10 Building an economy: Government planning vs. entrepreneurial innovation

> "Reconquer the domestic market!" is a rallying cry invented by the government in its effort to reduce France's foreign trade deficit and stimulate citizens to buy nationally-made products in preference to imports.[1]

While globalization has opened up markets everywhere, it has also thrown the inherent tension between government economic activism and entrepreneurial freedom into sharp relief. We now take up crucial questions about the proper role of government on the one hand, and the place, indeed the very future, of entrepreneurship on the other.

In our global economy entrepreneurs are frequently competing with companies supported and directed, and often controlled, by the governments of the countries where they do business. It is hardly an even match: such policies inevitably engender hidden or overt preferences for buying local products.

Clearly, state-controlled economies pose a serious challenge to the basic concept of entrepreneurship and the ability of foreign corporations to operate freely within those economies. By raising barriers to international sales opportunities, they clearly increase the inherent risks of launching new entrepreneurial businesses. Under such conditions, it is fair to ask whether the individualistic and "random" entrepreneurial process, gated by so many unpredictable circumstances, can be counted upon in the future as a significant economic driver. Must governments everywhere become much more involved in supporting ambitious entrepreneurs focused on creating new markets? This is a pressing issue for countries like the

[1] J. Gee, "Five year target for France," *Data Processing*, vol. 25, no. 9, November 1983, pp. 37–39.

US, which have a tradition of free markets and limited government support of their industries.

We opened this book on the entrepreneur in the global economy by outlining how governments involve themselves in building local economies. In Chapter 2 we looked at the importance of entrepreneurs in creating new companies and industries. The succeeding chapters tracked the fortunes of twelve entrepreneurs, from David Sarnoff of RCA in the first half of the twentieth century to Lynn Liu of Aicent at the opening of the twenty-first, as they strove to build competitive companies in an increasingly globalized economy.

In this chapter we will ask whether and how governments and entrepreneurs can coexist and cooperate, and explore the ramifications of that question. This covers such topics as, to what extent will governments take on the roles of venture capitalist and entrepreneur, choosing the technologies and building the industries of the future? In what areas is government participation most likely to be healthy and productive? How can entrepreneurs and corporations responding to market conditions make better decisions?

THE HAZARDS OF TARGETING INDUSTRIES

To set the stage, we will review two diametrically opposed views of economic development, as described initially in our opening chapters. They represent the most extreme positions in the argument over industrial policy in the developed world: pure free markets versus heavy state involvement.

There is plenty of public support for an untrammeled entrepreneurial approach. Free-market advocates insist that the US government (and by extension governments in other free-market countries) should stay out of the markets and let entrepreneurs chart their own course. According to these proponents, "The country needs to unleash entrepreneurs, who will only be held back by tax-funded make-work projects."[2]

[2] E. Glaeser, "Detroit's decline and the folly of light rail," *The Wall Street Journal*, March 25, 2011, p. A17.

Others question the efficacy of this approach. They believe that the idea that "entrepreneurs are the foundation of the [US] economy" is a myth,[3] and that the US and other free-market countries might be better off with a targeted industrial policy to ensure the growth (and protection) of domestic industries, particularly new ones based on domestic innovations.

A better way to frame the argument is to ask the following question. Is it realistic to believe that government planning, supported by taxpayer money, can force-feed industrial innovations into the commercial marketplace? Can it totally replace the more chaotic but much more flexible and dynamic entrepreneurial process?

As an approach to answering this question, it is worth keeping in mind the observations of Nassim Taleb in his book *The Black Swan*,[4] in which he summarizes the views of Nobel Laureate economist Friedrich August Hayek, a famous proponent of the free market.

> For Hayek, a true forecast is done organically by a system, not by fiat. One single institution, say, the central planner, cannot aggregate knowledge; many important pieces of information will be missing. But society as a whole will be able to integrate into its functioning these multiple pieces of information. Society as a whole thinks outside the box. Hayek attacked socialism and managed economies. Owing to the growth of scientific knowledge, we overestimate our ability to understand subtle changes that constitute the world, and what weight needs to be imparted to each such change.[5]

On a theoretical level, then, there are limits to what can be done with "top-down" economic planning. Hayek suggests that any attempt to dictate a national approach to a dynamic market will be

[3] R. Foroohar, "Don't hold your breath," *Time,* June 20, 2011, pp. 22–26.

[4] N. S. Taleb, *The Black Swan* (New York: Random House, 2010), p. 180.

[5] See F. A. Hayek, *The road to serfdom* (Chicago, IL: The University of Chicago Press, 1994), for a statement of his positions.

unsuccessful in the long run. Instead, the most productive strategy for fostering economic growth is likely to be the creation of national policies that focus government on what it does best, leaving private capital and entrepreneurs to areas where they function more efficiently. We will clarify the dividing line between these two spheres by looking at some examples of government actions and their outcomes.

Government as entrepreneur

On the face of it, it seems like a good idea to have the national government fund the creation of industries around promising technologies in the hope of expanding the economy and building exportable products. Proponents of this approach envision using subsidies and other incentives to accelerate the growth of the chosen industries. This would be done in partnership with private industry if possible – and without it if private funding is not available.

This may sound familiar because it is an old idea. We encountered it in our discussion of Colbert, who targeted growth industries for seventeenth-century France. China runs a modern version of the strategy.

Although this approach can achieve quick success, it usually runs into trouble later on. The availability of "easy" state money spawns enterprises with uncompetitive cost structures. They become too far removed from the discipline of the competitive marketplace to achieve profitability. Bereft of entrepreneurial management, companies built on this model risk becoming permanent wards of the state. This actually happened in Colbert's France.

There is a bigger problem with this approach: it too often fails, especially when newer technology is introduced. We can understand why when we contrast industrial development with infrastructure and defense, two functions crucial to economic growth and stability that governments can carry out quite effectively.

Infrastructure (roads, airports, and water and power utilities) is convenient for the citizenry – and absolutely necessary for industrial development. Likewise, defense programs uphold national security – and also spur the growth of industry by underwriting R&D programs. Even the most radical proponents of limiting the power of government would agree that both of these activities are the rightful province of the state. Governments are the only entities with the resources to plan and finance such sweeping programs. They are also dealing with known quantities: it is relatively easy to project infrastructure requirements and forecast future defense needs.

Deciding which new innovative industries to subsidize, on the other hand, is a far less certain undertaking than determining when and where people will need roads and sewers. It is nearly impossible to predict future market trends and competitive threats with any great degree of accuracy. As a result governments are notoriously poor at picking winning new commercial industries for long-range development. Such attempts have often generated disappointing results.

Long-term planning, longer odds

There is another reason why governments have such a poor track record in planning technology industries: the nature of their decision-making process. They are not the only entities affected by this shortcoming. It is common in large corporations as well.

As can well be imagined, thousands of planning meetings take place every day in large organizations around the world, with committees deciding economic and technological matters large and small. Whether these meetings occur in the government bureaucracies of planned economies or in the boardrooms of large corporations, one thing is certain. Lone visionaries, even if present, have little chance to influence the ultimate decision. In addition, most of the people in the room will be far removed from the actual technologies under discussion.

Yet funding decisions must be made, often long in advance. And unfortunately what appears to bureaucrats or board members to be the low-risk approach has a good chance of being the wrong path to take. That is why so many radical innovations come from individuals or small independent teams. They have the freedom to assume risks of their own choosing and the financial freedom to fund programs that balance high risk against high rewards. They also have the flexibility to modify their decisions quickly, without waiting for the next budget cycle.

Planning industrial development is no task for the faint of heart. But countries have to place their bets and take their chances in the competitive global market. The question is how do governments in open economic systems like the US establish policies and fund programs that lead to innovative businesses, without trapping themselves in dead ends.

One would think that a country like China, which has had great success with a planned economy, would have an answer. But even China understands the difficulty of long-term industrial planning. For example, its first five-year plan of 1951 called, among other things, for 6 million tons of cement, 5 million tons of pig iron, and 4.2 million tons of steel. These objectives were achieved because the state paid for the construction of the plants required to produce these products, and the technology was acquired from foreign sources.

But things have changed since then. In what is now the second largest economy in the world, the multitude of industries and priorities are too complex to be sorted out by state planners. Now China's five-year plans target only industries deemed to be of major strategic importance. Hence, the twelfth plan (2011 to 2015) puts great emphasis on broader issues such as employment, energy efficiency, increased funding of research and development, the expansion of top-quality universities, and environmental improvements.[6]

In spite of the pitfalls of planning by committee, critics of the free-market model worry that the transition from innovation to commercialization, when paced by the capitalist profit motive, is too slow in countries such as the US. They call for a more focused

[6] "A new epic: China's new five-year plan is at odds with itself," *The Economist*, October 23, 2010, p. 88.

national industrial policy helped along by government funding, which they feel is essential to accelerate the pace.

People who advocate this approach are basing their recommendations on the rapid growth of China and its perceived ability to quickly build industries practically from scratch. In their enthusiasm they tend to gloss over the gap between China's more predictable path of importing existing technology as opposed to the chancy nature of developing innovations.

In defense of government planners, however, they may not be much worse at forecasting the future of transformational technology than the private sector. We will have occasion below to judge the efforts of analysts and technology experts outside the government in predicting which innovations will have a serious impact on the economy. Nor should one assume that government investments in technology never deliver positive results. We will also highlight cases where government involvement has produced truly transformational technology.

However, history is littered with the remains of failed state-funded industrial initiatives.[7] One such case is especially interesting in that it concerns France, a centuries-long bastion of state planning.

Targeting growth industries: A government goes it alone

In 1983, in an effort to develop new growth industries that could compete with foreign firms (see the quote that opens this chapter), the government of France launched a five-year, $20 billion program to stimulate the development of domestic information technology companies. Its program targeted computers, semiconductor components, and industrial software. At the time all of those fields were dominated by the US.

The program also included funding for the expansion of Minitel, a new videotext service pioneered in France. Minitel used a

[7] Josh Lerner of the Harvard Business School discusses salient examples in *Boulevard of broken dreams* (Princeton, NJ: Princeton University Press, 2009).

combination of television and the telephone system to interactively provide information to homes and businesses across the nation.

It was not surprising that France should target specific industries for investment. This approach was consistent with the country's history of state industrial planning and financing, starting with Colbert in the seventeenth century. What was surprising was the program's lack of success.

- French computer companies were never able to keep pace with the rapid international progress in the computer industry. The national champion, Groupe Bull (named, ironically, for its Norwegian founder Fredrik Rosing Bull), was nationalized in 1982 and re-privatized in 1994. It has undergone many takeovers, mergers, and name changes, including joint ventures and ownership relations with overseas companies General Electric, Honeywell, NEC, and Motorola. Now called simply Bull, it remains a marginal competitor in need of state support.
- During the semiconductor industry's greatest growth period, between 1980 and 2000, France remained a minor player. Thomson Semiconducteurs, the leading French chip company, merged with Italy's SGS Microelettronica to form SGS Thomson in 1987, but sold its ownership share in 1994. Meanwhile Japan and Taiwan joined the US as major global chip suppliers.
- France developed many niche players in industrial software, but the US raced ahead, and Germany's SAP proved to be a world-class enterprise software innovator.
- Although Minitel was a truly innovative service and did achieve some popularity in France, it was eventually overwhelmed by the success of the Internet – a technology unknown in 1983. The obsolete service was officially terminated in 2011.[8]

Among many explanations for these disappointing results, one key factor, we believe, was insularity. France's program focused on funding domestic companies to execute the turnaround of the computer industry. Its intent was to boost French industry by relying as much as possible on French resources.

[8] M. Cochester, "France Telecom will bid adieu to Minitel," *The Wall Street Journal*, July 25, 2011, p.B4.

Another factor was the program's reliance on established (one might say ossified) providers. No new entrepreneurial ventures were in the equation. It was a state initiative, rife with the bureaucratic malaise that such programs commonly entail. The French authorities ignored the example of Colbert, the finance minister who had vigorously recruited foreign entrepreneurs to bring in new technical talent and start new companies in seventeenth-century France.

Contrast this failed effort with what some other countries were doing during the same period, and with the results they achieved.

- Entrepreneurial activity in the US, substantially funded by venture capital, led to an explosion of new businesses, many of which became world leaders in their categories.
- During the same period Japanese companies imported foreign technology under license to get started. They then used domestic product development to fuel the growth of world-class businesses such as Fujitsu, Toshiba, and NEC.
- Taiwan's semiconductor industry began with foreign technology, with RCA a major licensor, giving TSMC and other semiconductor companies the foundation they needed for success.

Targeting growth industries: Government teams with the private sector

When state initiatives to develop new industries fail, it is the taxpayer who foots the bill. Where the government has recruited private capital and entrepreneurs to join such initiatives, however, the economic effects are amplified. Entrepreneurs and their investors are left stranded along with the taxpayers, potentially affecting the availability of funding for other, more promising innovations. Three US government "clean energy" programs illustrate how this can happen.

Clean energy is currently one of the most popular areas for investment, so it was easy to persuade private investors and companies to participate. All the programs were targeted at reducing fossil fuel consumption and controlling greenhouse gas emissions, though in very different ways. Two programs addressed the electrical utility industry, while the third subsidized sales of hybrid electric automobiles.

Of the two programs targeting electric utilities, the first sought to replace non-renewable fossil fuels (oil and coal) in power plants with biomass (wood and other organic materials). Biomass was touted as a "clean" and renewable energy source.

The other program aimed to build a so-called "smart grid" to improve the efficiency of the electrical power distribution network. With a more efficient grid, the electric industry could meet the demand for power with less fuel. Both programs had the worthwhile goal of reducing the amount of CO_2 spewed into the atmosphere by generating plants.

These initiatives were in line with other programs intended to combat global warming and reduce energy consumption, then under way around the world. It is estimated that global funding for such efforts reached $200 billion in 2010, a nearly fivefold increase from $44 billion in 2004. This figure includes private investments as well as government funding.[9]

In the US, however, private funding for energy-related R&D was on the decline. It dropped 50 percent between 1991 and 2005.[10] In response, in 2009 the Department of Energy allocated an incremental $5.4 billion for development of renewable energy sources. Part of that funding went to the biomass program, created to encourage electric companies to use biomass in place of fossil fuels. This was in line with an initiative supported by Congress as far back as 1978 to reduce the country's reliance on imported oil. Private investors invested substantial funds as well, in anticipation of a major business opportunity from a new generation of power plants that could use renewable fuels.

The program's success depended on widespread adoption of the new technology. To make the desired impact on reducing fossil fuel

[9] "Climate change," *The Economist*, November 29, 2010, pp. 59–61.

[10] D. M. Kammen and G. F. Nemet, "Reversing the incredible shrinking energy R&D budget," *Real Numbers*, 2005.

consumption, electric utilities would have to generate at least 25 percent of their power with biomass fuels. Unfortunately, it is more expensive to use biomass than fossil fuels. That means biomass-fueled electrical generation simply isn't profitable without charging businesses and consumers substantially more for electricity. Without increased prices for power, there was little incentive for utilities to make the switch.

Private investors had assumed state regulators would make biomass plants profitable by permitting utilities to raise their electricity rates. They did not take into account the difficulty of forcing through a utility price increase, at least in a democracy. Electricity rates in the US are largely set at the state level by a utility commission. Most commission members are political appointees, and revising rate structures is an inherently political process. Consumers may consider clean energy a worthy cause in the abstract, but when it came down to paying more for electricity, their resistance to price increases was fierce. To complicate the matter, opponents found other good reasons to hinder the profitable operation of biomass plants.

Most state regulators took the path of least resistance, and did not implement mandates forcing the use of biomass fuels. To further frustrate program proponents, operating costs for the new biomass plants that actually got built turned out to be even higher than anticipated.

Finally, with the public increasingly concerned about air pollution from burning biomass fuels, state officials issued costly new regulations to control emissions from generating plants that used the new technology. For example, the Massachusetts Department of Energy Resources decreed that biomass power plants had to increase their efficiency by 60 percent to reduce their level of pollutants. This was not practical. They also required extra filtration of emissions, which increased the cost of building such plants.

With these and other obstacles to profitable operation in their path, by 2010 biomass-fueled electrical generation plants were being phased out as uneconomical. In one case Sierra Pacific Industries of California closed down a 16-megawatt plant because environmental restrictions made it difficult and costly to obtain wood from forests.[11]

Our second program, the "smart grid" initiative, offers another object lesson in the difficulties of forging a public/private partnership to develop a new approach to business. Partly funded by the Federal government, this program had the goal of improving the efficiency of electrical power generation by two means: using new metering technology in homes and businesses; and improving communication and control in the power generation distribution network.

One of its goals was to reduce demand for electricity during peak periods, such as warm summer afternoons when air-conditioning use is at its highest. Utilities have to maintain "peaking capacity" to meet this demand, an expensive resource that otherwise stands idle. If they could even out demand across the day, they would not have to maintain as much peaking capacity, reducing the overall cost of generating electricity.

The "smart grid" initiative called for new electric meters, called "smart meters," as part of the solution. These devices not only record how much power consumers use over the course of a day and billing cycle, but show consumers how much electricity they use at different times of the day. With "smart meters" in place, utilities could institute a policy to charge more for electricity used during peak periods.

Planners assumed that if consumers knew they would be charged more for electricity during peak periods, they would shift chores that require a lot of electricity to times when rates are lower. For example, they might run washers and dryers at night instead of during the day. The architects of this initiative believed that consumers would welcome this scheme because it gave them some

[11] J. Carlton, "(Bio)mass confusion: High costs and environmental concerns have pushed biomass power to the sidelines in the US" *The Wall Street Journal*, October 18, 2010, p. R5.

control over the price they paid for electricity and could lead to lower electric bills.

With this noble objective in mind, the Federal government set aside $3.4 billion in 2009 to help fund home installation of the smart meters. Since these new devices have built-in communication capabilities, utilities can read them remotely in real time, and give consumers timely access to data on their electricity use.

Given the tens of millions of homes and businesses where meters can be installed, this represents a multi-billion dollar opportunity. Its enormous potential attracted many companies, including startups, to offer the new smart meters and the communications links needed to connect them to the utilities. Of course the utilities expected that the net cost of the meters (after Federal subsidies) would be passed on to their customers.

It sounded like a good program for everyone concerned: utilities would achieve more efficient power use, consumers smart enough to time-shift their use of major appliances would get lower-cost electricity, and meter providers would rack up sales and profits.

However, it didn't quite turn out that way. In a classic clash between an obvious public good and public unwillingness to pay for it, consumers rebelled. While smart meters have been deployed on a small scale in some states, legal actions in California and Hawaii, among other places, have blocked their mass deployment. Consumers simply don't want to pay for them, directly or indirectly.[12]

Eventually smart meters will very likely be deployed more widely, as they are now in some parts of the US and other countries. But their spread will be at nowhere near the rate anticipated by the promoters of the government's smart grid plan, or by investors in the companies trying to benefit from a national program.

We come now to an example of industrial planning that is more familiar to and more popular with the average consumer: the Federal subsidizing of plug-in electric automobiles. We are not talking about

[12] See report in *Bloomberg Businessweek*, September 26, 2010, pp. 44–45.

funding research and development here. (The US Department of Energy did in fact provide low-interest loans to two electric vehicle startups, Tesla Motors and Fisker Motors, for product development, but it is too early to assess the success of this investment.) Our topic is the government rebate of part of the purchase price of electric cars, which is given directly to consumers. About $5 billion has been allocated by the government for this purpose, all in the spirit of reducing oil consumption and helping to create a cleaner atmosphere.

These automobiles exhibit a very limited degree of true innovation. The core enabler is a new generation of a very old product: storage batteries. Advances in battery technology are making such slow progress that one can question whether the cars they power actually represent a new generation of products with long-term value.

Whatever the answer to that question, one thing is certain. With the possible exception of the very expensive Tesla roadster, which claims to travel 245 miles on a full charge, electric vehicle driving ranges are too short to make them credible competitors to gas-powered vehicles. Nissan's Leaf, an all-electric car, requires four to eight hours of charging on a 220-volt circuit to travel 100 miles or less. Its American competition, the Chevrolet Volt, runs only 35 miles on a fully charged battery pack. A built-in gasoline-powered generator extends the Volt's range to 300 miles, but during that operational mode it is not a true plug-in electric. (Fisker's Karma automobile is similar in range and operation to the Volt.)

Given their limitations, electric cars are very much a niche product. Without subsidies it is highly unlikely that they would have been introduced to the general market.[13]

These Federal initiatives show what happens all too often with government plans in a country like the US, where promulgating new industrial standards or forcing people to buy products is not a simple matter of a decree from Washington. Because these initiatives tried

[13] M. Ramsey, "Bumpy road for electrics: Boosters see bright future for battery cars, but some say drawbacks too severe," *The Wall Street Journal*, October 18, 2010, p. B1.

to mandate innovations without taking into account public resistance to their cost or negative consequences of their implementation, they were pre-ordained for failure.

All three programs did some things right: they were conceived for a worthwhile purpose; they displayed a vision, however limited, of the future; and they created new business opportunities for innovators and entrepreneurs. Yet they were by no means as successful in driving new business as the planners or the entrepreneurs who bet on them could have hoped. The energy-related initiatives have been a disappointment, and the success of electric cars is still in doubt. This is all a result of factors outside the control of the Federal government or of entrepreneurs.

Before leaving this topic, it is worth noting that as subsidized industries build constituencies, they have a way of becoming entrenched, leading to misallocation of resources. A case in point is the US Federal program to subsidize the production of ethanol from corn. Started in the 1970s in the midst of the oil embargo, this program was aimed at reducing America's dependence on foreign oil by providing a substitute fuel that could be produced from a major US crop. In addition, ethanol was thought to be far less polluting than oil. Huge private investments were made to build plants to produce it, and its use was mandated by law.

But here is what an original proponent of this program, former US Vice President Al Gore, had to say about it in 2010: "The benefits of first-generation ethanol are trivial … but it's hard once such a program is put in place to deal with the lobbies that keep it going." Corn producers are strong supporters of this program, and of course the powerful farm lobby is intent on retaining the subsidy. Yet not only is ethanol not delivering the expected benefits, it is now believed to contribute more greenhouse gas emissions to the atmosphere than fossil fuels.[14]

[14] "Al Gore's ethanol epiphany," *The Wall Street Journal*, November 27–28, 2010, p. A16.

WHY LONG-RANGE TECHNOLOGY PLANNING IS SO CHANCY

So far our examination of the uncertainties of industrial planning has focused on market misreadings by the planners, and on the impediments to progress that a democratic society can place in the path of government initiatives. Now we turn our attention back to the central issue of industrial innovation: selecting new technologies that show promise as the basis of new industries.

People who undertake this task face a different set of issues from the ones industrial planners take for granted. They are dealing with technology in the early stages of development, when much of its potential has yet to be revealed, and before it has been tested in the market.

As already noted, picking winners is very hard. So hard, in fact, that forecasts from experts in the private sector as to which technology will succeed are not much better than those of government planners. As proof, here is a salient example from the not-so-distant past.

In 1995 *Scientific American* devoted an issue to "Key technologies for the 21st century." In his introduction to the survey, Paul Rennie, editor of the magazine, cautioned the reader on the hazards of technology prophecy.

> "The future is not what it used to be," wrote the poet Paul Valéry decades ago, and it would not be hard to share in his disappointment today. As children, many of us were assured that we would one day live in a world of technological marvels. And so we do – but, by and large, not the ones foretold. Films, television, books and World's Fairs promised that the twilight of the 20th century and the dawn of the 21st would be an era of helpful robot servants, flying jet cars, moon colonies, easy space travel, undersea cities, wrist videophones, paper clothes,

> disease-free lives and, oh, yes, the 20-hour work week. What went wrong?
>
> …
>
> Of course, many technologies do succeed wildly beyond anyone's dreams … In fact, it is tempting to think that most great innovations are unforeseen, if not unforeseeable … The truth is that as technologies pile on technologies at an uneven pace, it becomes impossible to predict precisely what patterns will emerge.[15]

Rennie went on to assert that technology predictions fail for many reasons. He cited such factors as practicality (the jet-pack looked good in theory but proved unusable in the field) and an overly optimistic assessment of how fast a technology will advance. But the biggest reason why forecasts are inaccurate is that they are, in his words, "simplistic, and hence unrealistic," failing to take into account the challenges a technology will face from market forces, economic conditions, public policies, timing, fashions, and more.

For example, visions of industrial robots taking over the work-place have been tempered by the fact that they are too costly for many applications. Likewise, the exotic (and expensive) materials that experts once thought would replace silicon in semiconductor chips were relegated to niche applications as more advanced silicon chips matched their capabilities.

Looking back at visions of the future

To really appreciate how hard it is even for experts to predict which technologies will shape the future, it helps to look at predictions by some of the smartest people of a prior era. In spite of his cautions about the enterprise of prophecy, Rennie – give him credit for great courage – nevertheless assembled a set of predictions around

[15] P. Rennie, "The uncertainties of technological innovation," *Scientific American*, September 1995, pp. 57–58.

several areas of technology. So we will see how the predictions of 1995 compare to the reality of 2011.

- *Information technology*. Only two technologies mentioned in this area have continued to create enormous economic value. Driven by steadily advancing manufacturing technology, microprocessors have evolved in complexity and value creation more or less as indicated by what has become known as Moore's Law. Wireless networks, the second technology, have become an increasingly important part of computer technology. The other five technologies singled out for future importance have not lived up to the hype. These include artificial intelligence and virtual reality.
- *Transportation*. None of the predictions have panned out. High-speed rail systems still use steel wheels and rails, not superconducting schemes, for support. None of the few maglev trains built up to now has demonstrated any significant advantage in speed over a conventional high-speed train. As for customized automobiles, they never happened. Nor have any revolutionary commercial airliners been built. Boeing's 787 Dreamliner, which went into service in 2011, is only an evolutionary advance over previous airplanes. Its development took ten years and billions of dollars in cost overruns.
- *Medicine.* Gene therapy has proven to be a continued investment area, though practical results are still in the future. No artificial organs are even close to replacing the use of transplanted real organs.
- *Machines, materials, and manufacturing*. Here the miss is almost total. Self-assembling materials and high-temperature superconductors are still not commercially significant technologies.
- *Energy and environment.* Solar power is beginning to make an impact in the field of renewable energy, but hydrogen fusion, which attempts to replicate the energy production process of stars, is as far in the future as ever.

A list of the technologies that were not highlighted or mentioned in these visions of the future, but did prove successful, would be just as revealing as the miscast predictions. For example, the forecast of a wireless future envisioned the use of *satellites* for general broadband data communications. In fact, broadband data now reaches consumers through telephone, cable, or fiber optic lines, and through the cellular wireless network. But the biggest miss of all is the fact that the Internet is not featured as an innovation with enormous transformational impact.

It would be comforting to think that the *Scientific American* missed so many of its predictions because it chose visionaries with unorthodox views about the technologies of the future. But that was not the case. The magazine selected highly respected experts to present their views in each technical area.

As a further demonstration of how inaccurate visions of the future tend to be, we will consider a set of predictions from another group of respected experts, also issued in 1995. It was published as a *Technology Forecast* by Price Waterhouse (now Price Waterhouse Coopers), the well-known accounting and consulting firm.[16]

This thick, 650-page tome includes predictions on the likely direction of information technology over the coming years. While its forecasts of evolutionary changes turned out to be right on the money, it notably missed the Internet and its related applications. Also missing is data virtualization – a technology that has revolutionized the use of computer systems in data centers.

INDUSTRIAL PLANNING VS. TECHNOLOGY FUNDING

Up to now we have looked at the difficulties of industrial planning. We have also reviewed the dismal record of planners and prognosticators in accurately predicting which technologies would prove successful in the marketplace. Fortunately, there are positive aspects to the planning process. These include government policies that recognize how important entrepreneurship is to economic development.

As observed before, entrepreneurs do not generate new businesses in a vacuum. They need access to intellectual property developed by others on which to base product offerings. They have

[16] Technology Center, *Technology Forecast 1995* (Menlo Park, CA: Price Waterhouse World Firm Technology Center, 1995).

to identify and exploit promising new markets, develop funding sources, and attract talented employees. And contrary to myth, they rely heavily on the infrastructure, resources, and business environment established by government.

Even in free-market countries like the US, the government has more involvement in the development of new industries than most people realize. We saw how David Sarnoff took advantage of cooperation between the US government and private companies in the 1920s to create the broadcast industry as we know it. Without the original government initiative to establish RCA, he would not have had the opportunity.

Of the entrepreneurial innovators we cover in this book, Sarnoff is the earliest by some sixty years. But he took full advantage of government policies and funding, and US entrepreneurs have followed his path right up to the present.

To prove the point, consider a prominent example from our own era: the digital industries pioneered in the US after World War II. Everyone talks about the famous entrepreneurs who created iconic companies such as Apple and Microsoft, but few mention that these and many other enterprises had their genesis in technologies developed under government-sponsored R&D funding.

Many of the companies we discuss in this book replicate the pattern. The technology that underlies RMI, RDA, and SanDisk can be traced to government-funded initiatives if you go far enough into the past. In the case of Ness Technologies, the roots of some of the technologies it commercialized can be traced to work sponsored by the governments of Israel and other countries.

This research was conducted under government funding in universities, national laboratories, and private industry, and originally may have been targeted at applications in the defense and space programs. But somehow the resulting technologies, developed in unrelated settings for different purposes, found their way to the world market. The results were spectacular: the creation of new electronics, computer, and telecommunications industries that have literally transformed the way people live, work, and communicate.

Non-commercial planning produces results

When a controlled economy like China's is slowly backing away from detailed targeting of industries for development, what course should relatively free economies like the US or the UK take? They already do extensive planning and resource allocation in areas of national concern such as defense and infrastructure. Should they increase their role to include general industrial development?

It is not true that free-market governments never become involved in industrial activity. They always get involved during wartime, when resources are mobilized for expanded weapons development and production, and for meeting communications, transportation, and logistics requirements. These projects are generally successful, in large part because the customer base for defense products is well defined, as are the applications.

But peacetime targeting of industries in commercial markets is an entirely different matter. It involves understanding market opportunities, competitive costs, and international trade issues. This is not something that bureaucrats are particularly noted for, as seen in the US government's abortive entrée into environmental projects. Where, then, can government planners make a positive contribution to industrial development? A look at history gives us some answers.

Starting in the 1960s, US government funding of research and development played a key role in developing a number of innovative technologies that revolutionized whole industries. Government planners did not directly target the building of modern US industry, but their role was indirectly important nevertheless. Technologies initially intended for defense and space applications ended up in the commercial world.

Once the technologies were in place, they were seized on by private capital for commercial exploitation. Further development and commercialization of many of these technologies was carried out by privately funded research. The resulting products and services built companies and industries that became the envy of the world.

Cold war R&D

Take, for example, the great entrepreneurial successes that built the foundation for the commercial digital revolution in the US after the 1970s. They were built on core technologies developed under federally funded, defense-related initiatives aimed at increasing the military capabilities of the US in the face of a perceived threat from the Soviet Union. These initiatives were focused on advanced computing technology, semiconductor devices to enable those computers, and such communications technologies as satellites, fiber optics, and lasers.

Another good example of a government initiative with huge (unplanned) commercial impact was the Apollo space program. Launched under the Kennedy administration in 1961, its goal was to land a man on the moon within a decade. Creating the manned space capsule required rapid development of such new electronic technologies as low-power, high-performance computing devices, software, and instrumentation.

This meant creating more and more powerful chips and other devices. As a result, the Apollo program gave enormous impetus to advances not only in rocket technology, life sciences, and support systems, but in microelectronics, displays, and light-emitting diodes (LEDs). R&D contracts to develop these technologies were let to universities, national laboratories, research institutions, and corporations. The technological fallout from that work ultimately infiltrated the commercial marketplace.

By any measure the government's investment in the technology of space flight reaped huge returns. One estimate of the benefit of the Apollo program is that for every dollar of R&D spent, seven dollars came back to the government in the form of corporate and income taxes from new jobs and economic growth.[17]

Building the digital domain

We cannot leave this topic without mentioning the government initiative that yielded the biggest commercial impact, the Internet.[18] Now the universal global medium for communication and commerce, the Internet took almost thirty years from conception to commercial reality. It was started not for a commercial purpose, but to address a specific communications problem among researchers.

The Internet as we know it grew out of a novel network, originally conceived by computer scientists in 1964, designed to let computers communicate. Its creators envisioned it as a communications facility for research institutions. They never imagined that it would spread outside the research community to become a major force in the world economy.

Actual deployment of such a network became possible only because of the independent invention in 1962 (published 1964) of an early version of a packet-based digital communications software protocol, which eventually became the IP (Internet Protocol). As proof of the capricious nature of R&D, the contribution of IP to the Internet came as a result of an unrelated Department of Defense (DoD) research program funded at the RAND Corporation. The rationale for this program was the need for robust military communications to minimize disruptions to the system.

DoD's Advanced Research Projects Agency undertook the actual management of the first network to link research laboratories. This network, called ARPAnet (later DARPAnet), eventually became available to the general public as the Internet. It is noteworthy that AT&T, then the monopoly owner of the US telecommunications

[17] www.thespaceplace.com/nasaspinoffs.html, accessed November 6, 2010.

[18] An excellent review of the history of the Internet can be found in J. Naughton, *A brief history of the future: The origins of the Internet* (London: Weidenfeld & Nicolson, 1999).

industry, refused to operate such a network for fear of creating competition for its established voice and data network (so much for visionary thinking in monopolies).

Chips and lasers

Among the other notable outcomes of R&D funded under government defense and space programs were the standard manufacturing process for integrated circuits and commercially feasible lasers. Both innovations were developed at RCA, the company built by David Sarnoff.

Today practically all chips produced worldwide are made in the CMOS process. But it began as a DoD project at RCA in the 1970s. DoD wanted to explore the possibility of creating computing chips with lower power dissipation than the then-current technology could produce. After successful completion of the project, CMOS technology was used to manufacture chips for avionic radar systems, among other applications. It found its way into the commercial market in the 1980s.

Our second example, the development of semiconductor lasers at RCA Laboratories, was a program I headed. The pioneering work on this technology was originally funded in the 1960s by DoD to develop infrared searchlights that could illuminate a battlefield, but would be invisible to the naked eye.

As the technology progressed in the late 1960s and early 1970s, it became clear that it would be possible to use such lasers in fiber optic communications and other systems. RCA announced a commercial laser in 1969 that was based on technology developed largely under DoD funding.

In two earlier books[19] we have described how thousands of entrepreneurs with access to private venture capital seized the

[19] See H. Kressel and T. Lento, *Competing for the future: How digital innovations are changing the world* (Cambridge: Cambridge University Press, 2007); and *Investing in dynamic markets: Venture capital in the digital age* (Cambridge: Cambridge University Press, 2010).

opportunity to develop pioneering commercial products around electronic technology that had been partly or fully developed under government funding. For example, several companies were founded to capitalize on the semiconductor laser and its applications. As a result, it appeared in numerous applications over the next few years.

Companion technologies also sprang up that greatly expanded the ways in which lasers could be used. This led to their current status as not only the key to all fiber optic communication systems, including voice and data networks, but as the enabling technology of millions of instruments, DVD players, and a host of other devices.

Government research and commercial innovation

Do these examples of government-funded technologies seeding great industries constitute a unique set of events, or are they representative of a highly effective approach to industrial development? Free marketers and proponents of state control may debate that question, but the fact remains that government-sponsored research and development does eventually migrate into the commercial and industrial markets.

In the US, at least, the government is still a major funder of innovative R&D that has broad applicability outside narrow defense applications. The 2010 US Federal R&D budget of $147 billion covers a vast scope of activities, from medical science to new sources of energy.

Corporate funding of basic research, on the other hand, has waned. Corporations are focused on product-oriented development programs aimed at producing quick results in the marketplace. They are much less invested in long-horizon projects that may or may not produce breakthrough innovations.

One recent study by Block and Keller, published in 2008, offers a view of the sources of industrial innovation in the US between 1970 and 2006. It confirms the increasing importance of government funding for R&D, and the continuing abdication of the field by corporate entities. During this period, as documented in the study, large firms contributed a declining fraction of the innovations, consistent with the decline in corporate research laboratories, while government-funded contributions from universities and national laboratories increased. Block and Keller sum up the situation this way: "If one is looking for a golden age in which the private sector did most of the innovating on its own without federal help, one has to go back to the era before World War II."[20]

SUMMING UP

Government policies play an important role in determining a nation's industrial destiny, no matter what that nation's professed economic philosophy might be. China achieved resounding success in industrializing its economy through a tightly targeted form of "top-down" industrial development.

These policies can change over time to reflect national priorities. In the hopes of generating industry from its own innovations, China is now backing away from its highly prescriptive model to allow a greater degree of "bottom-up" initiative. It may have no choice. In a world where innovation is a key driver of long-term industrial success, government must promote policies that encourage creative entrepreneurship while avoiding, in general, targeting of specific product initiatives.

One such policy is the funding of basic technology development. This approach has paid off handsomely for the US in the past, and will continue to do so in the future. But just generating technology is not enough for economic value creation. The fruits of R&D investments must move into the marketplace. That requires collaborative efforts between those who innovate and companies that can generate successful new products and services around their innovations.

[20] F. Block and M. R. Keller, "Where do innovations come from? Transformation in the US national innovation system, 1970–2006," *Information Technology & Innovation Foundation*, July 2008, p. 16.

We are back once again to entrepreneurship as an engine for economic growth. In Chapter 2 we outlined the positive impact that entrepreneurs can have on an economy. They create new companies or rebuild existing ones that drive innovation into the market, where it fails or succeeds on its own merits. If the new company's innovation is successful, it creates significant and lasting value. If the company fails, it makes way for the next company with the next big idea. Firms created by government action, by contrast, tend to persist long after they have outlived their usefulness.

Government can support businesses through creative industrial programs like those of the Fraunhofer Institutes, also discussed in Chapter 2. Under this arrangement the German government helps fund collaborative development between the Institutes and small and medium-sized companies. Normally such companies could not afford an ongoing innovation effort. By sharing a technology development resource, they can stay competitive. If they are startups, this arrangement gives them the opportunity to develop products that can compete in the global market.

Government-funded R&D programs and mechanisms for supporting businesses have proven highly successful as foundations for new companies and new industries. This only bolsters an already solid case for the continued importance of entrepreneurs in taking innovations to market. How entrepreneurial activity should be funded, however, is a source of significant disagreement among economic theorists.

Some point to the level of global competition, and the growing number of countries that directly underwrite industrial development, as reasons for developed countries to fund the creation of new companies. They believe this is the only way they can build an industrial base that will sustain their economies and their continued prosperity. Others maintain that this role should be assumed, as it has been historically, by private companies and entrepreneurs with funding from private sources.