Let A Hundred Flowers Bloom! Decentralization and Innovation

BY LEONARD NAKAMURA

Which is more likely to encourage creativity and innovation: a centralized or a decentralized system of support? Should large organizations and recognized experts determine which parties get funding for their ideas? Or should small businesses, patrons, and foundations provide the primary support for innovation? Leonard Nakamura looks at the case for both sides using economic analysis, empirical studies, and anecdotal evidence. He also describes the role rivalry plays in innovation.

Michael Tomasello, co-director of the Max Planck Institute for Evolutionary Anthropology, has argued that what separates humans from chimpanzees and other nonhuman primates is their ability to maintain and build upon innovations — teaching children and peers the best ways to act and think. It can be argued that the cumulation of knowledge is not just the most important source of economic growth but also the most important factor in the flowering of human civilization and the dominance of our species on the planet.

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Given the importance of knowledge, how should we organize its advance? Should innovation be centralized, with recognized experts determining which parties get funding to develop their ideas?[1] Or should innovation be decentralized, with small groups and individuals — small businesses, patrons, incubators, and foundations — supporting a lot of innovation? And to what extent can we rely on the market system to facilitate developing and disseminating new ideas and cultural products?

Of course, scientific, intellectual, and cultural genius does not appear simply because institutions are favorable. Innovation can occur when existing institutions are neglectful of it and even when they actively oppose it. But creativity is more likely to flourish and have its fruits more widely disseminated when it is recognized and supported. After all, artists, scientists, and scholars need offices, laboratories, and studios; they need time for their creative activities; and if their products are to matter, they need to find audiences — art dealers, students, talent scouts, journal editors, and the buying public.

The market system is often viewed as nearly synonymous with decentralization. But modern capitalism rewards innovation with monopoly rights. Copyrights and patents that protect intellectual and cultural property give innovators exclusive right to reproduce cultural, scientific, design, and engineering innovations. Thus, innovators gain property rights that may enable them to monopolize their markets and thereby possibly to control future access to innovation and distribution. Capitalism, by distributing resources to those successful at innovation, may encourage or discourage decentralization. This is currently an important policy issue, one aspect of which has been raised by the antitrust suit against Microsoft. Our question, in this context, becomes: Does market power, such as Microsoft's market power in software, encourage or discourage innovation? Parallel issues may arise, for example, in media mergers or in government research policy.

Similarly, government support for research need not imply centralization. Rather, research may also find

[1] Centralization refers to the existence of a single decision maker — a government agency, a monopoly firm, or a cartel — in a given industry, specialty, or product line that determines which innovative efforts to support.

support from large and small profit-making firms and nonprofit organizations such as foundations and universities. So government research agencies may well be important players within an efficient and decentralized innovation network.

THE CASE FOR CENTRALIZATION

In recent decades, economic analysis has made important strides in understanding the advance of knowledge. An earlier strand of economic studies focused on the potential advantages of centralized innovation.

Barriers to Entry Support Innovation. Harvard professor Joseph Schumpeter was the seminal economic thinker on innovation and its role in the economy. He argued that developing and marketing new products was the key to economic development and that innovative firms needed to be repaid for this expensive process.

But if competitors are able to enter the markets for these new products and undercut the innovator, the price of the product will be bid down to its cost of production, and there will be no compensating profit for the innovating firm. To pay for development of new products, innovating corporations need to exclude imitative competitors for some period, to reap temporary supranormal profits. Corporations in some cases may be able to obtain monopoly power over their innovative products with intellectual property rights, such as patents and copyrights, trademarks, and brand names. Often, these will not be enough to adequately protect the innovation. The innovator may have to resort to alternative methods to protect its profits. For example, a firm may field a large sales force that specializes in selling the new product; building such a sales organization would be time consuming and costly for a potential entrant.

Going a step further, Schumpeter also argued that a large incumbent monopolist may have a strong incentive to innovate because a monopolist typically will have a large existing customer base to which it can quickly and easily market new products. Thus, a monopolist with a strong position in the marketplace can turn a profit on a new product far more quickly than a newcomer to the market would — raising the expected return to innovative activity. To be sure, Schumpeter was no apologist for perpetual monopoly. He believed that as long as entry was not impeded by regulation, all such monopolies were temporary, as entrepreneurs struggled amid a "gale of creative destruction."[2]

However, there are drawbacks to innovation through a succession of temporary private monopolies. First, the monopolist uses its market power to sell its product at a high price. Therefore, some customers who would like to use the product — and who could afford to pay its marginal cost of production, but not the monopoly price — may not be able to buy it. Second, a monopolist will be reluctant to introduce innovations that compete directly with their existing products. Therefore, the monopolist's incentive to innovate in a given industry is generally lower than an outsider's. Finally, the monopolist incumbent may use its powerful position within the industry to reduce potential entrants' ability to introduce new products profitably.

[2] For a further discussion of Schumpeter's theory, see my *Business Review* article.

Public Involvement May Facilitate Innovation. For these and other reasons, economists and others have often argued that governments and public entities are better supporters of innovation and creativity. Indeed, in the United States, the National Science Foundation, the National Institutes of Health, the National Endowments for the Arts and the Humanities, and the military research and development (R&D) paid for by the Department of Defense all bear testimony to the belief that the federal government is a natural source of such funding. In his 1960s exercise in social forecasting, Daniel Bell predicted the increasing socialization of knowledge production. Bell argued that knowledge (including innovations and creative products) is what economists now call a nonrival good because its transfer to and use by others does not reduce its benefit to original holders, unlike with material objects.[3]

The government can overcome the monopoly problem of prices being too high because it can pay for the fixed cost of innovation with taxes, then

[3] Economists distinguish between public goods and nonrival goods. When an individual or group produces a public good, they can't exclude others from enjoying its benefits. For example, national defense is a public good. A nonrival good may be kept from others, but there is no direct additional cost to providing it to others. For example, an idea for a new innovation that is kept secret is not a public good, but it is a nonrival good. If the idea cannot be kept secret, it is a public good. Since over time knowledge tends to become public, whether it is considered public or nonrival depends on the time period considered. Thus, some economists regard knowledge as a public good.

A good example of the potential for a public solution to the problem of innovation is vaccines.

distribute the innovation at marginal cost. A good example of the potential for a public solution to the problem of innovation is vaccines. When a vaccine is distributed widely enough, it may be possible to eliminate all hosts for a disease and thereby eradicate the disease itself, as appears to have occurred with smallpox. In two articles published in 2001, Michael Kremer argued that governments ought to pay inventors of vaccines the social value of the vaccine, then make the vaccine available at the lowest possible price.[4]

Moreover, government support of research may be valuable because although the research may have no immediate practical applications, it may provide the basis for more profitable research in the future. For example, many important mathematical insights have flowed from theorems that establish that two different and seemingly unrelated branches of mathematics share a common structure: Andrew Weil's recent proof of Fermat's Last Theorem is an example. Proofs of this kind often have no direct potential for profit, and indeed mathematical propositions are generally not patentable. (However, see Robert Hunt's article for changes in tests of patentability.)

Government support of basic research has long been accepted in the United States and has been an important source of the country's competitive advantage due to spillovers. Although basic research may not have direct applications, the expertise of those involved in it may be a valuable resource for more directly profitable enterprises.

Another implication of Bell's argument is that societies with strong business-government collaboration (Japan, Singapore) may also be good at creating and using knowledge. Indeed, the success of the East Asian model of economic development from 1960 to 1990 can be viewed as an illustration of this concept.

Centralization can prevent wasteful duplication of research: Private parties racing to produce the same innovation are likely to duplicate one another's efforts unnecessarily. Moreover, since research is highly risky, it is valuable for researchers to hedge the risk that their project will fail. That is, if several different researchers are working on separate lines of research or different attacks on the same problem, it is possible that only one will succeed. Since it is often impossible to predict which line of research is most promising, the successful outcome of one approach need not imply that only one of the researchers was of value and working hard. By centralizing and pooling support and funding, all may receive at least some reward. Indeed, the modern corporation with its research laboratories can be viewed as an institution for pooling risk in this way. Central and secure funding for innovators also may encourage scientists and artists to be more cooperative about sharing discoveries and techniques, further reducing risk and duplication of effort.

Arguments in favor of government support for research are reinforced when the research projects in question are very expensive. Examples include space travel, particle colliders, the mapping of the human genome project, and nuclear fusion electrical generation. Moreover, coordination among private parties who might profit from the research may be difficult because sharing intellectual property rights can result in excessive competition. And when research is very expensive, even private-sector monopolists may find the project too risky to undertake.

Anecdotal Evidence for Centralized Innovation. Told as anecdotes about the accomplishments of big government and monopoly firms as innovators, much of the evidence from World War II and the two decades following appeared to favor Schumpeter's and Bell's arguments.

Researchers at Bell Labs, the research arm of AT&T and the regional Bell companies before their breakup, produced many inventions crucial to the modern age. Most famous among them was the transistor, the key breakthrough that brought Nobel prizes to three Bell Labs scientists and ushered in the electronic age. During that same period, Bell Labs developed much of the information science that underpins ever-increasing bandwidth, including information theory and coding theory.

IBM, the giant corporation that dominated the computer industry from the mid-1950s to the mid-1980s, developed many inventions crucial to the computer and electronics, including the development of the first major programming language, Fortran.[5] One of IBM's great breakthroughs was the 360 computer series. Prior to the invention of the 360 series, computer operating systems were usually tailor-made for the particular computer model they ran on. Consequently, when companies wanted to upgrade their

[4] In general, Kremer, in a 1998 article, proposed using an auction to disclose the private expected value of the patent. Private parties would bid for the right to patent. Some of the time, the private parties would be allowed to win the patent, so the private parties would have a strong incentive to bid accurately. The winning auction bid should be a reasonable estimate of the value of the patent to a private monopolist. Most of the time, the government would step in and pay the inventor a *premium* over the auction price, and the premium plus the auction price reflects the average social value of the patent, a value that Kremer conservatively estimates is twice the private value. The social value includes both what the monopolist would earn and the consumer surplus (benefits to consumers above and beyond the price they pay).

[5] See the book by Emerson Pugh.

computer systems, they would have to rewrite or adapt all their existing computer programs. The 360 operating system, by contrast, blended the computers in the 360 family so that computer programs written on smaller ones could run almost seamlessly on larger ones.

Government R&D has also had spectacular successes, including the Manhattan Project, which developed the first atomic bomb; the development of ENIAC, the first general-purpose programmable computer; and NASA, whose Apollo program successfully put astronauts on the moon within a decade.

Centralization Also Has Drawbacks. But central authorities — government and business monopolies — can fail to recognize the right path to innovation. If centralization requires consensus, it may be harder to make progress when the consensus is flawed. Encouraging iconoclastic innovation may require subjective judgments from science bureaucrats. But these well-intentioned government bureaucrats may be reluctant to break the mold for fear that they will be accused of arbitrary or self-serving behavior that would conflict with government accountability regulations.

As a consequence, the activity of nongovernmental supporters of research — whether they be for-profit corporations, nonprofit foundations, or universities — can be crucial to the speed of innovation. During the past three decades, a period of exceptionally rapid innovation, the government's share of R&D has declined. When we consider basic and applied research and product development, the federally funded share has fallen from 64 percent in the 1960s to 26 percent in 2000, while industry-funded research has risen to 68 percent (Table 1).

Private, rivalrous industries, such as pharmaceuticals, finance, and semiconductors, just to name a few obvious ones, have been at the heart of much of modern innovation. This has increased interest in understanding how companies actively competing with one another might be good at conducting R&D. Moreover, more systematic views of the evidence have long suggested that the anecdotes about Bell Labs and IBM research oversold the case for big research centers.

THE CASE FOR DECENTRALIZATION

It may be that the top experts in a given field are not the best judges of innovation. One way of ensuring that many different talents and ideas have the opportunity to find an audience is to have many venues through which the people with talent and ideas can obtain funding and publicity. Decentralization thus may be a superior way to develop new products when it is hard to discern the best talents and ideas.

Free Entry Is Best When "Nobody Knows." In his path-breaking book on the organization of creative industries, Richard Caves argues that in innovative and creative markets, no one can know in advance who will succeed, a condition he calls "nobody knows." Decentralized gatekeepers — teachers, book and journal editors, movie producers, department chairs, art dealers, and curators — compete to develop new products and talents. Every success invites entry into the next round, and the right gatekeepers of today may not be the "hot hands" of tomorrow as markets, meanings, and tastes evolve. Under decentralization, the audience — whether scientific peers or customers — rather than the individual gatekeeper becomes far more important to the evolution of the industry in question.

For example, before 1948, the major Hollywood film studios had achieved substantial market power for their products by vertical integration: The studios owned a large proportion of U.S. movie theaters. This enabled the studios to jointly control production and distribution and made new entry into film-making by independent producers a daunting task. Not only did the studios control their own theaters, but independent movie theaters often either had no access to the most popular films or were required to book multiple titles in advance without the power to review the titles, a practice known as blind booking. After these practices were declared illegal in 1948, the quality of films, as measured by their audience popularity, critical reviews, and awards, became much more important in determining studios' profitability and the success of their management.

In his 1982 article, Boyan Jovanovic developed a theory to model industrial performance under a "nobody knows" condition, in which firms discover whether they are "talented" by

TABLE 1

Sources of Support for All Types of R&D by Source of Funds

All R&D: Basic and Applied Research, and Development

Year	Federal	Industrial	Other
53-59	59.6%	38.1%	2.3%
60-69	63.9%	33.6%	2.5%
70-79	52.9%	43.6%	3.6%
80-89	45.7%	50.5%	3.8%
90-99	34.2%	60.6%	5.2%
2000	26.3%	68.4%	5.3%

Source: National Science Foundation, *Science and Engineering Indicators*, 2002.

"Other" includes universities and colleges, state and local finance of university and college research, and other nonprofit organizations.

facing the market test. We can think of talented firms as including literally talented entrepreneurs and also firms with intellectual property that provides them with a sustained advantage in innovative activity. In this model, talented firms grow bigger and make more profits. Industry productivity and profits increase over time as some firms learn that they are untalented and exit, and new entrants, some of them very talented ones that will survive, take their place.

In his book, Michael Porter argues that having free entry and rivalry keeps companies on their toes, encourages innovation and efficiency, and discourages political favoritism. The United States, by being home to Intel, Texas Instruments, IBM, Hewlett Packard, Motorola, and AMD — all producers of microprocessors — has obtained a sustained advantage in the computer industry because it has this kind of rivalrous industry.

Why does rivalry work so well? In part, because rivals give each firm a yardstick for performance. Excuses — whether made to a superior, to the government, to shareholders, or to oneself — just don't play as well when the competitor across the street or across town is doing better. Moreover, the visibility of the competitors' practices stimulates both emulation and one-upping — spillovers of information. And since new ideas by new entrants may be offered to a variety of bidders, outsiders are encouraged to add fresh talent to the mix. Overall, using a variety of industries and countries, Porter convincingly illustrates that nations that have such rivalrous industries obtain lasting national advantage over other countries.

On the negative side, rivalry often seems to incite deep personal antagonism.

How Rivalry Drives Innovation. In a series of papers, Philippe Aghion and co-authors developed a formal theory that supports the value of rivalry in innovation. The authors describe industries that have step-by-step innovations and differentiated products, with one company sometimes breaking out of the pack with a new innovation. We can think of an innovation as being a new generation of a product line, such as a new generation of video game players, a new type of car like the minivan, or a new class of drugs. Because products are differentiated and some customers have strong preferences, one company's innovation does not drive its competitors from the market immediately, but the innovator's profits rise dramatically. The possibility of this dramatic rise in profits spurs innovation.

Consider two rivals, which we will call Inventor Bell and Tinker Bell, who are in the business of supplying custom cell-phone chimes. They share the market for 16-bit chimes but are racing to develop 32-bit chimes. Each knows that the first firm to come up with 32-bit chimes will win 80 percent of the market, which is sure to expand because 32-bit chimes will enable phones to play the "Star Wars" theme song. There are thus two effects: the market expands and the innovator gets a larger share.

Now suppose Inventor Bell is the first to invent and market the 32-bit chimes. Since Tinker Bell is able to examine Inventor Bell's product, Tinker Bell's cost of *imitating* are lower than Inventor Bell's cost of finding the *next* innovation.[6] If Tinker Bell can succeed in imitating the innovation before Inventor Bell moves on to, say, 64-bit chimes, its profits will rise substantially and Inventor Bell's profits will drop sharply. Therefore, Tinker Bell has a strong incentive to get back in the race. But if Inventor Bell moves on before Tinker Bell can imitate, it knows that Tinker Bell's incentive to innovate may drop sharply, as it will need two rounds of success to catch up. This might leave Inventor Bell with a clear field and a long period of very high profits. Thus, Inventor Bell has a very strong incentive to continue to innovate.

As long as there remain in the industry some competitors who haven't fallen very far behind, the incentives to innovate for all of the competing firms, both leaders and followers, will be high, as long as imitation isn't too easy. If imitation is too easy — if it's much cheaper to imitate than to innovate — the incentive to innovate will be muted because the leader retains its profits for too short a period to justify the expense of innovation.

Put another way, if Tinker Bell can imitate Inventor Bell's invention for one-tenth of the cost Inventor Bell paid to discover the invention, and vice versa, each will prefer the other to be the first innovator. Then it is possible that neither will invest in innovation. The result will be an industry that is competitive precisely because there has been no innovation or progress. In this model, innovation and competition will have an inverted-U relationship: The most innovative industries will be those with some competition, not those with lots of competition or monopoly.

DECENTRALIZATION MAY BE SUPERIOR WHEN ADVANCES ARE UNFORESEEABLE

One factor underlying the relative performance of centralized and rivalrous methods of innovation is how knowledge evolves. A key question is: To what extent does knowledge evolve

[6] When the original innovation is patented, the follower has to find a way to imitate the product without violating the original patent. Edwin Mansfield, Mark Schwartz, and Samuel Wagner found that a majority of the sample of patented inventions they studied were successfully imitated within four years and that, on average, the cost of imitation was a third less than the cost of the original invention.

along foreseeable paths rather than result from old views being replaced by new ones?

If Scientific Advance Is Foreseeable. One way of looking at the evolution of knowledge is that knowledge is mainly cumulative. If this is true, the world should become more certain. The more we know, the more sure we will be in our knowledge. If our views are built on bedrock, that is, if fundamental theories are correct, new evidence will only confirm them. In this case, new truths do not displace old ones. Past knowledge is a reliable guide to future knowledge. Similarly, our concepts of what is beautiful — what constitutes a good painting or good music — are not subject to radical reconstruction.

In this type of world, senior experts are friends of progress. The theories that the senior experts have learned and taught are citadels. The most valuable new research in this situation extends the reach of existing theory into new areas and applications. This type of scientific advance enhances the value of existing knowledge, rather than conflicting with it. In a world like this, peer review committees function well, since senior scientists don't disagree too much.

Since knowledge is cumulative, older scientists tend to know more than younger scientists. Seniority is a good reason to pay someone more or to allow someone more decision-making authority.

But If Science Advances by Revolutions. Another possibility is that as knowledge advances, what we know often becomes obsolete. When new ideas threaten to make old ones obsolete, the incumbent experts may attempt to block the development of new ideas. As the pace of gathering knowledge accelerates, anomalies that contradict existing theories are likely to accumulate faster; so the advance of knowledge more often requires making old theories obsolete.

A more subtle effect of this kind can occur when new inventions make old methods obsolete and thereby render old knowledge less useful. For example, the hand-held calculator rendered the slide rule and the ability to manually calculate square roots less useful. A senior scientist's or engineer's knowledge base can become outmoded in this fashion, even though it is not contradicted. Similarly, the advent of photography supplanted the purely documentary function of painting in favor of innovative and imaginative aspects.

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The development of the telescope led Galileo to discoveries that deepened questions about the Aristotelian-Ptolemaic theory of the universe. The ability to measure the speed of light overturned the Newtonian universe. The ability to decipher genetic code will change our understanding of biology and evolution and, perhaps, may change what it is to be human.

Who knew that jazz would be the seminal form of American music in the 20th century? Not the musicologists of the time. But the invention of the phonograph, which captured the excitement of improvised music and made it available to the multitudes, made jazz a worldwide musical influence almost overnight.

Universities and Academic Stars. One of America's strengths in innovation is a diverse collection of private and public universities that have substantial freedom to hire academic innovators. A recurrent question is: How should universities use appointments and tenure decisions to attract and support the best scholarship?

From the perspective of the individual university, the question is: How does a great university stay at the top? One way is to offer professorships to academics who have published path-breaking research and have already achieved universal acclaim.

The alternative is to attract innovators when they are doing their best work — hiring them when they are doing the work that will win them their Nobel prizes, rather than after they win. This option is clearly riskier, since the innovator's work may not prove to be the best. The university may get stuck with the losers, particularly if other universities poach its stars. But if innovation is proceeding fast enough, hiring professors who are past their prime may gain the university a reputation for standing in the way of progress, rather than representing the best.

On the other hand, it may well be that great scholars or artists will be founts of creativity for a long time. For example, when Joseph Schumpeter came to the Economics Department at Harvard in 1932 at age 49, he still hadn't written three of the four works for which he is best known.[7]

[7] Those works are *Business Cycles* (1939), *Capitalism, Socialism, and Democracy* (1942), and *History of Economic Analysis* (published posthumously in 1954). *The Theory of Economic Development* was first published in German in 1911.

A diversity of universities, each possessing its own methods for rewarding teachers for producing knowledge and for teaching, is an immense asset for any economy. Within this system of higher learning, competition — and decisions on how to compete — will play a powerful role in determining the overall rate of innovation in the economy. [8]

ANECDOTAL EVIDENCE FAVORING DECENTRALIZATION

The "low level of productivity of Eastern Europe relative to that in Western Europe," as Stephen Nickell writes, is "an impressive example of what can be achieved by repressing the forces of market competition." It was not just that the centralized economies of the Soviet bloc were inefficient; they also progressively fell behind at innovating and in adopting innovation.

In basic research, where findings may be too far from direct application to be profitable, the federal government remains predominant with a 49 percent share, although its share has declined (Table 2). But the grant-making of federal science support may not be able to adequately diversify its research base: How do we decide whether a research idea that goes against the mainstream might be successful anyway? Typically, peer review panels will not support such long shots. When this happens, private foundations and for-profit corporations can valuably supplement government support.

Craig Venter's "shotgun" approach to genomic research was derided by members of the federally funded Human Genome Project.[9] Indeed, earlier he had proposed to use the technique to decode the genome of a bacterium, only to have his grant request rejected. He appealed the rejection; meanwhile he used private funding to proceed with his research on the bacterium. The NIH review committee rejected his appeal on the grounds that it was unfeasible. A few months after the rejection, he published his transcription of the bacterial genome in the prestigious journal *Science*. He then went on to use this method in the draft decoding of the human genome, again with private funding, substantially accelerating that landmark event.

As described earlier, IBM was one of the most successful innovators of the 1950s and 1960s. In the late 1960s, alarmed by the rapid advances in technology made possible by miniaturizing integrated circuits, IBM embarked on a project aimed at greatly increasing the usefulness of computers called FS (for Future System). As Emerson Pugh recounts in his history of IBM, although a number of technological breakthroughs occurred, IBM never came close to a marketable product and settled for a modest extension of the 360 series, which it called the 370 series.

After this failure, IBM became much more risk averse, and it became more difficult for innovative projects to advance cost effectively through the IBM project management process. Consequently, as described in Paul Carroll's book, IBM was slow to enter the personal computing market. After a few in-house failures, IBM was forced to turn to outside sources — Intel for the microprocessor and Microsoft for the operating system. Although the IBM PC thus produced was an instant success, IBM lost control of the PC market and both Microsoft and Intel profited more in the long run.

The French Academy of Beaux Arts supported students and artists. The identification of Paris with painting continued well into the 20th century. During the 19th century, art students from around the world, including Americans like Thomas Eakins, came to Paris to learn how to paint in the grand style. Yet painting was in the midst of an upheaval, beginning with Impressionism, which was foreign to the tastes of the reigning French painters of the academy and the official salons. As Annie Cohen-Solal's book shows, the new painting came to prominence despite the opposition of the state-supported institutions of painting. Private art dealers, aristocratic patronage outside the academy, a network of independent teaching artists, and artists' colonies both in Paris and in the provinces were all important sources of support for the new painting.

These examples point out not that government or large businesses

TABLE 2

Sources of Support for Basic Research by Source of Funds

Basic Research

Year	Federal	Industrial	Other
53-59	57.1%	32.2%	10.8%
60-69	68.7%	19.2%	12.1%
70-79	70.0%	14.5%	15.5%
80-89	64.6%	19.4%	16.0%
90-99	55.3%	26.3%	18.4%
2000	48.7%	33.9%	17.5%

Source: National Science Foundation, *Science and Engineering Indicators*, 2002.

"Other" includes universities and colleges, state and local finance of university and college research, and other nonprofit organizations.

[8] This issue made headlines at Harvard University when new President Larry Summers vetoed two appointments to the Harvard faculty, as described in the *Wall Street Journal* article by Daniel Golden.

[9] See the magazine article by Richard Preston.

cannot successfully support research or creativity but that a proliferation of sources of support can be crucial to rapid progress in the arts, sciences, and commerce.

SYSTEMATIC STUDIES DON'T SUPPORT CENTRALIZATION

Systematic Empirical Studies. A vast empirical literature investigating the relationship between competitiveness and innovation, most of it produced between 1965 and 1995, argued that there was little systematic relationship between competitiveness and innovation. Work by F. Michael Scherer showed that "there was little evidence of disproportionately great R&D input or output associated with the largest corporations, and market concentration showed no significant positive impact on progressiveness." Studies summarized in Wesley Cohen and Richard Levin's article echo this theme.

More recent studies, which were based on detailed and systematic data on innovations by industry in the United Kingdom, have argued that industry innovation declines as industry concentration rises. Richard Blundell, Rachel Griffith, and John Van Reenen found that while dominant firms tend to innovate more than other firms, this dominance dampens innovative activity for other firms in the same industry. On net, they found empirically that the dampening effect on the smaller firms outweighed the innovative activity of the dominant firm.

Stephen Nickell showed that industries that are more competitive have faster rates of innovation as measured by the rate of increase of *total factor productivity* (TFP).[10] TFP measures the growth of industry output that can't be accounted for by the growth of labor, capital, or materials alone. This is a very good measure of overall growth of innovation, since innovations are the main explanatory factor omitted from the measured inputs.

In 2002, a study by Philippe Aghion and co-authors garnered a result that is perhaps closer in spirit to Schumpeter's original argument. They found an inverted U-shape relationship between patenting activity and competitiveness: Very competitive industries have low patenting activity as do industries that are very profitable.[11] This is Schumpeterian in that too much competitiveness appears to be detrimental to innovation, since the rewards to innovation vanish too quickly to repay it. At the same time, the study found that monopolization of an industry results in too little innovation, perhaps for the reasons suggested by Michael Porter. Overall, these results conform to their model of step-by-step innovation.

[10] Nickell's survey asked managers whether the company had more than five competitors in the market for its products. He used this as one measure of competitiveness. Another measure of competitiveness is profit margin, which is the amount a firm can charge for its products above costs, where costs include labor and capital. In general, competition should drive profit margins close to zero, so that large profit margins imply lack of competition. Nickell defined profit margins as profits less capital costs, divided by value added.

[11] Like Nickell, Aghion and co-authors use profit margins as an inverse measure of competitiveness. They define profit margins as operating profits divided by sales. Their analysis uses a series of changes in industrial regulation in Britain to identify the role of competitive conditions in influencing gains in industrial productivity.

CONCLUSION

Is our era one of incremental knowledge or of innovation? To the extent that it is an age of innovation, decentralized and competitive structures — whether capitalist or government supported, profit or nonprofit — will favor economic growth.

Can a centralized system decentralize? Ultimately, this is an empirical question. In principle, a monopoly can operate like a decentralized system. That is, a monopolist may be able to use internal competition — between managers or divisions — to obtain results similar to those obtained through market competition.

But the monopoly has its own incentives that may not align with progress. New products may reduce profits on existing products when the new products are successful and waste them when they are not. Moreover, new products may require changes in corporate focus that make production of existing profitable products less efficient.

Clearly the existence of rivalry — competing institutions that encourage innovation — is very valuable in generating innovation. Yet we should be mindful that even where competition has free rein, progress may be unnecessarily slow. Excessive competition may arise where imitation is too easy. Moreover, the return to innovative activity may be too distant from the innovation to provide adequate private incentives to create.

Thus, innovation may best be served when there are a wide variety of sources of support: large and small firms, small foundations and big government agencies, new-firm incubators, and venture capitalists.

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