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The Power of Technological Innovation in Rural America

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Technological innovation often stimulates economic growth by creating new products, improving efficiency, and opening doors to new markets. Yet many rural communities believe these advantages are off limits to them—because their towns are either too small or too remote for their entrepreneurs to create technological innovations.

In reality, though, the advantages of innovation are often well within the reach of rural America. Size and distance may limit a rural entrepreneur's ability to produce *radical new* innovations. But adopting new technologies and retailoring them for new and better uses exemplify the traditional spirit of rural America, especially in agriculture. In the language of economists, rural places are adept at *technological adoption*, a kind of innovation that improves existing technologies. The key players in this crucial game of innovation are rural entrepreneurs.

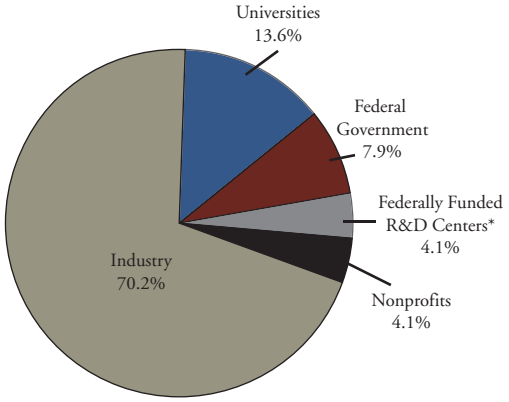
Can technological adoption help invigorate rural economies? This article explores how such innovation can boost rural prosperity in three ways: by creating new products, improving production processes, and opening doors to new markets. The article also discusses some of the federal policies that support technological adoption in rural America.

Innovation Creates New Products

Innovation is the fuel entrepreneurs use to power economic engines. In the United States, private industry spends billions each year to discover the next great invention, hoping it will spawn new products that will transform the economic landscape and create new sources of economic return. According to the National Science Foundation, U.S. private industry spent $300 billion on research and development (R&D) in 2004, about 70 percent of the nation's total (Chart 1).

Chart 1

U.S. R&D Expenditures
(Share of U.S. Expenditures by Performer, 2004)



Source: National Science Foundation

* Federal money spent on research and develop that is administered by universities, colleges, nonprofits, or individual firms. For example, the National Renewable Energy Lab in Golden, CO spends federal money on research and development and is administered by the Midwest Research Institute, a nonprofit organization.

As critical as inventions are to the R&D process, they alone do not transform economies—innovations do. Innovations are commercialized inventions that generate new economic value in the marketplace. These inventions are often the product of small entrepreneurial firms.

The personal computer industry is a good example of how innovations can transform the economy. More than one small firm has exploited new technologies that were developed, but then overlooked, by larger firms. The fledgling firm known simply as Apple adopted and improved an innovative graphical interface technology developed by the giant Xerox—and so the Macintosh personal computer was born. Soon after that, a tiny Microsoft workforce revolutionized the industry by adopting and recasting the BASIC computer programming technology that larger firms had developed for mainframe computers.

Since World War II, more than two-thirds of all innovations—and more than 95 percent of the radical innovations that have led to dramatic and sizable transformations in the economy—have been adopted, improved, and developed by small entrepreneurial firms.[1]

Innovation Enhances Production Processes

The second way technology transforms economies is by improving the production process, which boosts productivity. American agriculture is a classic example of how this happens. In the 20th century, new technologies such as tractors, hybrid seed corn, and pesticides led to a surge in productivity growth. The number of labor hours required to produce 100 bushels of corn plunged from 80 in 1850 to less than two today.[2] In the 21st century, new technologies are emerging in biological and life sciences. R&D in this new field promises yet another wave of technological innovations to boost agricultural productivity.

Innovation also transformed processes in the manufacturing and retail industries. A century ago, Henry Ford introduced the assembly line to the process of building cars, an idea that changed the world of manufacturing. In the 20th century, Wal-Mart proved that a small store in rural Arkansas could become the world's largest retailer by adopting an innovative, highly efficient distribution system. And more recently, the Internet has transformed the way businesses interact. From 1999 to 2004, manufactured shipments sold using e-commerce technologies rose almost 30 percent, while overall manufactured shipments rose only 1 percent. One quarter of all manufactured shipments are now based on e-commerce.[3]

Of course, access to the Internet has traditionally posed a serious obstacle for rural businesses—but lately access has become more common. In 2000, only 23 percent of sparsely populated ZIP code areas (those with less than six people per square mile) had at least one subscriber with high-speed access. By 2006, that figure had jumped to 89 percent (Table 1). As a result, many small businesses like Pro-Trainer, Inc., which designs and manufacturers recycling containers in Alexandria, Minn., can use the Internet to reach new customers both at home and abroad.[4]

Table 1

ZIP Codes with at least One High-Speed Subscriber by Population Density

Persons per square mile	June 2000	June 2002	June 2004	June 2006
	(Percent of ZIP Codes)			
More than 3,147	97.3	98.7	98.9	99.4
947-3,147	95.8	98.2	98.5	99.5
268-947	93.4	97.5	98.5	99.4
118-268	86.7	95.2	97.7	99.2
67-118	77.9	93.0	97.6	98.8
41-67	65.4	88.0	96.4	98.9
25-41	54.5	81.0	94.3	98.4
15-25	39.2	70.0	88.5	97.1
6-15	31.3	60.9	83.5	96.5
Fewer than 6	23.0	49.6	73.4	89.3

Source: Federal Communications Commission

Innovations in technology are also transforming some rural economies by making them a home to providers of business services. In an age when outsourcing jobs to other countries in global markets is on the rise, technologies like the Internet are also enabling businesses to "homeshore" high-skilled services to places in rural America. The fastest growing homeshore service firms in rural America are those that provide professional and business services.

Many homeshore firms in rural places enjoy lower operating costs than similar firms in major metro markets. And they are much closer to home than outsourced services. Wages for software developers are $35 to $40 per hour in rural areas, compared to $75 to $100 per hour in major metro markets and $20 per hour in India.[5]

Innovation Unlocks New Doors

Today, thanks to e-commerce technology, rural firms can market their products to customers in places they never could reach before—in ways they never imagined. In the retail sector since 2003, e-commerce sales have grown 25 percent annually, while overall retail sales have risen only 6.8 percent. Rural companies are participating in this growth. For example, Internet visits to Cabela's, an outdoor sporting goods retailer headquartered in Sydney, Neb. climbed 36 percent in 2005.[6]

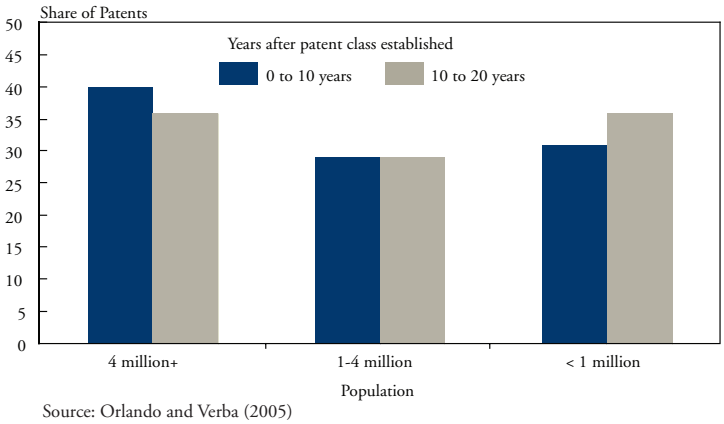
Internet access and sales have also soared in the agribusiness industry. The percentage of farmers using the Internet soared from 13 percent in 1997 to more than 50 percent in 2004.[7] Farmers tend to use the Internet for price tracking, information gathering, and communications. The sale of farm products appears to be migrating to the Internet domain as agribusinesses continue to report stronger e-commerce sales. The wholesale e-commerce sales of raw material farm products jumped 18.5 percent in 2005, while sales for the sector as a whole rose just 6.5 percent.[8]

In the midst of the activity spurred by innovation, however, a serious question remains: *Does technology offer entrepreneurs higher economic returns?*

New technologies bring new competitive pressures to the economic landscape, and businesses unable to adapt to these competitive pressures typically disappear. Firms that can adopt new technologies and turn them into new sources of competitive advantage may be able to cultivate new economic opportunities.

Chart 2

U.S. Patent Activity over Time



Source: Orlando and Verba (2005)

For entrepreneurs, advanced technologies appear to support higher economic returns. According to Census Bureau data, entrepreneurs owning high-tech manufacturing firms earned about $82,800 in 2006, or 11 percent more than medium-tech factory owners and 50 percent more than low-tech factory owners.

It takes time, of course, to fully integrate technology into a business operation and reap its full benefits. Business owners and managers often face steep learning curves before they can decide how their existing business practices need to change. For example, in 2000, farmers in the Great Plains tended to expect a small financial payoff from the Internet. At the same time, many farmers expected the benefits to increase as the technology moved beyond its general purpose attributes and became more specialized to the farm sector.[9]

Innovation in Rural America

It is true that size and remoteness limit the ability of many rural communities to produce the radical innovations that can transform local economies. For example, analysis of the spatial distribution of patents in the United States reveals that rural places tend to produce fewer patents than more urbanized locations. Rural places typically produce less than one patent for every 10,000 people, compared to more than 2.5 patents in metropolitan areas.[10] As a result, rural places are typically not viewed as a seedbed for invention and innovation.

However, a deeper exploration of patent activity reveals that rural places do spur inventions in more mature industries, where inventions and commercialized innovations are more likely to be process-based. In fact, as technologies mature, patent activity in smaller communities often rises. For example, patent activity in less populous places is higher in patent classes that are older than 10 years, compared to activity in patent classes younger than 10 years (Chart 2).[11] Moreover, in the older patent classes, the share of patents in the least populated places was almost as high as patent activity in the highest populated places.

As technologies mature, the ability of rural communities to adopt them often depends on knowledge dissemination. The size and remoteness of rural places often raises the costs of transmitting

knowledge and information. In contrast, more populous places have "thicker" markets—that is, their body of buyers and sellers is more developed—which makes the inputs to innovation cheaper and more readily available, particularly for specialized products.

Knowledge is most efficiently shared when people interact with each other. But rural communities offer fewer personal interactions due to their sparse populations and remoteness from thicker markets. As a result, the cost of transferring knowledge is higher in many rural places, even though new communications technologies, such as the Internet, have improved the connections between rural and urbanized places.

The high costs of information and knowledge dissemination severely limit radical innovation in rural places. But as technologies mature, the costs associated with additional incremental innovations decline because the knowledge and know-how are already disseminated. In fact, rural manufacturers tend to be quite similar to their metro peers in regards to adopting and improving new technology.[12]

How is Public Policy Helping Rural America Innovate?

The importance of technological adoption to rural prosperity has long been recognized in American public policy. Many of America's university and college systems were designed as institutions of technology transfer to rural places representing one important role for policy.

At their inception, land grant universities were charged with more than providing higher education. They were also charged with discovering new technological innovations and transferring those innovations to rural regions through extension systems. Today, many land grant universities are transforming their extension systems for the 21st century, but technology transfer often remains a founding mission. Many land grant universities have established "offices of technology transfer" with a mission of turning inventions in university laboratories into commercialized products.

For example, Discovery Park at Purdue University brings university scientists and the marketplace together to spur new entrepreneurial ventures from university research. These activities are then located throughout the state of Indiana.

Technology transfer has provided a second role for federal policy through the National Institute of Science and Technology (NIST). The Hollings Manufacturing Extension Partnerships is one NIST program geared to transfer technology to smaller manufacturers. The Hollings program is a national network of resources providing technical and business assistance to U.S. manufacturers. Many other programs are also associated with both rural and urban universities and community colleges. Many of the NIST success stories involve businesses incorporating technology to create new products, enhance production efficiencies, and reach new markets.[13]

The 2002 Farm Bill represented a third role for policy. It established the Agricultural Innovation Center (AIC) program to fund "innovation centers for work on providing technical and business development assistance to agricultural producers seeking to enter into ventures that add value to commodities or products they produce." In 2003, 10 grants of roughly 1 million each were awarded to centers across the country. Most of the centers are directly associated with land grant universities. These centers help agricultural producers write business plans, conduct research, and provide counselors to help new venture creation in the agricultural sector.

Land grant universities, NIST programs, and the AIC program are examples of how public policy and institutions are supporting the transfer of knowledge to rural places. However, rural places need to find ways to tap technology in the private sector. As stated earlier, more than 70 percent of the R&D expenditures emerge from the private sector. And these dollars are often geared to developing commercialized products, in contrast to some of the public sector research programs, which aim to advance basic research.

To boost productivity and prosperity, many rural firms have adopted new technological innovations to create new products, reach new markets, and enhance production efficiencies. The size and remoteness of rural places raise the costs of knowledge sharing and information transfer, which in turn limits radical innovation. However, creating networks that support the transfer and adoption of new technologies may lay a foundation for revitalizing many rural communities.

Endnotes

[1]National Commission on Entrepreneurship (NCOE). No date. *Embracing Innovation: Entrepreneurship and American Economic Growth.* White Paper.
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[11]The U.S. Patent and Trademark Office groups patents into patent classes based on the characteristics of the technology. Patents with similar technology are grouped together in the same class. For example, chemical fertilizers and batteries are grouped into separate patent classes.
[12]H. Fredrick Gale, David A. McGranahan, Ruy Teixeira, and Elizabeth Greenberg (1999) "Rural Competitiveness: Results of the 1996 Rural Manufacturing Survey," Economic Research Service, USDA, Agricultural Economic Report No. 776. Obtained May 11, 2007, at *http://www.ers.usda.gov/publications/aer776/aer776.pdf.*
[13]Business success stories are available at *www.mep.nist.gov.* Survival rates were higher for single-unit manufacturing plants that used manufacturing extension programs to enhance plant productivity. For more detail see Jarmin, Ronald (1999) "Governmental Technical Assistance Programs and Plant Survival: The Role of Plant Ownership Type," CES-WP-99-2, Center for Economic Studies, Census Bureau. Obtained May 11, 2007, at *www.ces.gov.*