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The Innovation Process, Economic Growth, and Public Policy

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ABSTRACT

Influential economists and federal policy makers are of the opinion that much of U.S. economic growth can be attributed to technological change. Alan Greenspan, Chairman of the Federal Reserve, credits the current economic expansion to the creation and diffusion of new technologies which have led to an expansion of business investment, increased productivity, and low levels of inflation and interest rates. Many of these new technologies, including improved products and services, are results of the monetary incentives endogenous to our free enterprise system. Firm competitive sustainability is accomplished through innovation processes assembled and managed by entrepreneurs. The growing role of innovation in the U.S. economy presents important and interesting challenges to contemporary policy making, especially in the areas of education, research and development, venture capital, business regulation and law, and intellectual property rights.

The Innovation Process, Economic Growth, and Public Policy

Summary

Much of the recent growth in the U.S. economy can be traced to technological change. A major source of this technological change is the innovation processes of individual firms. As a consequence, public policies impacting innovation have taken on increased importance. This report provides a background analysis to help Members of Congress understand the innovation process and its role in our changing economy and how they relate to policy decisions.

While innovation has always been a major force in the U.S. economy, its character and pace have changed dramatically. For example, experts contend that one-half the store of human knowledge has been produced just during the last 50 years. Also, today's automobile has more computing power than the Apollo 11 lunar landing module which put men on the moon. These developments are in part the consequences of firms pursuing profits within an increasingly competitive environment.

Successful firms continuously innovate. The goal of the firm's innovation process is to capture and maintain comparative competitive advantage. This goal is largely accomplished through an innovation process designed to acquire and create knowledge and transform that knowledge into business value — higher profits and owner equity.

The growing dependence between technological change and the public well-being causes one to consider the role of government and public policies in this economic process.

- Education policy: Economic growth comes from technologies, technologies come from knowledge, and knowledge comes from a well educated workforce.

- Research and Development: Much of technology and therefore economic growth comes from private expenditures on R&D. Public policies encouraging private R&D spending would increase economic growth.

- Venture capital: The amount of private funds available to be invested in relatively high risk business ventures has grown in recent years, filling a need in the financing of business innovation and growth. Government's "venture" role is in the area of seed investment.

- e-commerce: The Internet has great potential to empower individuals and impact global growth and standard of living. Policy stakes are very high.

- Innovation and the courts: Some compare the *U.S. vs Microsoft* antitrust suit to that of the breakup of AT&T. Major policy directions are forthcoming.

- Patents and intellectual property rights: The global market can be a great source of incentives for continued innovation if they can be effectively captured.

Contents

The Innovation Process, Economic Growth, and Public Policy[1]

In the Spring of 1999 the United States completed its eighth year of uninterrupted economic growth, the longest peacetime expansion in history. To what or whom do we owe this accomplishment? There are, of course, many contributors, but Alan Greenspan, Chairman of the Federal Reserve System, gives much of the credit to the enhancement of competition generated by the business innovation process and resultant new technologies. Greenspan contends that new technologies have helped to create a competitive business environment which has led to an expansion in business investment spending, increased labor and capital productivity, and low levels of inflation and interest rates.[2] Innovation, according to management expert Peter Drucker, ".... is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. ....Entrepreneurs need to search purposefully for the sources of innovation, the changes and their symptoms that indicate opportunities for successful innovation. And they need to know and to apply the principles of successful innovation."[3]

The primary goal of this paper is to describe the contemporary innovation process, its relationship to economic growth, and discuss related public policy issues, current and future. It is critical that policymakers understand the workings and nature of this so-called "new economy" and how rapidly innovation is changing it. After all, public policy prescriptions formulated on outdated views and myths of the economy are at best meaningless, likely wasteful, and perhaps counterproductive.

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[1]For excellent background on this topic, the reader is encouraged to read *Entrepreneurial High-Growth Companies: A Framework for Thinking About the Federal Policy Role,* Alan S. Gregerman, Visiting Scholar in Economic Growth and Entrepreneurship, Economics Division, Congressional Research Service, Library of Congress, June 19, 1998.

[2]Greenspan, Alan, "Testimony of Chairman Alan Greenspan Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate," Federal Reserve Board, Washington, D.C., February 23, 1999.

[3]Drucker, Peter, *Innovation and Entrepreneurship: Practice and Principles,* New York, NY: Harper and Row Publishers, 1985.

The Increasing Importance of Innovation to Today's Business Firm

In the mid-1970's financial writer Andrew Tobias speculated that the U.S. economy of the future would be dominated by fewer than 500 giant corporations.[4] This economic structure, according to Tobias, was the inevitable consequence of what he regarded to be one obvious truth: In the capitalistic system, competition is innovation and innovation is expensive, thus bigness is necessary. Tobias predicted that the"giant corporate sector would balloon" and the independent, small business sector would shrink. The small business would be but a nostalgic memory. To Tobias, the trends were obvious, this was to be the "new economy."

We know now of course that something quite different happened. Many large corporations have been splintered and downsized while coincidently new entrepreneurial startups are at record levels.[5] While job creation is not the objective of the entrepreneur — making a profit is — most of the 20 million new jobs generated during the past 15 years have come from smaller and newer companies.[6] It's become acceptable — although not unchallenged — to characterize today's U.S. economy as a "small business economy."[7] This phenomenon, many economists argue, is largely due to the explosion and pervasiveness of new technologies in the economy and available to entrepreneurs — the "electronic tonic." A relatively inexpensive computer with the appropriate business management and financial software can enable the most capital-disadvantaged and inexperienced business person to become an owner of a successful, growing, and valuable business enterprise. In addition, small companies can appear huge and cutting-edge on the world wide web (www). The "domain" of the small business today may not include a parking lot for customers or employees, or a building or even a street address, yet be visited everyday by hundreds of thousands of customers and be a major contributor to global economic commerce. These businesses for all intents and purposes exist and operate only in the virtual reality of the www. ebay, for example, one of the more successful publicly traded Web companies, employs one of the oldest means of commercial interaction, the auction. Yet the commerce that ebay is fostering is astonishing. ebay, having gone public only two years ago, is today the worlds largest on-line auction company offering 2 million auctions each day to its 2 million world-wide registered customers.

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[4]Case, John, "The Wonderland Economy," *Inc.* (1995), www.inc.com/incmagazine /archives.

[5]Kirchhoff, Bruce A., *Entrepreneurship and Dynamic Capitalism,* Westport, CT: Praeger, 1994.

[6]Office of Advocacy, "The Facts About Small Business," Small Business Administration, Washington, D.C., Revised September 1997.

[7]Birch, David L., *Hot Industries,* Boston: Cognetics, Inc., 1998; Hopkins, Michael, "Help Wanted," *Inc.* Magazine, *The State of Small Business—1997*, pp. 35-41. There is some disagreement on the nature of job creation in high-growth firms. See hall, C., "The entrepreneurial Engine," *OECD Workshop Paper*, June 16, 1995; Dennis, William J., "More Than You Think," *Journal of Business Venturing*, 12 (3) 1997, 175-196; Davis, Steven J., et. al., "Small Business and Job Creation," Cambridge, MA: *NBER Working Paper* #4492; and Kirchhoff, Bruce A., *Entrepreneurship and Dynamic Capitalism*, Westport, CT: Praeger, 1994, for various views on the issues.

On average, ebay records over 800,000 bids per day on its auctions. ebay is comparatively lightly capitalized and employs about 100 people. Is ebay a small or large company?

Some contend that there is an "even newer economy," where company size and "tech status" are irrelevant.[8] Number of employees, asset value, even annual sales are archaic, less useful measures of a company's true worth and influence in the industry. High-tech and low-tech can be misleading characterizations as well. A company using or producing the latest and highest technology is no guarantee of commercial success. According to the Small Business Administration, technology generation is not size-dependant as small companies (500 or fewer employees) produce 55 percent of all new technologies.[9] But said another way, large companies of which there are many fewer in number, produce 45 percent of all new technologies. In addition, users of new technologies can be as much high-tech as the producers of those new technologies. Wal-mart, for example, is a high-tech retailer. What determines a company's success is the company's profit potential and industry leadership.[10] Companies today are valued not so much by where they are, but where they're going and how fast will their innovation process get them there. And successful innovation processes can be found in all industries and sizes of companies. The current product of the firm and the innovation process embedded in the firm are far more determinative of a company's success than size and tech status, however measured.[11]

Successful innovation depends on the integration of many factors including management capabilities. Peter Drucker contends that technological change, innovation, and economic growth as we know them today would not have occurred without the development of management as a discipline and profession during the last 40 years. In fact, Drucker refers to management as the "new technology" which is rapidly converting the American economy into the entrepreneurial economy.[12]

No challenges are greater or more important to the rapid growth business firm today than the creation[13] and management[14] of its innovation process. This process has evolved from the traditional R&D function of the firm.[15] It is this process that defines

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[8]Browning, John, and Spencer Reiss, "So What is the New Economy?" *Wired magazine*, (1998), www.wired.com/wired/special/ene/part1

[9]Office of Advocacy, Ibid.

[10]Neff, Michael C. and William L. Shanklin, "Creative Destruction as a Market Strategy," *Research-Technology Management*, Industrial Research Institute, May-June 1997.

[11]Cusumano, Michael A. and Richard W. Selby, "How Microsoft Competes," *Research-Technology Management*, Industrial Research Institute, January-February 1996.

[12]Drucker, Peter, Op. Cit.

[13]Padmore, Tim, Hans Schuetze, and Hervey Gibson, "Modeling Systems of Innovation: An Enterprise-Centered View," *Research Policy*, No. 26, 1998.

[14]Roberts, Rhonda, "Managing Innovation: The Pursuit of Competitive Advantage and the Design of Innovation Intense Environments," *Research Policy*, No. 27, 1998.

[15]Meyersdorf, Doron, and Dov Dori, "System Modeling of the R&D Domain Through the

(continued...)

and determines the firm's economic pace and height "trajectory."[16] Business valuation has come down to essentially "how fast and how high."

The innovation process is first and foremost a systemized, creative, learning and application process. It's goal is to capture and maintain comparative competitive advantage for the company.[17] The firm largely accomplishes this goal through an innovation process which is designed to acquire and create knowledge and transform that knowledge into business value — higher profits and equity.[18] Throughout time the source of knowledge has traditionally been those people who desire to learn and to change, and who are alert, aware, open-minded, and are capable of capturing and interpreting vast quantities and diverse levels of knowledge and information.

Competition today comes from a culture of innovation, and creativity has become an important component to this culture.[19] John Kao of Harvard teaches creativity as the new applied and actionable managerial mindset.[20] Companies adopting this mindset create an inventive environment within the innovation process which stimulates ownership and employee creativity—they "jam" or play off of one another. A company's innovation process could well involve literally hundreds of people consciously and continuously sharing experiences and information and seeking and inventing together. Jamming often occurs inter-firm as well involving extensive networks within which employees foster and facilitate the interchange and flow of information and knowledge between firms while maintaining company rivalries.[21] Equally important, the innovation process of the successful company interacts with consumers and government and other businesses including suppliers, retailers, wholesalers, manufacturers, bankers, and others. It's not surprising that the clustering or co-habitating of these successful firms in relatively small geographic areas—Silicon

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[15](...continued)
Object-Process Methodology: A Practical Tool to Help R&D Satisfy its Customer Needs," *R&D Management,* No. 27, 1997.

[16]Brockhoff, Klaus, "Technology Management as Part of Strategic Planning — Some Empirical Results," *R&D Management*, No. 28, 1998.

[17]Nelson, R. R., (Ed.) *National Innovation Systems: A Comparative Analysis*, Oxford: Oxford University Press, 1993. See also "Co-evolution of Industry Structure, Technology and Supporting Institutions, and the Making of Comparative Advantage," *International Journal of the Economics of Business*, Vol.2, 1995; "Why do Firms Differ and Why Does it Matter?" *Strategic Management Journal*, No. 12, 1991; Nelson and S. G. Winter, *An Evolutionary Theory of Economic Change*, Cambridge, MA: Harvard University Press, 1982.

[18]Drake, Keith, "Firms, Knowledge and Competitiveness," *The OECD Observer,* No. 211, 1998.

[19]Hirshberg, Jerry, *The Creative Priority: Driving Innovation in the Real World,* New York, NY: Harperbusiness, 1998.

[20]Kao, John, *The Art and Discipline of Business Creativity*, New York, NY: Harper Business, May 1996.

[21]Porter, M., *The Competitive Advantage of Nations,* London: Macmillan, 1990.

Valley, Boston Route 128, for example—has contributed to the pace of innovation.[22] Idea generation in these environments is almost spontaneous. The highest-performance companies, however, have taken jamming yet one step further. These companies have learned to leverage information and knowledge technology through the global internet thus creating a gigantic brain which theoretically multiplies creative ability and potential many times over—an idea generation paradigm perhaps never before imagined.

The innovation process itself is evolving. Joe Costello, president and CEO of Cadence Design Systems Inc., hazards to speculate that organizational forms as Microsoft, et al, will soon become obsolete.[23] Mr. Costello contends that rapidly changing consumer needs and market forces can only be satisfied in a timely fashion by a "virtual corporation." Costello describes the ideal organization as follows: "I like to use the example of a structure that works in entertainment: the rock concert tour. It comes together for a short period of time, assembles the right expertise (regardless of the source) and hits the road. People focus on what they do best—sound, lighting, performing, marketing, logistics, etc.—and when it's over, they go their separate ways, usually with a healthy profit to show for it. The movie industry operates the same way." It's interesting to make the observation that Costello's organizational innovation is no-tech in the traditional sense, but rather pure management and entrepreneurship.

Today's economy isn't about small firm versus large firm, new versus old, high tech versus low tech, or services versus manufacturing. It's about what it has always been about, competition. But the rules and tools of competition have changed.[24] New products and innovations are quickly diffused and easily copied. The biggest firm can be toppled by the newest idea. Justifiably, today's company's owner needs to be as concerned about what's going on in America's garages as in America's executive suites. Competition in the "newer economy" is more about process than product; about innovativeness than innovation.[25] While grossly unappreciated at the time, J. A. Schumpeter, in 1944 described this competitive process best as "creative destruction."[26]

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[22]Baptista, Rui, and Peter Swan, "Do Firms in Clusters Innovate More?", *Research Policy*, No. 27, 1998. For a disagreement see Pouder and St. John, "Hot Spots and Blind Spots: Geographical Clusters of Firms and Innovation," *Academy of Management Review*, Vol. 21, 1996.

[23]Costello, Joe, "The Golden Age of Change," *Upside*, November 1997.

[24]Barnholt, Edward W., "Fostering Business Growth with Breakthrough Innovation," *Research-Technology Management*, Industrial Research Institute, May-June 1996.

[25]Buckler, Sheldon A., "The Spiritual Nature of Innovation," *Research-Technology Management*, Industrial Research Institute, May-June 1996.

[26]Schumpeter, J. A., *Capitalism, Socialism, and Democracy*, London: George Allen and Unmin, 1944.

The Increasing Role of Innovation in National Economic Growth

The growth of the American economy has become increasingly dependent upon innovation and improved technologies.[27] Real Gross Domestic Product has increased a little over $1 trillion during the last five years and, depending on the source, any where from one-third (Landau) to 80 percent (Solow) of this growth can be attributed to the innovation process and resultant technological change, roughly between $70 billion and $165 billion on average per year.[28] Many experts believe that technological progress is responsible for up to one-half the growth of the U.S. economy.[29] Being "technological" is seen as knowledge-fostered growth, as opposed to growth attributable to merely adding more labor, capital, and/or natural resources to the economy. In addition to creating new and different goods and services, technological knowledge is society's understanding of the best ways to produce goods and services.[30]

New technologies associated with information and knowledge are also credited as being key reasons for the structural shift from manufacturing to services in the U.S. economy: From 1959 to 1994, the service sector grew from 49 percent to 62 percent of Gross Domestic Product (GDP), while manufacturing declined from 28 percent to 17 percent.[31] The expansion of the service sector, according to the National Science Foundation, has been driven largely by industries that are often classified as "knowledge" industries.[32] Alan Greenspan, Chairman of the Federal Reserve System has noted that America's total output, measured in tons, is little more than it was 100 years ago—despite a twenty-fold increase in real GDP value.[33]

The monetary policies of the Federal Reserve System under the leadership of Chairman Alan Greenspan, have been given much of the credit for the current historic

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[27]Depending on how "technology" and "capital" are defined. See: Fuhrer, J. C., and Jane Sheddon Little, "Technology and Growth: An Overview," *New England Economic Review,* Nov. -Dec. 1996.

[28]Landau, Ralph, "Technology, Economics, and Public Policy," in *Technology and Economic Policy,* Ralph Landau and Dale Jorgenson, editors, Cambridge, MA.: Ballinger, 1986. See also, Robert Solow, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics,* August 1957; "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics,* February 1956; "Growth Theory and After," *American Economic Review,* June 1988.

[29]Schacht, Wendy H., "Industrial Competitiveness and Technological Advancement: Debate Over Government Policy," *CRS Issue Brief,* Congressional Research Service, Library of Congress, Washington, D.C., Updated December 5, 1997.

[30]Mankiw, N. Gregory, *Principles of Macroeconomics,* Fort Worth, TX: The Dryden Press, 1998.

[31]National Science Board, *Science and Engineering Indicators - 1998,* Arlington, Va.,: National Science Foundation, 1998.

[32]Ibid, p. 8-8.

[33]"The World Economy Survey," *The Economist,* Sept. 1996.

economic expansion.[34] Greenspan himself, in remarks before the U.S. Senate Committee on Banking, Housing, and Urban Affairs, however, gives credit to fiscal policies which have contributed to the budget surplus by continuing to constrain federal spending and to public policies fostering open and competitive global markets.[35] In his concluding comments to the Committee, Dr. Greenspan noted that "The availability of new technology to each company and its rivals affords both the opportunity and the competitive necessity of taking steps to boost productivity" and that "Competitive markets . . . have kept our production efficient and on the expanding frontier of technological innovation. The determination of Americans to improve their skills and knowledge has allowed workers to be even more productive, elevating their real earnings."[36]

Could this economic expansion go on forever? Paul Romer of Stanford University is a prominent proponent of a new growth theory which portrays the U.S. economy as virtually limitless.[37] This theory of "endogenous growth" contends that today's economy is most accurately characterized as being knowledge or idea-driven and not defined or constrained by scarcity in the resources of labor, land, and capital. Rather, endogenous growth theory argues that the economy will continue to grow as long as the economic system provides sufficient incentives to it's people to acquire knowledge and generate and exploit ideas, innovations, and technologies.[38] Such incentives include real profits and take-home wages and salaries.

At the core of the innovation process and technological change is information and it's application, knowledge. Depending perhaps on one's professional perspective, the age in which we live is called either the "information society" or the "knowledge economy." Whatever term may be most accurate, the way American's live and work today is decidedly different than the way we functioned a mere generation earlier, and the magnitude and pace of this change is getting nothing but greater and faster. By one estimate, more than one-half the store of human knowledge has been produced over the past 50 years; more than one-half of U.S. patents have been issued in the last 40 years; and the number of new products, services, and innovations put on the market annually has tripled compared to 20 years ago.[39] Today's automobile has more computing power than the lunar landing module of the Apollo 11 mission that put

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[34]Crutsinger, Martin, "Greenspan: Economy Remains Robust," Associated Press, February 23, 1999.

[35]Greenspan, Alan, "Testimony of Chairman Alan Greenspan Before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate," Federal Reserve Board, February 23, 1999.

[36]Op. Cit., p.8

[37]Romer, Paul. M., "The Origins of Endogenous Growth," *The Journal of Economic Perspectives,* Winter 1994.

[38]Kelly, Kevin, "The Economics of Ideas," *Wired Magazine,* www.wired.com/wired/4.06/features/romer, June 1996.

[39]Cox, W. Michael, and Richard Alm, "How Free Markets Can Unleash Technology," *Consumer's Research Magazine,* July 1997.

man on the moon[40]. The rate of innovation diffusion or adoption by the consuming public has also quickened. For example, while it took 35 years to get the telephone into one-quarter of American's homes, the personal computer requiring much more sophisticated skills, has accomplished that objective in but 16 years. As technology builds on itself, the pace of innovation in the future will likely accelerate.

The Innovation Process: Current Policy and Policy Issues

The interest of the public in the innovation process and technological change is clear. Innovation is instrumental in determining the level of economic output and growth, and the nation's standard of living. The nation looks to innovation to create new jobs, higher incomes, investment opportunities, better entertainment, to solve problems, protect us against our enemies, cure diseases, establish global leadership and pride, among other expectations. Americans have grown to expect the best from their economic system and are not comfortable coming in second, especially in the contest of world commerce. Paul Romer has stated the situation very concisely: "Doesn't the key to economic success lie in a nation's ability to introduce valuable new goods, to improve the quality of existing goods, and to find more efficient ways to manufacture and deliver these goods?....the most important job for economic policy is to create an institutional environment that supports technological change."[41] Peter Drucker believes that underlying successful innovation ". . . is the need for a massive reorientation in policies and attitudes, and above all, in priorities. We need to encourage habits of flexibility, of continuous learning, and of acceptance of change as normal and as opportunity—for institutions as well as individuals."[42]

For all intents and purposes, the federal government has no formalized, coordinated public policy relative to innovation or technology. Yet the stimulative effect of technology and innovation has long been recognized and appreciated by the federal government. Efforts by the federal government, while well intentioned, have led to an innovation policy that is ad hoc, uncoordinated, and lacking political consensus. According to Schacht "Despite the importance of technology to the economy, technology-related considerations often have not been integrated into economic decisions.[43] This is not to say that the lack of a planned, coordinated, and bipartisan public innovation policy has been detrimental. After all, the lack of a policy can be seen as a policy. However, in response to the promise of technology, the federal government over the years has developed a variety of initiatives largely focused on how to augment private sector innovation and technological development.[44]

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[40]*Ibid.*

[41]Romer, Paul M., "Beyond Classical and Keynesian Macroeconomics," *Policy Options*, July-August 1994.

[42]Drucker, Peter, Op Cit.

[43]Schacht, Wendy H., Op. Cit.

[44]Schacht, Wendy H., Op. Cit.

The public sector does have and likely will continue to have an impact on the innovation process, whether by design and intent or not. After all, an important function of government is to help create and preserve an economic, social, and political climate and environment that fosters change and tolerates risk. A number of possible policy/regulatory/legal interventions are identified and discussed below. These interventions are analyzed relative to their import and influence on the innovation process.

Education and the Innovation Process[45]

The connection and relationship between education and the innovation process may be described as follows: Economic growth and standard of living comes, in part, from technology; technology, in turn, comes from innovation; innovation is fostered by knowledge; and at the source of much knowledge is education. An innovation-driven economy is a "knowledge economy."

Public education programs impact America's economy and society in countless ways. A well educated citizenry is more knowledgeable, smarter, curious, innovative, creative and better able to identify and successfully pursue opportunities. They can contribute to economic growth and productivity by adding value to the lives of their neighbors while enriching their own. Education reduces the fear of change and diversity and leads to more choices and better public and individual decisions. Clearly if the U.S. is to effectively compete on the world stage in the 21st century, U.S. innovation and educational policies must be mutually supportive.

As the knowledge economy will bring continuous change and disruption in lives, education policies, among other objectives, could help students and the general public understand and appreciate the workings of the free market system and the methods and consequences of competition and promote life-long learning as a life style. In addition, the knowledge economy will reward those workers who have mastered math, engineering, and science skills. Skills associated with starting and owning a business—entrepreneurship—may be valuable as well. Idea generation may be a critical step in the innovation process suggesting the desirability to integrate creativity and change and opportunity awareness and evaluation into curricula.

Perhaps the most important role for education to play in the knowledge economy, however, is to maximize its effectiveness and outreach to the presently educationally disadvantaged. While almost 25 percent of the white population completed 4 years of college or more in 1997, this educational attainment level was achieved by only 13 percent of Blacks and 10 percent of Hispanics.[46] The national economy will become increasingly dependent upon minority groups as Blacks plus Hispanics as a percentage of the total U.S. population is projected to increase from

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[45]For a more comprehensive treatment of this subject, see Robert J. Tosterud, *The Knowledge Economy and Education Reform,* Congressional Research Service, The Library of Congress, Washington, D.C., forthcoming.

[46]U.S. Bureau of the Census, *U.S. Census of Population, U.S. Summary,* PC80-1-C1.

24 percent in 1999 to 28 percent in 2010.[47] The future of the innovation process and economic prosperity is directly tied to continuous education improvement.

Research and Development and the Innovation Process

Research and development is an important ingredient in the innovation process. In 1994 the National Science Foundation (NSF) and the Bureau of the Census conducted a survey of 1000 U.S. firms for the purpose of gathering information about the innovation activities of firms, the innovation process, and the factors that affect that process.[48] Certain industries were identified as particularly innovative: Computer hardware manufacturing, precision instruments and equipment, pharmaceuticals, and chemicals, for example. The survey found that 97 percent of the companies surveyed in these innovative industries planned to introduce soon new innovative products and /or processes. Over 90 percent of these same firms currently performed R&D and had plans to continue their efforts in research and development in the future. According to the survey, firms perform R&D to improve product quality, to maintain market share, and to have a lead time advantage over competitors. Also, communication with other companies was identified as the most often used method of inter-company innovation diffusion.

Given the importance of innovation to competition, its not surprising to learn of the growing commitment of the U.S. to research and development.[49] In another study, the National Science Foundation found that since 1980 total expenditures by all sources, private, public, and non-profit, have increased by almost 75 percent in real dollar terms, from $104.5 billion to $182.2 billion in 1997.[50] Real private expenditures by private industry during this same period, however, have increased at even a faster pace, growing 129 percent, from $50.5 billion to $115.7 billion. Total R&D expenditures as a percent of GDP has risen from 2.3 percent in 1980 to 2.6 percent in 1997. Industry now accounts for almost 64 percent of total national R&D expenditures, compared to a 48 percent share in 1980. Industry has also greatly expanded its participation in a variety of domestic and international R&D partnerships.[51]

Lending credence to the contention that innovation is not firm size dependent, the NSF survey found that relatively small businesses (employment below 500 employees) dramatically increased their R&D expenditures from $5.9 billion in 1985 to $16.7 billion in 1995 a 183 percent jump in ten years. Small business's share of

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[47]www.census.gov/population/projections/nation/

[48]Rausch, Lawrence, "R&D Continues to be an Important Part of the Innovation Process," *Data Brief,* Science Resources Studies Division, National Science Foundation, Washington, D.C., August 7, 1996.

[49]Menke, Michael M., "Managing R&D for Competitive Advantage," *Research-Technology Management*, Industrial Research Institute, November-December 1997.

[50]National Science Board, *Science & Engineering Indicators -1998.* Arlington, VA: National Science Foundation, 1998.

[51]Jankowski, John E., "R&D: Foundations for Innovation," *Research-Technology Management*, Industrial Research Institute, March-April 1998.

total industry R&D expenditures during this same period increased from 7 percent to 13 percent. Also, inventing and "tinkering" is an American tradition and favorite pastime and so it's anybody's guess as to how much informal or "recreational" R&D is performed in the sheds, basements, and garages across the nation, and therefore "off the books."In addition, while small businesses received only 4 percent of Federal R&D dollars, they accounted for 38 percent of all patents granted in 1994.[52] Small businesses are important contributors to the nation's research and development efforts and therefore technological change and economic growth.

As indicated earlier, government's role in research and development both as a performer and a funder has changed during this period. Twenty years ago, in 1977, the federal government either directly performed or funded 51 percent of all U.S. R&D. Preliminary data for 1997 shows the federal government's share dropping to 31 percent. This decline in the federal government's share of total R&D spending is largely due to reductions in defense-related R&D spending. Industry's share of total national R&D expenditures since 1977 has climbed from 45 percent to almost 64 percent. Universities and colleges directly fund almost $4 billion of R&D activity. There is little reason to believe that these trends will reverse.[53] That is, the federal government's share of R&D will likely continue to decline in relative terms while that of the private sector will continue to increase. In fact, since achieving its peak in 1987, real federal expenditures in R&D have actually declined from $70.1 billion to $55.6 billion.

Kenneth M. Brown in his book *Downsizing Science* cautions that we should not take too much comfort in the healthy state and the growing dominance of private sector R&D.[54] This research and development, Brown points out, is highly targeted to product lines and done strictly for profit. In addition, private companies want to "own" and control the products of research. Conversely, public research and development is directed to national needs and usually has a wider application and limited appropriability. As the federal governments' commitment to R&D has declined in real terms during the last decade, we can reasonably assume some science, innovation, and technology development has not occurred. The consequence to the U.S., according to Brown, is probably a permanently depleted science infrastructure with serious long term costs and ".... a picture of diminished excellence, with increasingly evident traces of mediocrity."[55]

The substantial and continuously increasing dollar commitment to research and development activities by the business community is a good indicator that these activities are perceived as a good investment. As a general proposition, one can

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[52]Bibbens, Terry, "Industry Maximizing Innovation Through Government and Industrial Partnerships," Office of Advocacy, Small Business Administration, November 1997.

[53]Davey, Michael E., "Research and Development Funding: Fiscal Year 1998," *CRS Issue Brief,* Congressional Research Service, Library of Congress, Washington, D.C., Updated March 22, 1999.

[54]Brown, Kenneth M., *Downsizing Science, Will the United States Pay a Price?,* Washington, D.C.: The AEI Press, 1998.

[55]Ibid, p.127

expect more innovations, technological change, and improved economic growth, the greater the outlays by the private sector of their funds for R&D endeavors. Policies designed to encourage private sector research and development efforts would be beneficial to the public interest.[56] Whether this same logic and conclusion extends to R&D performed by the public sector remains an open issue.

Venture Capital and the Innovation Process

Another important attribute of the "new economy" and to the innovation process in particular, is the birth and growth of the venture capital industry.[57] Virtually non-existent until the early 1980's, private risk capital available from venture capital firms has become an important source of company financing, especially for funding innovations and growth in "higher tech" industries. As a general rule, venture capitalists are seeking relatively large returns on their investments and an active role in the management of the borrowing company.[58] According to the National Science Foundation survey, by 1995 over $37 billion of venture capital was under management. Also in 1995, venture capital firms disbursed a total of almost $4 billion. Following this money provides some interesting insights into the priorities and direction of this new economy:[59]

U.S. venture capital disbursements by industry, 1995:

Software and services	$ 760M (20%)
Medical/Health care related	$ 547M (14%)
Consumer related	$ 405M (11%)
Telephone and data communications	$ 399M (10%)
Biotechnology	$ 205M (5%)
Commercial communications	$ 191M (5%)
Computer hardware and systems	$ 183M (5%)
Other electronics	$ 141M (4%)
Industrial products and machinery	$ 125M (3%)
Industrial automation	$ 26M (<1%)
Energy related	$ 3M (<1%)
Other products and services	$ 874M (23%)
TOTAL	$3,859M

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[56]Cox, William A., "Tax Preferences for Research and Experimentation: Are Changes Needed?", *CRS Report for Congress,* Congressional Research Service, Library of Congress, Washington, D.C., August 4, 1995.

[57]See, for example, National Venture Capital Association, www.nvca.com/policy; and American Entrepreneurs for Economic Growth, www.aeeg.org

[58]Gravelle, Jane G., *Capital Gains Taxes, Innovation and Growth,* Congressional Research Service, Library of Congress, Washington, D.C., January 28, 1999.

[59]Gruner, Stephanie, "The Trouble With Angels," *Inc.*, www.inc.com/ ncmagazine/archieves

Contrary to popular belief, venture capital firms have a minor interest in seed and business startup investments.[60] [61] Fifty-seven percent of venture capital funds in 1995, in fact, were devoted to "other early stage" financing and helping existing businesses expand. This so-called "professional" risk money is attracted to these companies generally because they have a near-proven innovation process and are now in need of growth capital. U.S. venture capital disbursements by stage in 1995 were as follows:

Seed	$ 232M (6%)
Startup	$ 663M (17%)
Other early stage	$ 580M (15%)
Expansion	$1,614M (42%)
Leveraged buyout/acquisition	$ 338M (9%)
Other	$ 442M (11%)
TOTAL	$3,859M

In a sense, the federal government performs as a venture capitalist. The federal government has played an active and direct role in providing financial assistance to startup companies for decades.[62] The promotion of small business has been a major policy goal for decades, and for many reasons, including their contributions to the achievement of national interests and goals. Federal small business assistance programs often targeted aid toward firms in technology-intensive industries. War, the threat of war, and the space race were great stimulants to government involvement.

Today the federal government sponsors a number of direct financial aid programs, some of which require matching private-sector dollars. The objectives of these programs are clearly different, however, from earlier endeavors. For example, the stated objective of the Small Business Innovation Research (SBIR) Program, in addition to satisfying agency mission needs, is "to increase government funding of work with commercialization potential in the small, high technology company sector."[63] The SBIR program is founded on the following set of beliefs: 1) small firms are particularly innovative, 2) innovation is essential to the economic well-being of the United States, 3) that the private sector provides insufficient capital to new product development, and 4) that the government can identify firms where investments will ultimately yield high social and/or private returns. The SBIR program requires federal

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[60]Vesper, Karl, *New Venture Mechanics,* Englewood Cliffs, NJ: Prentice Hall, 1993.

[61]The *1992 Economic Census, Characteristics of Business Owners,* U.S. Census Bureau, shows that of those business owners responding, more than 76 percent reported that no borrowed capital was required to start their business. Virtually all borrowed funds came from "friendly" sources, particularly family and acquaintances.

[62]Buss, Terry, *New Entrepreneurial High-Growth Companies: Is There a Capital Gap Warranting Federal Action?,* Congressional Research Service, The Library of Congress, Washington, D.C., February 26, 1999.

[63]Schacht, Wendy H., "Manufacturing, Technology, and Competitiveness," *CRS Issue Brief,* Congressional Research Service, Library of Congress: Washington, D.C., Updated January 12, 1999. Also see: "Small Business Innovation Research Program," *CRS Issue Brief,* Congressional Research Service, Library of Congress: Washington, D.C., Updated September 11, 1998.

agencies to set aside a certain percentage of their R&D budget for small high-tech firms. There are a number of other similarly situated and justified federal programs including the Small Business Development Centers Program, the Advanced Technology Program, the Small Business Technology Transfer Program, and the Venture Capital Fund Guarantee Program.[64] These programs which involve targeted direct federal spending for product development, as opposed to funding of basic research and development, are not without their critics.[65] It can be argued that these programs are but veiled attempts at piecemeal industrial planning and the federal government trying to choose technology "winners and losers." Detractors also argue that company's successful in getting federal grants may simply reduce proportionately their own R&D spending.[66]

e-Commerce and the Innovation Process

If an economy can be defined as commercial interaction, then the Internet is becoming central to the new economy. A novelty just a few years ago, government statistics now show that traffic on the Internet doubles every 100 days, and that 8.2 percent of the U.S. economy is devoted to Internet technology.[67] Today more than 2.6 million "virtual" businesses operate online and have access to over 90 million world wide web users, with an estimated 30 percent being shoppers.[68] Perhaps as many as 50 million people will be shoppers on the Internet by the turn of the century. No wonder advertizing expenditures on the net now approach $2 billion per year. Several businesses born and raised in cyberspace have gone the initial public offering (IPO) route and are now publically traded. The magazine *Industry Standard* estimated U.S. Internet commerce at $2.3 billion for just the month of May, 1998.[69] Andrew Wyckoff of the Organization for Economic Cooperation and Development (OECD) predicted that e-commerce revenues world-wide could reach $1 trillion by 2003, eighty percent of which will be business-to-business, as opposed to business-to-consumer, commerce. Also, the OECD official estimates that 80 percent of these sales will transpire in the United States — $800 billion worth.[70] Wyckoff calls his a "sober" view of the ability of e-commerce to transform the world's economy.

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[64]Lerner, Josh, "The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program," NBER Working Paper, National Bureau of Economic Research, Canbridge, MA., September 1996.

[65]Tibbets, Roland, "An Analysis of the Distribution of SBIR Awards by State," Office of Advocacy, Small Business Administration, Washington, D.C., February 1998.

[66]Lerner, Josh, Op Cit.

[67]See Business Software Association, www.bsa.org/statistics/intro-c.

[68]"A Closer Look at Small Business Online Sales," *Industry Standard*, May 1998, See www.thestandard.net/metrics/display/0.

[69]"Global Web Commerce Up 205 Percent," *Industry Standard*, September 1998, See www.thestandard.net/metrics/display/0.

[70]Essick, Kristi, "E-Commerce Will Play Small Part in Global Economy, Report Says," *Industry Standard*, September 1998. See www.the standard.net/mettrics/display/0.

The Internet has created a new market and competitive environment which has had a profound effect on the process of innovation. It's difficult to conceive of an effective innovation process that doesn't have the Internet as an integral component. The Internet as a communication devise, has facilitated literally millions of people to interact with each other on a continuous and largely unregulated basis. The depth and breadth of this global "conversation" has not only brought down geographic, business and economic barriers, but political, racial, and cultural barriers as well. The diffusion of knowledge, facts, and ideas, as well as opinion, rumor, and propaganda is accomplished literally at the speed of light. The resources at one's fingertips make problem solving and knowledge sharing and gathering less onerous, if not a pleasure. The Internet has also helped many markets to become much more competitive and efficient. Economic and business opportunities are both more easily identified and created. The Entry into even a global market is accomplished simply by registering a "domain" address and designing a home page. Modifying the business or closing the business is just as easily accomplished, dramatically lowering the cost of misjudgements. A desk top can become a world trade center. The Internet or "virtual" business is more dependent upon mental than physical facilities and abilities.

The Internet is comparable to the wheel with respect to it's potential to empower individuals and impact global growth and standard of living. Y2K aside, the technology also has the potential to do great harm and foster international conflicts. Pornography and industrial and military secrets are as easily transmitted as recipes and baby pictures. Some degree of government regulation of the Internet is likely inevitable. The challenge to government is to design regulations including taxation policies that accomplish legitimate public objectives while minimizing impediments to the growth of e-commerce.

Regulation, the Courts, and the Innovation Process.

One innovative company finds itself locked in battle over antitrust law and policy in *U.S. vs. Microsoft*.[71] Some consider this antitrust showdown as significant as the cases leading to the breakup of Standard Oil and AT&T.[72] The issues underlying the case with respect to its potential impact on innovation are very complex, but essentially come down to these: 1) Does Microsoft have an effective monopoly in personal computer operating systems and can it therefore raise barriers to entry in the industry, or constrain innovation while providing inferior products?; 2) Has Microsoft leveraged it's leadership in the PC software industry to gain an innovation-stifling monopoly in another technology, specifically browsers (via "bundling")?; Or 3) is antitrust law being used by unsuccessful and disgruntled competitors to politically harass and disable Microsoft's innovation process?[73]

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[71]For an overview of this case see Christopher J. Sroka, *The Microsoft Case: An Economic Analysis of the Issues,* Congressional Research Service, The Library of Congress, Washington, D.C., August 24, 1998; also see "Findlaw: Legal Subjects: Antitrust and Trade Regulation: Microsoft," www.findlaw.com.

[72]"Is Microsoft a Menance?", *Reason Online*, www.reason.com/bimicrosoft.

[73]Check, Dan, "The Case Against Microsoft," www.ourworld.compuserve.com

Microsoft contends that integrating it's Internet Explorer browser into Windows is entirely consistent with it's innovative process and competitive policy of continuously enhancing it's product and is not only legal but critical to maintaining it's competitive position in the market. Microsoft's detractors, including the Department of Justice, argue that Microsoft is abusing it's market dominance to the detriment of competitors, consumer interests, and long run innovativeness and technological progress.

The implications of this case for the innovation process and therefore economic growth are extremely important. First, innovation and technological progress bring change and change creates winners and losers. Businesses are born and new jobs are created. Businesses go bankrupt and people lose their jobs. In a very real sense, the free enterprise system is both a creative and a destructive process. Understandably, "losers" will pressure government to intervene in their behalf to influence and alter economic outcomes. Such interventions are difficult to limit and may permanently change the course of innovation and economic growth. On the other hand, monopolists may well find it in their interest to limit innovation. In any event, it's important to recognize and appreciate the central role that profits perform in innovation, technological change and economic growth. At the heart of economic growth and an improved national standard of living, is personal self-interest seeking and economic incentives. A most basic principle of economics is that people respond to incentives in predictable ways—the opportunity for personal gain. As a general proposition, the greater the "take-home" profits, the more and greater the innovations and the higher the nation's standard of living. Said another way, economic growth is compromised when the government intervenes to artificially limit the ability of innovators to fully exploit an innovation, absent monopolistic behavior.

Regardless of the outcome of the Microsoft case, the central question is whether antitrust laws may need to be overhauled in light of rapidly evolving industry structures being brought about by innovation and technological change.[74] A related question is whether a company can be too innovative for the national interest.

In addition to legal proceedings, the federal government influences business decisions and profitability through regulations. The Bureau of the Census reported in its *1992 Economic Census of Characteristics of Business Owners* that only 3.5 percent of business owners surveyed felt that the regulations associated with The Americans with Disabilities Act had a major or even minor impact on company profits.[75] Low negative impacts were also recorded for federal environmental regulations (10.9 percent) and the Occupational and Safety and Health Act (OSHA) (7.9 percent). Only 16.4 percent of business owners expressed the opinion that Internal Revenue Service regulations and penalties had a negative impact on their profits.

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[74]Knautz, Robert, "Target: Microsoft. Antitrust and Free Competition," *Policy Spotlight*, August-September 1998.

[75]Bureau of the Census, *1992 Economic Census, Characteristics of Business Owners,* U.S. Department of Commerce, Washington, D.C., September 1997.

Another point related to business law and public regulation needs to be raised. Much of innovation and technological change comes from new company startups, and new business venture creations are at record levels. But it is important to understand that typically entrepreneurs try two or three times before things "click" and fall into place. Failure is a cruel but very effective teacher. Evidence suggests that the incentive structure encouraging business startups appears to be healthy and bankruptcy laws entrepreneurially friendly. Policies, regulations, and laws, however, should be monitored and evaluated with respect to their impact on new business creations.

Patents, Intellectual Property Rights, and the Innovation Process[76]

The purpose of a patent is to advance ideas and new products, processes and technologies by giving people incentives to come up with new ones and at the same time requiring that the new idea, product, process, or technology be added to the knowledge base. In return for disclosing and sharing the idea, it's originator is given a monopoly on its use for a specified period of time. Hopefully, it is during this time that the inventor can recapture research and development costs associated with the creation of the new idea plus earn a profit, which is the incentive for the development of the innovation. The importance of innovation and technology in today's economy has drawn renewed interest in the issues surrounding patents and copyrights. Some of this interest is focused on the question of global proprietary rights with respect to intellectual property. It is contended that the right to reap the rewards of knowledge and innovation discovery and creation must be protected if more is to be forthcoming, and is therefore central to the innovation process, technological development, and economic growth.

While the magnitude of the impact could be challenged, according to the Business Software Association (BSA), the software industry alone lost more than $11.2 billion in 1996 due to international patent piracy. BSA estimated that this piracy resulted in the loss of 130,000 jobs and $1 billion in tax revenues in the U.S. during that one year.[77] While the U.S. federal government has taken a leadership role in policy development in this arena, economic globalization complicates the issue greatly. The countries of the world are a long way from having a "harmonious" policy on intellectual property rights.

The profit potential of sales in the international market offers great incentive to American businesses. The size of this incentive could provide substantial stimulus to innovation development and technological growth. But economic globalization also presents a challenge to federal policy as there is presently little to prevent many foreign businesses and even governments from pirating innovations. Violations of patent and intellectual property rights are common. Unauthorized reproductions and cloning of products by foreign manufacturers are expected. This inability of

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[76]Background on this topic may be found in Schacht, Wendy, *Patents and Innovation: Issues in Patent Reform*, CRS Report 97-599 SPR, and *R&D Partnerships and Intellectual Property: Implications for U.S. Policy*, CRS Report 98-862 STM.

[77]www.bsa.org/statistics/intro

entrepreneurs — regardless of nationality — to capture the full benefit associated with their innovative effort, in the long run cheats the world.

Democracy and the Economy: A Reminder

America's standard of living and quality of life are tied directly to its free enterprise system and America's free enterprise system, in turn, is wholly reliant upon it's political traditions and institutions.[78] Any analysis or explanation of America's economic and innovation prowess and success must give recognition and credit to America's democratic foundations of justice and freedom.

At the core of our economic system are incentives. Within legal constraints, citizens must be free to acquire and dispose of property to their personal advantage. Justice and freedom links personal gain to personal effort. One must be able to profit from initiative. Equally important, in their selfish pursuit of profit, enterprising people create many "externalities," among them businesses, jobs, income, wealth, saving, investment, taxes, not to mention new and better products and services. These externalities are the essence of economic and productivity growth and ultimately an improved standard of living for the nation.

Indeed, the origins of today's dynamic American capitalism and the nation's standard of living are directly traceable to the political formation of the United States itself. In fact, one cannot fully understand and appreciate the success and global dominance of the economic institution of the free market system of the 21st century without understanding and appreciating the institution of democracy as formulated in America in the late 18th century. Contemporary efforts to replicate by transfer and imposition American capitalism and the free market in other parts of the world void of foundational democratic institutions—such as a legal and justice system which, among other things, protects individual property rights—have proven less than successful.[79] Traditional communist countries cannot achieve a successful economic transition let alone obtain economic prosperity by leapfrogging or assuming away such democratic institutions as individual freedom and the pursuit of self-interest.[80] Simply put, America's success as an economy is entirely attributable to her political heritage. In every sense of the term, America is a political economy.

Summary and Conclusions

While innovation has always been a major force in the U.S. economy, its character and pace has changed dramatically in recent years. Such notables as Alan

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[78]Hall, Robert E., and Charles I. Jones, "Why Do Some Countries Produce So Much More Output Per Worker Than Others?", *The Quarterly Journal of Economics*, February 1999.

[79]Gray, Cheryl W., "Reforming Legal Systems in Developing and Transition Countries," *Finance and Development*, International Monetary Fund, September 1997.

[80]Camdessus, Michel, *Russia and the IMF: Meeting the Challenges of an Emerging Market and Transition Economy*, address before the U.S.-Russia Business Council, Washington, D.C., April 1, 1998.

Greenspan, Chairman of the Federal Reserve System, now see innovation and technological change as the primary "driver" of economic growth and prosperity. New technologies arising from innovation processes are given credit not only for gains in efficiency and productivity, but also as a primary force in controlling inflation and increasing real wages.

Business success in today's economy has little to do with tradition, heritage, allegiances, or even yesterday's accomplishments. Company size, location, experience, alliances, can be of only momentary importance and relevance. Industry "leadership" and "state-of-the-art" are but transient phenomena in many industries and rapidly becoming less meaningful concepts. Rather, successful companies today are often consciously and continuously seeking new and better ways to compete. They have little choice as competitive advantages are fleeting. What typically determines many companies' success today is their potential for competitive sustainability, and competitive sustainability comes from the company's talent at generating new products and technologies. That talent is housed in the company's innovation process. The success of an innovation process is not measured by what a company knows, but rather how fast the company can learn something new.

At the macro level, America's standard of living and quality of life have become increasingly dependent upon these company innovation processes. New technologies such as the laser, fiber optics, satellites, and ever improving computer capabilities, have enlarged the employment, consuming, and investment opportunities for all Americans. In addition, these processes as wombs of technological change are transforming not only the U.S. but also the world economy. People living in the most remote areas of the world can become important contributors—including as consumers and competitors—in global commerce via satellite and the Internet.

By any measurement, innovation and technological change are having profound impacts on our daily lives. In recent years it has become the source of much of our nation's economic growth and improvement in our standard of living. The consequences and pace of this change have also brought a degree of turmoil and instability. As technology has a way of growing on itself, the breadth and intensity of this turmoil and instability will likely only increase. Given this growing dependency between technology and the public well-being, it's important to consider the role of government in this economic process.

Clearly, the growing role of innovation in the U.S. economy presents interesting and important challenges to policymaking.[81] A key challenge is for policymakers to understand the workings and nature of innovation and how it is changing the economy. This enhanced understanding could lead to public policy, regulatory, and legal prescriptions which will facilitate innovation and citizen well being. There are also those who argue that the slow and deliberate pace of policymaking is frequently unable to cope with the rapidity of technological change, or argue that the wisest public policy is to leave well enough alone.

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[81]Slaughter, Michie P., "Entrepreneurship: Economic Impact and Public Policy Implications," Center for Entrepreneurial Leadership, Ewing Marion Kauffman Foundation, prepared for the Library of Congress, Congressional Research Service, March 1996.

In any event, most would argue that it is an appropriate government role to help to create and preserve an economic, social and political climate and environment that fosters innovation and tolerates risk. Public policies related to education, research and development, venture capital investments, e-commerce, business regulation and law, and patents and intellectual property rights are believed to be particularly influential to a healthy and growing private sector innovation process. As with most public policies, innovation policy—formal or informal, stated or implied—will evolve over time.