Fostering Innovation

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Definitions

Innovation ... It is a word used in hushed, almost reverential terms today, often with confusion between invention and creation. They may seem to be the same, and in modern business language are often confused, but they are very, very different.

Genuine creation, in the original sense of *creatio ex nihilo* — something from nothing — is very rare and often most appropriately used in art rather than commerce. The painter paints on a blank canvas, the writer on a blank screen. When they are done, there is something where there was nothing. Innovation, by contrast, is actually the process that best describes the progress and accretion of knowledge and technical progress in human history.

Another very important way to think about innovation is to compare it to invention. We celebrate inventors: Leonardo, whose ability to conceive seems, even now, otherworldly; Thomas Edison, whose work covered generating electricity, electric light bulbs, and movies (it is worth noting here that a place called Hollywood was started by renegade film makers who did not want to pay royalties to Edison's company for using its products, and one has to wonder how many studio executives, producers and directors today know that).

Yet invention, which can be startling and world changing, is not creation *ex nihilo* any more than innovation is. Leonardo lived in a world where his ability to imagine what could be done outstripped what was possible with the technology and knowledge of the time (Leonardo's notebooks sketch ideas for a helicopter, a kind of machine gun or multi-shot weapon, a submarine and a tank, among many others). Edison lived in a world looking for solutions to gas lighting, a world that had already seen a more primitive version of moving pictures (the kinescope was one).

The difference is profound and entire, for invention to move beyond imagination there must be a whole infrastructure/ecosystem that can support the new invention (or it must be possible to create one — an example of this is mobile phone networks in countries and places that have never had fixed lines; it is cheaper and easier to build networks of mobile base stations than it is to run wires or fiber optic cables).

Examples

The steam engine is a good case in point. Although we normally think of James Watt as being the inventor, there were earlier, less efficient iterations (at least one dating back to the first century AD). The fact that there were so many attempts and niche iterations over the centuries shows that for a steam engine to be invented there were prerequisites that had to be in place first: access to iron ore (and some understanding of metallurgy), access to sources of fuel (in the case of steam first wood, then coal, then oil), sources of transportation (at the time in Europe, rivers were still primary arteries) to carry both ore and fuel, and there had to be demand. Watt's engine was patented in 1769. He had the singular good fortune to be working at the very beginning of the Industrial Revolution, when the demand for mechanized power had begun to soar.

In *The Most Powerful Idea in the World* (Random House, 2010), William Rosen writes of the beginning of the Industrial Revolution: "A skilled laborer, a weaver, perhaps, or a blacksmith in 17th Century England, France or China spent roughly the same number of hours at his trade, producing the same number of bolts of cloth, or nails, as his ten times great grandfather did during the time of Augustus." That would change. A steam engine on a raft becomes a steamboat, a steam engine on a horse-drawn cart becomes a locomotive. Looking back, the process seems as though it should have followed almost immediately.

That is partly true. In 1787, an American named John Fitch built a workable steamboat which sailed between Philadelphia and Trenton, New Jersey, but his venture failed. In 1807, Robert Fulton constructed a steamboat using an engine he had ordered from Watt and it traveled between New York City and Albany, New York.

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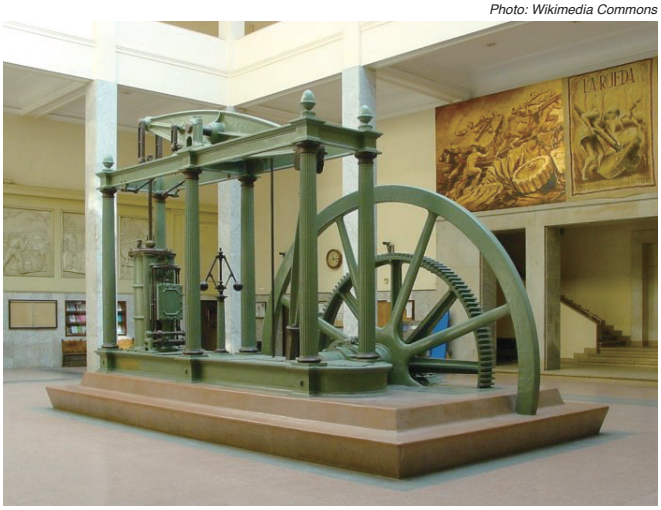

A beam engine of the Watt type, built by D. Napier & Son (London) in 1859

Steamboats had a very long stretch of development. Fulton's boat sailed around the same time as Admiral Horatio Nelson won one of the most famous naval victories at Trafalgar with a fleet of sailing ships.

Steam locomotives for rail also had a similar trajectory. The first full-scale working steam locomotive ran along a tramway in Wales in 1804.

The basic ideas were obvious, it was the sheer scale of innovation required to realize the ideas that was staggering.

Early steamships were paddle wheelers and still made of wood. They had limited range and no more storage space for food and water (nor means of preserving them) than their sailed predecessors had. They required regular and predictable refueling and resupply stops (and it was partly that necessity that brought Commodore Perry and the Black Ships to Japan). Their hulls were still wooden. There are many illustrations of the strange hybrid warships that emerged; some had, in addition to paddle wheels, full sailing rigs (in case they could not refuel), which actually gave them less deck space for cannons than their earlier sailing counterparts had.

It would be a century before the first warship we could recognize as modern — H.M.S. Dreadnought, an iron-hulled, multi-turreted battleship — sailed. Yet, in the interim, the Suez Canal was completed (1869), excavations for the Panama Canal had started (1881), and worldwide trading routes had been established. And paddle wheels (as well as auxiliary sailing rigs) had been abandoned to the much more efficient system of rear propellers (finding the proper alloy mix for propellers, an effective way of controlling forward and backwards motion for a ship, to say nothing of more effective cannon for a warship, and more efficient means for the storage of provisions — all had to be integrated). Some of these were entirely new inventions, some were innovations, all were required before a Dreadnought, or a Titanic, could sail.

On land, railways needed less time to develop, but the arc of innovation was sharper. Rail gauges needed to be very precisely calculated and then standardized. Casting methods for rails and train wheels also had to be standardized (a process that would have been next to impossible before industrialization). Track signals and switches had to be developed.

Steam railways would be the first mechanized physical connectors most people had ever seen. Before them, there were ships, horses and various horse-drawn carriages. And despite the huge distances and difficult terrain, even the first stages of the Trans-Siberian Railroad were complete by 1904.

If we use Watt's engine as the template original, then steam boats and steam locomotives, regardless of their transformative effects, seem to be much more innovations than inventions, or, put differently, applications of Watt's invention (something underscored by Robert Fulton's purchase of a steam engine from Watt).

Without delving into the often byzantine intricacies of patent law, it is possible to draw a simple line that an invention, by definition, is always innovative, while an innovation (or application or improvement) can be, and often is, as transformative, as innovative, as the original.

It is also important to note, especially in light of current debates, that the spread of steam, whether in the form of locomotives or ships, was what we would call today a private-public sector collaboration, whether that collaboration was in the form of direct subsidies, land grants, government use of facilities (such as having the railroads carry the mail, as airlines would do later) or after-the-fact purchases of equipment for government use.

Just a Matter of Time

Cooperation/coordination between government and the private sector to foster innovation precedes even the Industrial Revolution. In 1714, the Admiralty in London offered prizes ranging from £10,000-20,000 (today the equivalent would be millions) for a chronometer that would work on ships at sea. The problem was acute, and the need immediate. These were ships that might, with a fair wind, travel 200 nautical miles in a day. At sea with only sun and moon sightings and the North Star, with no terrestrial reference points, navigation could only be by dead reckoning. Without a working chronometer it was difficult for a ship's crew to judge their position with accuracy.

Britain was already a maritime power; circumnavigation of the globe had been accomplished more than a century before by Sir Francis Drake. It is difficult to imagine in an age when we have handheld devices that can determine our location with precision. Yet before even the age of steam began, there were enough ships and crews and together they were important enough to make this of paramount interest to a rising nation whose economy (and defense) rested on its navy.

It still took decades to solve. The eventual winner, John Harrison, produced four different designs in 31 years. Harrison was surely not the only one of his countrymen who was interested in that large a prize, nor was he the first to make the attempt. The Lords of the Admiralty were not entertaining thoughts of innovation, invention or crowd sourcing. They were looking for a solution to a problem.

The marine chronometer example is useful because the problem was recognized, and sufficient incentives were put in place for someone to work on a solution. Their Lordships might not have envisioned the 31-year development timeline, but as the design (designated H4, for the fourth submission by Harrison) was accepted, it is reasonable to assume that it was the one seen as best fulfilling the initial requirements of the longitude prize.

Let Them Build It & They Will Come

Rosen again comments on the effects of patent: "In England, a unique combination of law and circumstance gave artisans the incentive to invent, and in return, obliged them to share the knowledge of their inventions...Human character (or at least behavior) was changed, and changed forever by 17th Century Britain's insistence that ideas were a kind of property. This notion is as consequential as any in history. For while the laws of nature place severe limits on gold, or land, or any other traditional form of

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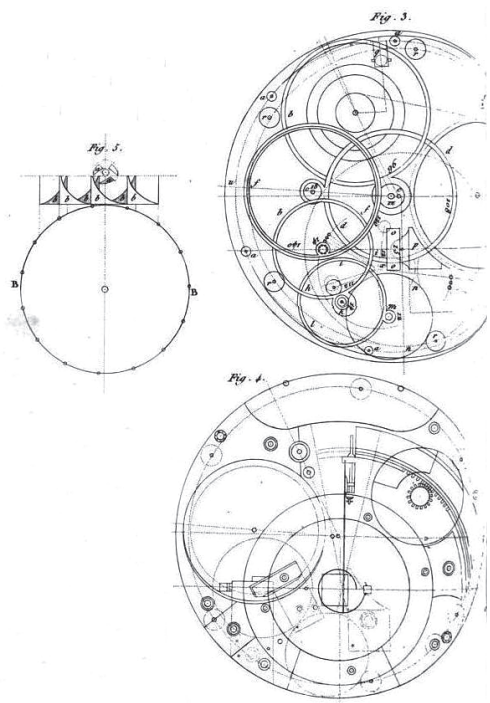

The Harrison H4 clock from "The Principles of Mr. Harrison's Time Keeper" *(1767)*

property, there are (as it turned out) no constraints at all on the number of potentially valuable ideas. The result was that an entire nation's unpropertied populace was given an incentive to produce them, and to acquire the right to exploit them."

Britain was then, and would remain for centuries after, a class-conscious hierarchy, yet at the same time it unleashed something that was inherently equalizing. The longitude prize was not won by a member of the gentry nor even by a clockmaker, but by a carpenter.

In recent years, a number of private awards have been set up for the purpose of encouraging specific innovations in specific fields (Spaceship X, for the first practical reusable spacecraft, is one such). Although the monetary prizes are not always sufficient to cover the development costs, the prize as first mover gives a developer the credibility to deal with private companies (for such uses as communications satellites in low earth orbit) or governments for observation satellites or even, as recently, a robotic resupply mission to the International Space Station.

The privatization of space launches and space flight is, of course, a very high profile endeavor which, if successful, could raise a company's public profile, immeasurably, with consummate rewards in the form of both public and private contracts.

Compared to that, the ordinary problems that are commonly discussed — refurbishment and/or replacement of aging infrastructure — seem mundane, and unless some spectacular event such as a bridge or tunnel collapse brings them into public view, they are invisible in ordinary life, even if their collective impact would be much greater for larger numbers of people than almost any invention/innovation imaginable.

We might then ask, what/where is the proper role of government in fostering the innovations and inventions of tomorrow? Neither Google nor Facebook was a government project, though both have been rightly credited with being transformative, yet neither company could exist without the complex ecosystems of high-tech (and, increasingly, mobile).

What Is or Can or Should Be New under the Sun?

That single question takes us back to the most urgent problems facing us. A recent report called Global Trends 2030 cited, among other things, increased competition for freshwater resources as a potential flashpoint in already unsettled areas of the world. Yet enormous amounts of fresh water are wasted through inadequate infrastructure, inefficient agriculture, and even such mundane things as using fresh water to carry waste each time a toilet is flushed.

In Japan, since the disaster at Fukushima, there have been dire predictions about energy shortages. Yet large amounts of energy are wasted, every day, in buildings that are not insulated (and thus cannot hold in either heat or cold for long), in single pane windows (which bleed hot or cold air), even in the lack of use of the most efficient lighting. These, of course, are structural, and could be remedied easily, the technology exists already.

If the energy produced by solar panels could be doubled, or even tripled, the knock-on contributions to the available grid power would be large. There is even more: both human and animal waste produce methane, which, when harvested and purified is another form of natural gas. Cities and suburbs as dense as Japan's are almost ideal for this. Once methane has been harvested, remaining solids can be used as fertilizer.

This is not theory. In the 1970s, New York City was ordered by the Environmental Protection Agency to cease dumping sewage waste in an area off the coast of New Jersey. Subsequent to that a program was instituted to use sewage waste as fertilizer (there was no methane harvesting) and the sewage was subsequently sold throughout the United States as fertilizer.

The solution was certainly innovative, yet it came as the result of a federal order resulting from a dispute between two different states. New York was ordered to stop dumping, a different disposal method was found, and that proved to be the innovation, yet it grew out of an environmental complaint. In this example, it can be said that "Necessity is the mother of invention and innovation." Yet there is a common thread between the solution found by New York and the solution found by the Lords of the Admiralty: the need to resolve urgent problems.

This should not be taken to mean that invention or innovation is always a response to an urgent problem. Both Facebook and Google grew out of projects that were perceived as needs that would fulfill particular interests/desires of Internet users. Both were and are

successful at present because they fulfill those particular roles (thus meeting demand). There is a case to be made for the compelling need to organize the enormous volume of information online but Google is not the only solution, and, considering that there were other search engines before, if Google had not emerged, another would have, given the demand.

Google was not the first popular search engine nor was Facebook the first popular social media site. Both companies distinguished themselves by getting into the market and offering different/better/faster/more interesting features than their competitors. Looking at Google and Facebook, alone without background or context, seems to make the case for letting market forces determine outcomes without government. With background and context, neither company could exist without particular government moves at particular times.

This is not simply saying government is responsible for the Internet (though credit where credit is due, without government support, both directly and for institutions like CERN where the World Wide Web originated, there might not be an Internet, certainly not in the form we recognize today). The roots go much deeper.

As the author Richard Rhodes cites in his recent book *Hedy's Folly* (Doubleday, 2011), both Alfred E. Kahn, an economist, and Charles D. Ferris, an attorney and physicist, began championing the use of multi-spectrum technology (without which there would be no mobile phones, WiFi or Bluetooth) in the late 1970s, against what were then entrenched interests in the military and the fixed-line telephone companies. Rhodes goes back even further than that to the actress Hedy Lamarr who, together with composer George Antheil, conceived of, and received, a patent for a torpedo which would use multi-spectrum technology to avoid being jammed by an enemy (Lamarr was an emigrant from Austria whose first husband was involved in supplying arms to fascist armies in Europe). That patent is one of the rare examples of one that was donated to the U.S. government, though it was not used during World War II. One of the points Rhodes cites is that this particular patent (and the invention behind it) can be considered as an *ur*-point for much of modern technology (although not used during the war, applications of it began to be used in military technology early in the Cold War).

A Hollywood star, a composer, a carpenter: all amateurs in the ways of invention (as was Edison, who was self-taught). Our world was made possible by them, and countless others, and the idea that ideas themselves, brought to bear on real world problems, have value, no matter their source. Real political enfranchisement was centuries away, but the enfranchisement of imagination and creativity, was not only a necessary precursor; it may be considered as, if not more, profound as the political ideas that followed.

Dark Futures & Bright Futures

There has been speculation that the wave of invention and innovation that transformed the world in the last three-plus centuries is ebbing and that we are now headed for an era of much slower growth, and even stagnation (the Global Trends 2030 report calls this the "Stalled Engines" scenario, though a more accurate description might be "Reverse Engines"). Given the sheer numbers of people on the planet, who would be competing for increasingly scarce resources, such a scenario would inevitably involve a major war, or even major wars, unless a major cataclysm were to seriously reduce the numbers of people on the planet.

Balanced against that are two equally powerful forces: more people have more access to more information than ever before in human history, and not just access to information, but the tools to realize their ideas (whether through sophisticated simulations, 3D printing, or cheaper apparatus for sophisticated operations like gene splicing). To be sure, there will be dark sides to such applications, just as there were to all inventions and innovations. And the new technologies that are foreseeable but not yet realizable (e.g. quantum computing and various aspects of nanotechnology) could and will likely have as transformative effects on the world as steam itself did.

What can happen in the interim, if we avoid the "Reverse Engines" scenario, are the incremental improvements that altogether will be additive enough, and productive enough, to keep the world economy going. A key component of this will not be the private sector anticipating short-term consumer demand, but governments, agreeing on the most important issues and offering incentives to individuals and companies that attempt to address longer-term problems.

This approach may fly in the face of some current economic thought but it has far more historical weight and examples behind it than a private-sector only approach. Even new areas that are being entered by the private sector, such as space flight, would never have been possible if it were not for the huge government efforts that preceded them.

Such an approach will call for realism, for government is no more likely to be successful at picking winners than private venture capital (where there are many losses for each success), but unlike private venture capital, government must consider not what are the likely successes that would achieve critical mass in the corporate and/or consumer sectors, but rather what are the potential projects that can offer the best solutions to the more urgent problems in contemporary life (whether energy production/consumption or others).

Some of these will be trans-national, and a trans-national body that could evaluate and coordinate between different nations could encourage the sharing of information and prevent the reduplication of resources.

Half a century ago, President John F. Kennedy, said in a speech "Our problems are man-made, therefore they may be solved by man. And man can be as big as he wants. No problem of human destiny is beyond human beings." JS

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