1980: II	} 1.9
Mount St. Helens eruption	Oregon, Washington	1980: II	
Hurricane Iwa	Hawaii	1982: IV	} 4.7
Floods	Arkansas, Missouri	1982: IV	
Hurricane Alicia	Texas	1983: III	5.7
Hurricanes Elena and Gloria	Atlantic and Gulf Coasts	1985: III	4.3
Tropical Storm Juan	Gulf Coast	1985: IV	} 4.2
Hurricane Kate	Atlantic Coast	1985: IV	
Floods	Atlantic Coast	1985: IV	
Hurricane Hugo	North and South Carolina	1989: III	17.8
Earthquake	Loma Prieta (California)	1989: IV	15.8
Fire	Oakland (California)	1991: IV	6.1
Hurricane Andrew	Florida and Louisiana	1992: III	63.9
Hurricane Iniki	Hawaii	1992: III	7.9
Winter Storm	24 Eastern States	1993: I	7.9
Floods	9 Midwestern States	1993: III	8.2
Earthquake	Northridge (California)	1994: I	74.8
Hurricane Opal	Florida plus 9 Southern States	1995: IV	8.6

[1] Reflected as additions to consumption of fixed capital.

Source: Department of Commerce (Bureau of Economic Analysis).

has been lost or damaged. Yet in most cases the reduction in the capital stock had only a limited impact on current sales and production, so that the disruption did not show up in the national statistics on output, income, or employment for the year. The same is true of strikes, even those that affect the communications or transportation infrastructure. The 1997 strike against the Nation's leading private package delivery service, for example, in the end had little discernible impact on GDP, in part because firms and individuals found other ways to ship their packages. Americans are, after all, very adaptable. Also, output that is lost in one month is often made up the next.

To be sure, it could be dangerous to generalize from these precedents. A disruption that affected the entire country, or that lasted more than a few weeks, would offer less scope for substitution. But even when a failure of major power cables cut power to the central business district of New Zealand's largest city for 2 months last year, the estimated effect on the year's GDP growth was small in the end.

To summarize, even if Y2K disruptions turn out to be on the serious side, they will most likely show up primarily as inconveniences and losses in some sectors, and not in noticeable macroeconomic terms. A survey of 33 professional forecasters reported an average expectation that the Y2K problem and efforts to address it would add 0.1 percent to economic growth in 1999 and subtract 0.3 percent in 2000. Given typical yearly fluctuations in GDP, it would be hard to identify effects of this magnitude after the fact. The huge efforts now under way, both in the government and in the corporate sector, should make a truly serious disruption, let alone a recession, less likely. Again, however, it is important to avoid complacency. We should all redouble our preventive efforts, to keep from having to put the adaptability of the economy to the test.

NEAR-TERM OUTLOOK AND LONG-RUN FORECAST

THE ADMINISTRATION FORECAST

The Administration projects GDP growth over the long term at roughly 2.4 percent per year—a figure consistent with the experience so far during this business cycle as well as with reasonable growth rates of the economy's supply-side components. One method for estimating the economy's potential growth is an empirical regularity known as Okun's law, which can be illustrated by a scatter diagram (Chart 2-10). The diagram plots the four-quarter change in the unemployment rate against the four-quarter growth rate for real output. According to Okun's law, the unemployment rate falls when output grows faster than its potential rate, and rises when output growth falls short of that rate. The rate of GDP growth consistent with a stable unemployment rate is interpreted as the rate of potential growth and