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Riding the S-Curve: Thriving in a Technological Revolution

by Jerry L. Jordan

Like most economists, I initially questioned how long the dramatic U.S. capital expansion of the 1990s would endure. What was driving this unprecedented growth? It seemed too strong to be accounted for by favorable tax policies, or the lower interest rates that come from breaking the inflation psychosis, or the life-cycle change that turned baby-boom spenders into baby-boom investors. I suppose that all of these events have played a role. But I think that something more important, more permanent is motivating such a strong and persistent expansion of physical capital. Like others, I believe we are in the midst of a great revolution in technology, one that we can see only in the wake of the new capital it has fostered.

When we reflect back on this period of history, I am convinced we will say it was an economic revolution on an order of magnitude rarely seen in a lifetime. And it is transforming the way all of us—business, labor, and government—must act.

This technological revolution offers a great opportunity to leap forward in our collective prosperity. All of us stand to benefit. But some will take to the revolution more easily than others. Because of this, we can expect to see widening gaps in the growth of prosperity across the gamut of economic agents. Not all of us have the same capacity or incentive to take advantage of emerging technologies. Some of us have invested heavily in capital and technology that will, inevitably, become obsolete.

New technology is a challenge to business as some rise to the challenge of new opportunities and stake out competitive advantages, while others cling to existing methods and see their usefulness ebb. So too for labor, where the educated will have an advantage over the uneducated. But new technologies are also a challenge to public policy.

The public sector is not usually celebrated for its flexibility, and when motivated to move, it is often tempted to slow the engines of change and smooth out the unevenness at which our citizens are prospering. But if policymakers act on this temptation, they will only exacerbate the costs of this great and inevitable transformation. The lesson from past revolutions is clear on this point. If economic policymakers are to play a constructive role in this environment, they must endeavor to become the agents of change, not impediments to it. Moreover, we must recognize that those among us who are least capable of reaping the benefits from new technology stand to benefit most. It is as much for them as it is for any of us that policymakers must endeavor to help us make our transition to the "new economy."

n Lessons from Revolutions Past—Riding the S-Curve

Revolutions as great as the one we're a part of today have occurred only once in a very great while. The Industrial Revolution and the introduction of electricity are two examples. In each of those revolutions, the economy behaved in remarkably similar ways, and people greeted change with a characteristic mixture of

The information technology revolution offers a great opportunity to leap forward in our collective prosperity. All of us stand to benefit. But some will take to the revolution more easily than others—policymakers have learned this lesson from previous economic revolutions. This *Economic Commentary* is adapted from a speech given by Jerry L. Jordan, president and CEO of the Federal Reserve Bank of Cleveland, to the Ohio Aerospace Institute on October 12, 2000.

acceptance and resistance. These patterns are emerging again in our current economy, suggesting that we might learn how to maximize the benefits of recent technological innovations by studying these earlier events.

The Industrial Revolution was a confluence of technological breakthroughs that began roughly with the invention of steam-powered equipment in the eighteenth century. Steam power amplified the horsepower being applied in the world's production processes. And that was exactly how it was used initially, merely as a substitute for the hydro-, wind-, and animal-powered systems already in place.

But this new technology offered something more than greater dependability and power. It was transportable, and that spawned new and exciting capital. Previous constraints that limited the dis-

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tance between the power source and the production activity were lifted, and the modern factory was born. So were new forms of transportation. Steamships and railroads dramatically reduced the limits imposed by vast geographic distances. In short, the motion of the world accelerated.

But this great step forward in economic prosperity was hardly smooth, and social opposition was often fierce. Much was invested in the old capital, and the pressure to maintain it was immense. Large amounts of labor were employed in operating and maintaining the old tools and methods, and there was great appeal in protecting old technology in the name of preserving jobs. Consider this letter, written in 1829 by Martin Van Buren, then governor of New York, to President Andrew Jackson.[1]

To: President Jackson,

The canal system of this country is being threatened by the spread of a new form of transportation known as "railroads." The federal government must preserve the canals for the following reasons:

One. If canal boats are supplanted by "railroads," serious unemployment will result. Captains, cooks, drivers, hostlers, repairmen and lock tenders will be left without means of livelihood, not to mention the numerous farmers now employed in growing hay for horses.

Two. Boat builders would suffer and towline, whip and harness makers would be left destitute.

Three. Canal boats are absolutely essential to the defense of the United States. In the event of expected trouble with England, the Erie Canal would be the only means by which we could ever move the supplies so vital to waging modern war.

As you may well know, Mr. President, "railroad" carriages are pulled at the enormous speed of 15 miles per hour by "engines" which, in addition to endangering life and limb of passengers, roar and snort their way through the countryside, setting fire to crops, scaring the livestock and frightening women and children. The Almighty certainly never intended that people should travel at such breakneck speed.

Martin Van Buren, Governor of New York

But this is the effect of innovation, what economist Joseph Schumpeter called "creative destruction." No new technology is possible that does not make obsolete an existing technology. And for a time, there will be some who will not welcome the new.

Perhaps we will be better able to facilitate this great transformation in the economy if we know what to expect. Indeed, there are many lessons to be learned from earlier revolutions.

First, the new technology was adopted in stages over an exceptionally long time, a phenomenon that economists call the S-curve. The new technology was slowly diffused at first. Then, much later, its adoption accelerated, and finally, it leveled off. In the case of the Industrial Revolution, the conversion from invention to full assimilation was drawn out over roughly half a century, although the most rapid period of advancement appears to have occurred very late in that process. Likewise, bringing electricity to U.S. households took nearly 40 years.

Second, national productivity declined during the initial 20 years of this assimilation. Before the Industrial Revolution, American productivity grew at a rate of a little more than ½ percent annually. That fell by about half between 1835 and 1855. Similarly, in the first 20 years after the introduction of electricity, the rate of productivity growth also fell.

Third, the period of technological assimilation was accompanied by a sharp rise in the inequality of income growth. In 1815, the premium paid to skilled workers was about 10 percent. By 1855, it had risen to about 75 percent. And when we moved from steam to electricity, income inequality rose sharply again.

What might cause these repeating patterns? Curiously, the long diffusion process that accompanies major technological breakthroughs lasts as long as the working life of one generation of labor. Indeed, it takes a new generation of workers, underinvested in the old technology and untainted by the limitations of that technology, to take full advantage of the opportunity.

Some economists now believe that productivity declines during the early assimilation period because production processes need to be realigned and the workforce needs to be re-educated. These activities are not easily measured in standard production statistics, so investment in new technology is often unseen in the metrics of economic performance. And the widened gap in the distribution of the fruits of this technology is almost certainly a reflection of the fact that not everyone is equally prepared or willing to assimilate the technology. Those who assimilate most easily make the greatest gains. The others fall behind.

Eventually, however, the revolutionary process runs its full course. And once assimilated, the new technology reveals its underlying productivity potential. In the case of the Industrial Revolution, productivity growth ultimately tripled from its prerevolution level. The nation entered an era where its citizens could expect to see living standards double every 60 years, instead of doubling every 175 years, as had previously been the case. Following the adoption of electricity, our capacity to improve our living standards doubled every 25 years.

Now we face another potential leap forward in our national well-being. And this revolution appears to be following the patterns seen a century before. The process of putting the new communications technologies in place is well underway. But if history repeats itself, we now stand on the cusp of enjoying the transformation's most substantial gains. Consider that it has been about 25 years since the development of the microprocessor, halfway through the process as indicated by historical experience, and only recently have we seen an explosive expansion of the U.S. capital stock.

As in past episodes, this new capital did not initially yield the productivity growth that it seemed to promise. Between 1975 and 1994, annual U.S. productivity growth fell from about 3 percent to 1½ percent. But it is increasingly clear that productivity growth is now rapidly gaining momentum again. In the past two and a half

years, nonfarm business productivity has grown at a pace of approximately 3½ percent annually—its best showing in about 30 years. And if past technological revolutions are a good indication, this may be only the beginning.

But also as in past revolutionary episodes, the gains from this new technology are not being spread evenly across our economy. The earnings gap between male college graduates and high school graduates has widened almost 30 percent since 1979, while the gap between college graduates and high school dropouts has grown about 40 percent. Clearly, not everyone is adopting the new economy with equal enthusiasm and success.

n Reaping the Revolution's Rewards: Learning How to Learn

New technology is transforming American industry and its products, and the speed of this transformation appears to be still accelerating. New innovations continuously hit the economy, forcing changes in how and with whom we interact. One of the most dramatic innovations we are seeing is the speed and exceptionally low cost at which data and ideas are transmitted around the globe; this technological revolution is, more precisely, a revolution in communication technology. In a very real sense, it is changing the world of ideas in essentially the same way that railroads changed our conception of physical transportation.

What we may fail to appreciate fully is that workers are subjected to the same market forces that are thrust upon business. The revolution is transforming what workers do and how they do it. A technological revolution, in fact, is as much a transformation of labor as it is capital. We simply cannot conceive of changing one without also changing the other.

We all marvel at the new products and services that come from technological innovations. It is less easy to adjust to the way the technological revolution makes old ideas and old ways of doing things obsolete and the increasing speed at which it is doing so. Schumpeter's idea of creative destruction applies to knowledge capital as forcibly as it applies to physical capital. The labor market is churning, simultaneously creating new jobs and destroying existing ones. The lesson from previous technological revolutions is that we must not only appreciate this, we must embrace it as the necessary cost of progress.

New knowledge is being acquired and incorporated much more quickly than before. This means that the useful life of certain types of knowledge is rapidly shrinking. That is, our human capital can, and almost certainly will, depreciate quickly. In an environment where current knowledge rapidly depreciates and the skills necessary to excel in the workplace constantly change, the state's role in establishing policies that help the public accommodate change is essential.

The idea that change is an inevitable cost of progress is the single most important lesson for economic policymakers to grasp. Unfortunately, our legacy is exactly the opposite. Economic policy since the Great Depression mostly has been aimed at ironing out the ups and downs of economic performance. Such policies, in my view, are antithetical to change.

Consider that, so far at least, the technological revolution has been largely an American phenomenon. Since 1993, the U.S. economy has expanded at an inflation-adjusted rate of a little more than 25 percent. Growth in western Europe has been almost 10 percentage points below that, and the growth seen in Japan has been about one-third of what we've experienced here.

One explanation for the uneven distribution of the revolution's fruits around the globe is that foreign labor and capital markets are less flexible than those of the United States. The costs of a displaced worker in Europe and Japan are higher than in America and, consequently, the risks associated with new hires and new business startups are greater abroad than here. But these impediments to change abroad are disappearing. Some are being eliminated with the adoption of a more enlightened social and economic policy, and some are being forced on policymakers as the revolution finds ways to circumvent the obstructions in its path. All around the world, new technology is beginning to revolutionize labor policy, trade policy, tax policy, and even the services governments are asked to provide, including educational systems.

Early in the twentieth century, a great demand arose for workers who could not only provide physical strength, but could also read and calculate. Educational institutions responded, and high school enrollment rose. Today, roughly two-thirds of high school graduates enter college. And as I have noted, the earnings gap between college graduates and high school graduates continues to widen.

n Conclusion

In the end, no one will be left untouched by the revolution now underway. Labor and capital are both changing to assimilate this new technology in order to harvest all the fruits it has to offer. We in the public policy arena are merely the gardeners of that process. If we are to play a constructive role, we must nurture the fastest and most broadly accessible assimilation of the technology. At the Federal Reserve, we take comfort in the fact that we have entered this period with a stable currency, a sound banking system, and a highly efficient payment system.

The current revolution has offered the world new, previously unimaginable financial and monetary competitors. As the U.S. central bank, the Federal Reserve must either become an important part of the infrastructure that helps these new technologies take hold or watch its own usefulness ebb away. The only thing I am absolutely confident about is that we cannot know where this process will end and what the financial system will look like when the revolution has finally run its course. Once we understand that, the lesson for our institution, as for many others, is that continued success will depend upon our ability to learn, and relearn, and learn again.

n Footnote

1. From Gary M. Walton and Hugh Rockoff, *History of the American Economy*, Fort Worth, Texas: Dryden Press, 1998, p. 198.

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