Technology and Innovation – Lessons from the Dismal Science

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Abstract

This article discusses some facets of technological innovation well known to contemporary economists and provides a useful basis to think rigorously about some societal problems arising from innovation. I review the role of innovation and economic growth, the evolution of the concept of disruptive technology, and the debate about technological unemployment. I hope to provide the lay person a more balanced view about technology and innovation in a time when news stories focus more on news worthiness than rigor.

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The Chinese dynastic history had a remarkable regularity – the population boomed then busted as a dynasty aged, but the standard of living of the general population remained close to subsistence level over time despite technological advances. This regularity is called the Malthusian trap which suggests that technological advances increase a society's supply of resources (such as food) and thereby improve the standard of living; but the resource abundance encourages population growth that eventually brings the standard of living back to near subsistence level. The Malthusian trap is often incorrectly[1] cited as the origin of economics being known as the dismal science.

Economists today know a lot more about technological innovation and economic development than Thomas Malthus. This article discusses some facets of innovation that contemporary economists know and busts a few myths along the way.

1. Preamble

It is surprisingly important to have a common vocabulary before going further -- the meaning of some economic concepts differs from their definitions in the English dictionary.

For this article (and generally for economic analysis), technology refers to how capital and labor are used as inputs to produce an output (product, service or knowledge) which is potentially useful. For example, my online calendar is an output which is useful to coordinate my activities with others. It is produced using tools (capital goods), such as smartphones, computers and software, with the help of many people including myself (labor). Technology refers to how these inputs produce the output, and not the tools such as smartphones or the internet.

New technologies emerge over time through invention and innovation. Invention refers to the creation of new products or processes. Innovation refers to the widespread adoption of the invention to produce economic impacts. Inventing a better mousetrap is great, but it changes nothing until there is an innovation, i.e. until the world beats a path to your doorstep to get that better mousetrap. The latest invention sometime stirs a media frenzy only to fizzle out after a few years. Innovation requires the invention and the economic conditions for widespread adoption.

2. Innovation and Economic Growth

Economic growth is the central question in development policy. Economists have long recognized that while increasing inputs can expand the economy (increase the amount of output an economy produces), it gets increasingly difficult to do so as more inputs are used. This Law of Diminishing Returns ultimately causes economic development to converge to a steady state in classical economic theory, unless we get a free lunch somewhere.

[1] See http://www.theatlantic.com/business/archive/2013/12/why-economics-is-really-called-the-dismal-science/282454/

That free lunch is innovation. For example, we need capital and labor to produce food, but over time we have introduced innovations such as the use of ploughs and animals, tractors, crop rotation and fertilizers, biotechnology in seeds and animal breeding, and even organization of farms, supply chain and market for trading food. These innovations allow us to increase output (food) often using less inputs (capital and labor).

Logically, unproductive inventions have less chance of being widely adopted in a functioning market, and innovation therefore generally increases productivity. Innovation allows us to produce more output for a given combination of inputs, which is another way of saying that innovation is the source of long run productivity growth. If we assume that the stock of knowledge is the ingredient for invention, there can be increasing returns for innovation with increasing stock of knowledge accumulated through research. The pace of innovation appears to have accelerated over time with the increasing knowledge base and the lower cost of sharing knowledge.

Post classical economic theories have come a long way in thinking about economic growth. The Solow-Swan model started by recognizing the role of innovation as the source of long run growth, but treated innovation as something that was unexplained by the model. In other words, this early model did not attempt to explain how innovation came about. In economics terms, we say that the Solow-Swan model assumed innovation to be exogenous. Subsequent growth models then incorporated accumulation of human capital, institutional arrangements, and entrepreneurship to explain innovation and economic growth.

3. Disruption, Diffusion and Economic Thinking

Mainstream economists generally view knowledge as "development-by-accumulation" of accepted facts and theories to fuel innovation. This means that knowledge increases incrementally. On the other hand, Schumpeter’s heterodox view of creative destruction driving innovation is also well-known. Innovation can vary from incremental to radical in this view.

To have some clarity about the nature of how knowledge increases, we turn to Philosophy as philosophers study the theory of knowledge in a branch of philosophy called epistemology. Thomas Kuhn argued that knowledge accumulation goes through periods of conceptual continuity interrupted by periods of disruptive change[2]. Years later, Clayton Christensen coined the term disruptive technology to refer to discontinuous innovation that cause established market leaders to be replaced by start-ups[3]. Today, the term “disruptive technology” has become a buzzword in danger of being overused and ill-understood. However, armed with an understanding of market characteristics, economic reasoning helps us view disruptive technology in perspective. For example:

Peer to Peer (P2P) Lending: P2P lending appears to be a disruptive technology for banking. The basic P2P lending model is to leverage the internet to match lenders and borrowers. Potential borrowers are screened and graded using a credit reference agency. P2P companies use loan terms with standard durations and sizes to match lenders with borrowers based on interest rate and risk, and

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[2] Kuhn, T.S.1962. “The Structure of Scientific Revolutions” Chicago, IL: University of Chicago Press.
[3] Christensen, C. 1997. “The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail” Cambridge, MA: Harvard Business School Press

charges a fee for their service. Variations of the basic model include the peer-to-business model by offering small business loans, provision fund/insurance to safeguard lenders against default, using collaterals for secured loans.

There are subtle but important differences between the economics of P2P lending and banking. P2P lenders (who provide the loanable fund) face the borrower's default, but depositors face the risk of bank default but not the borrower's default risk directly. In other words, if a borrower is unable to pay back his loan, the P2P lender suffers the loss, whereas in banking, the bank absorbs the loss and depositors are not affected (unless the bank goes bankrupt). Central banks, through regulations and other interventions, have generally tamed the risk of bank default to low levels.

Therefore, banks have lower borrowing rates, lending rates, and lending risk appetite than P2P companies. The products in P2P lending and banking serve distinct market segments and may be demand complements instead of substitutes. As complements, the rise of P2P lending instead of disrupting banking, may create a new consumer segment that was previously unable to borrow from banks to enter the market. Some of these P2P borrowers may borrow from banks (which have a lower rate) after establishing good credit history with P2P lending. Banks may invest in P2P companies to obtain preferential access to P2P borrowers with good credit history, rather than as a defence against the threat of disruption.

M-Pesa Story of Mobile Payment: Where in Kenya do you go to deposit your spare cash, transmit money, or withdraw some cash? For many people, the answer is not a bank or an ATM which is hard to find, but is what is known as mama shops in Singapore that sell prepaid mobile phone airtime. Buy some airtime credit and send it to someone just by an SMS. You can also send your existing credit to the shop owner for cash and viola you get an ATM. This financial service, known as M-Pesa, which processed transactions amounting to 43% of Kenya's GDP[4] in 2013, is not operated by any financial institution. Instead, it is operated by telecommunication operators using the extensive network of mama shops that already exist. This is a well-known story of disruptive technology.

However, using airtime credit like a currency is not common in Singapore (numoni.com is a niche player targeting the unbanked foreign workers in Singapore who use it for remittance). Why is the technological disruption not universal? There are two possible reasons.

The obvious reason is the availability of alternatives such as credit cards, NETS (A nation-wide electronic payment platform formed in 1985 by a consortium of local banks), and EZ link cards; and the ease with which ATMs can be found. Complementary assets for these alternatives such as distribution and brand positioning are already well established.

The non-obvious reason is positive network externalities favouring existing payment technology. A positive network externality arises when a product becomes more valuable when there are more users. For example, being able to pay by NETS is only convenient if many places accept NETS payment. Similarly, firms being able to accept payment by NETS would only benefit if many people are NETS users who can pay by NETS. For a new payment technology, retailers often find the set up cost for payment processing higher than the benefit from additional sales because there are few

[4] See http://www.forbes.com/sites/danielrunde/2015/08/12/m-pesa-and-the-rise-of-the-global-mobile-money-market/

users. Since few retailers can currently process the new payment technology, there is less reason for users to adopt it. This sets off a vicious cycle that gives early movers a strong advantage, even if earlier technology is inferior.

In sum, a better invention is not always adopted by users to become an innovation, and only innovations that cause established market leaders to be replaced by new companies are disruptive technologies. Disruptive technology is the exception rather than the norm because adoption of such technology requires overcoming the advantage conferred by complementary assets to existing alternatives. Positive network externalities sometimes raise the hurdle even higher.

4. Innovation and Jobs

Economist John Maynard Keynes in 1933 predicted technological unemployment “due to our discovery of means of economizing the use of labor outrunning the pace at which we can find new uses for labor”. There is general agreement that short-run technological unemployment is plausible but the debate on long-run effect is unsettled. The risk of technological unemployment is generally higher in low-skill jobs which are easier to automate, but high-skill jobs can also be at risk due to innovation in areas such as machine learning[5].

The award-winning book by Martin Ford “Rise of the Robots: Technology and the Threat of a Jobless Future” describes a pessimistic view that technological unemployment is inevitable. Ford states that “Ultimately, the question of whether smart machines will someday eclipse the capability of average people to perform much of the work demanded by the economy will be answered by the nature of the technology that arrives in the future— not by lessons gleaned from economic history.”

Economist Herbert Simon in 1960 applied[6] the concept of comparative advantage to this question: if machines can increasingly do whatever humans can do and do it faster, why won’t everything eventually be done by machines? Whether man or machines will be employed in a particular process depends not simply on their relative productivity, but on their cost as well. And cost depends on price. As machines become more productive, the prices of labor and capital will adjust such that the value of the output produced for each dollar cost of the inputs (machine or labor) is the same. Manpower will flow to those processes in which productivity per dollar of wage is high relative to the productivity of machines per dollar of machine usage and vice versa. In more concrete terms, in jobs where machines become better than humans, the wages of job-holders will decrease and people will move into other jobs where machines cannot replace humans and therefore pay better. Eventually, an increasing fraction of workers will be engaged in occupations where ‘personal service’ involving face-to-face human interactions is an important part of the job.

Short-run technological unemployment can arise from a mismatch between current job skills and skills required. The long-run employment effect is more controversial. For example, consider the effects of agricultural innovations over the last few centuries. Innovations (e.g. tractor) destroy some existing jobs but create new jobs (e.g. tractor repairmen) or even industries in the creative destruction process. The higher productivity from agricultural innovations has changed skills

[5] http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

[6] Simon, Herbert A. 1960. "The corporation: will it be managed by machines?" In Anshen, M.L. and G. L. Bach (eds.) Management and the Corporations. McGraw Hill.

requirements and shifted ‘excess’ agriculture labor to manufacturing and service sector jobs. Short-run structural unemployment can occur but labor can adjust by acquiring relevant skills. Higher productivity generally raises income and reduces average working hours. Nonetheless, long-run technological unemployment can occur if labor does not adjust sufficiently by acquiring relevant skills, resulting in a divide of higher income in one group and technological unemployment in the other. In the context of agricultural innovations, the skills that became relevant to the new jobs were not related to agriculture or technology in most cases, but were skills that matched jobs in the manufacturing and service sectors. In sum, whether long-run technological unemployment will occur is an empirical question contingent on market adjustment (i.e., will people pick up new skills) and also policy intervention (e.g. how effective governments are in aiding the re-training process).

5. Conclusion

Technology and innovation have always influenced the evolution of human societies. The good news is that most economies appear to have escaped the Malthusian trap. The bad news is that technological unemployment is a potential future threat. Economic reasoning provides a useful framework to think about the problem, and what the unanswered questions that empirical studies should answer are.