The future of economics: the case for an evolutionary approach

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Appendix

Some evidence of the changing pace of innovation

To see what has happened to the pace of innovation, it is easiest to consider the evolution of technology, meaning the activity that leads to the production of new physical objects — consumer goods, buildings, means of transport and communication, weapons, and new machines to produce those objects. That is not to say that the evolution of social behaviour and institutions has been less important, only that it is harder to follow.

Consider Britain. Until the 18th and 19th centuries there is little evidence of British inventiveness. The Romans, who occupied Britain from about 50 BC to 400 AD, and who had inherited knowledge from the Greeks, brought with them major technological innovations: new standards of building and road-making, of which we can still see the remains; as well as new crops and consumer goods, new tools and better weapons (and also superior civil and military institutions). But after they left and the Angles and Saxons invaded these islands, these innovations were largely lost.

After nearly 700 years a second wave of innovation was brought to Britain, this time by the Normans — those Vikings who, having conquered Normandy, had in a few generations turned themselves into Frenchmen. Their main technological contribution was in architecture and in warfare. They built powerful castles and also numerous grand abbeys in the style derived from the Romans that we call Norman or Romanesque; and they brought powerful cavalry equipped with armour, swords and the stirrup. But as regards non-military technology, Britain under the Normans was probably not as advanced it had been under the Romans.

After another 700 years, during which technical progress in Britain was slow, came the flowering of British inventiveness that produced the Agricultural and Industrial Revolutions of the 18th and 19th centuries.

The cultivation of technology

The British inventors of that era were few in number; as pioneers, they were inevitably amateurs. Institutions of higher education to teach science and engineering had been started in some of the states of Germany in the middle of the 18th century, but cultivation of scientists and technologists (in economic parlance, 'investment in human capital') had not spread to Britain, nor had it yet become a burgeoning form of competition amongst nations.

A seminal step in that direction was the creation by the French revolutionary government in 1794 of the *École Polytechnique*, the first grand technological institute established by a major European state to train, at the state's expense, scientists and engineers to serve the industries and the military of the society it sought to create. It is today a remarkable elite institution which, having been put under the military by Napoleon in 1804, is still administered by the military. Entrance to it is extremely competitive, the teaching is intense and of the highest scientific level, and the reward for the graduate is great: a top job as a technocrat, able to move between the public and private sectors. The *École* today declares on its website:

> The mission of the *École Polytechnique* is to train students capable of devising and achieving complex and innovative projects at the highest level possible, thanks to a strong pluriscientific

culture. Our mission is also to train young men and women in leadership skills so that they can become tomorrow's outstanding scientists, researchers, managers and public officials.

There followed the creation of *technische hochschulen* in Germany and other European states, and in 1861 the creation in the United States of MIT, privately financed, all modelled on the *École Polytechnique*. The teaching of science and engineering was also expanded in universities and schools. Britain, having become the leading industrial nation of the world without state-organised scientific education, was complacent and joined the competition in technology late, stirred by warnings that Germany was gaining technological ascendancy. Notable steps were the creation in mid-century of various schools that later became Imperial College of Science and Technology; the report of the Royal Commission on Scientific Instruction and the Advancement of Science in 1873 which, presided over by the Duke of Devonshire, himself a first-class mathematician and scientist, helped to persuade the government to reform Oxford and Cambridge in favour, *inter alia,* of science; and the creation in 1874 by the Duke at his own expense of the Cavendish Laboratory at Cambridge as an earnest of his concern for scientific education.

In the 20th century, military competition became the dominant force driving investment in technology. During the 1914–1918 war, some significant new means of warfare were developed — for example, gas and the tank. In the 1939–1945 war, competition in military research became intense and yielded epoch-making results, notably the development of radar, jet aircraft, the V1 and V2, the first computers and the atomic bomb.

In the arms race that followed WWII, resources were poured competitively into the development of nuclear weapons and delivery systems, and into non-nuclear weapons. There was also increasing recognition amongst economists and politicians in many parts of the world that scientific education and research were vital to their economic development. Consequently, total world spending on the cultivation of technology grew rapidly.

Amongst the leading powers that had been engaged in WWII, the balance between investment in military and civil technology was distorted in a remarkable manner between the victors and the losers. Whereas about half the expenditure on R&D of Britain and the United States at the height of the Cold War was devoted to the military, and the fraction in Soviet must have been higher, the fraction in Germany and Japan was negligible. Under the peace treaties imposed by the Allies on Germany and Japan at the end of WWII, they were disarmed and forbidden to produce major arms. Consequently, their R&D resources were directed to the civil sector — for example, into cars, electrical consumer goods and non-military machinery, whilst the victors, who had imposed this condition on their former enemies, poured their own R&D resources into the arms race. The competitive advantage consequently gained by Germany and Japan has long been visible: they became leaders in world markets for many peaceful manufactured products, whilst Britain, Russia and the US became in varying degrees dependent on sales from their research-subsidised arms industries to the relatively static and notoriously corrupt market for arms.

Russia's performance in the cultivation of technology in the 20th century was extraordinary and tragic. The Tsarist government had started to invest significantly in the training of scientists and engineers at the end of the 19th century, but there soon followed the revolution, the civil war and the terrible disruption and damage of WWII. It was astonishing that in 1957 when the Soviets launched Sputnik they were educating annually about as many scientists and engineers as the United States. They had clearly invested extremely heavily in the education of scientists and engineers. The tragedy is that under the Soviet regime, their talents were applied almost exclusively to military ends. How that happened is understandable. After the revolution, the Communists perceived the need to defend themselves against hostile capitalist powers; in WWII they did so at huge human and economic cost; and then they became enmeshed in the Cold War arms race. Further, under their planning regime, technology devised in the military sector did not flow into their crippled civilian economy. The consequence, evident today, is Russia's extraordinary reliance on imports of manufactured goods. As in Britain, but to a much greater degree, the Russian economy has been warped by concentration on military R&D. The United States has suffered less, and has indeed gained a competitive advantage in technology because it spent heavily on fundamental research through its military budget and ensured that the results were spun off into the development by private industry of new peaceful products: Silicon Valley is in significant part a child of military R&D (Janeway, 2012: 224–231).

France, like Britain, devoted a lot of resources to military technology, including the development of nuclear weapons, but it has been more successful than Britain in developing peaceful technology —for example, nuclear power and high speed trains. It may have been helped by its tradition of giving responsibility for the choice and supervision of technical projects to public servants who are technocrats, not humanists as in Britain.

Since the end of the Cold War, global investment in peaceful technology has surged as China, and other poor countries mostly in Asia, have invested in education and peaceful technology for the sake of economic development, rather as Japan, disarmed by the Allies, had been forced to do earlier. In China the development of military technology was important at first, but the resources that this vast country has put into technology have been so great that it has been able to catch up with the old 'superpowers' in weaponry and rush forward in its development of peaceful technology. Evidence of the success of these countries is the range of their manufactured goods that we are offered every day in shops and online; many of them, notably the electronic gadgets, visibly are a consequence of rapid innovation achieved in competition with the United States and Europe.

Reference

Janeway WH (2012) *Doing Capitalism in the Innovation Economy: Markets, Capitalism and the State*. Cambridge: Cambridge University Press.