The Two Innovation Economies: Follower and Frontier

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For 250 years, technological innovation has driven economic development. New technologies have not merely lowered the cost of producing and delivering goods and services that already are available. They have reconstructed the physical and information architecture of the market economy and enabled the production and delivery of goods and services previously unimaginable. As Arthur C. Clarke famously wrote: "Any sufficiently advanced technology is indistinguishable from magic."

From the mechanization of industrial production and the canals and railways of the first industrial revolution through the application of science to industry and the deployment of telecommunications networks during the second industrial revolution to the digital ICT revolution of the past fifty years, technology has created a succession of genuinely New Economies. But the economics of innovation are very different for those at the frontier versus the followers who are striving to catch up.

For those nations following the innovative leader, the path is clear. Mercantilist policies of protection and subsidy have been the effective instruments of an economically active state motivated by the forced need to sponsor accelerated economic development. Through the nineteenth

century, America's multi-generational effort to catch up with Britain began with the appropriation of British intellectual property: the first profitable American textile mills blatantly violated British patents. And ferociously entrepreneurial private enterprise was supported by a broad array of state investments, guarantees, and protective tariffs in accord with the "American System" advocated by Alexander Hamilton and Henry Clay. Further, the more specific "American System of Manufacturing," based on mechanized production of replaceable parts, was pioneered by the government armories that served the young nation's military and naval forces.

The great, neglected German economist, Friederich List, laid out a road map for his own country to catch up with Britain in his *National System of Political Economy*. It has been put to repeated and successful use: by Japan beginning in the last decades of the nineteenth century, then by the emergent Asian Tigers in the second half of the twentieth century and now by China.

Only nations that are the most competitively productive and that hold substantial net balances of international assets can afford to implement free trade without fear—think Great Britain in 1846 or the United States in 1945. Friedrich List put it succinctly some 170 years ago: "Any power which by means of a protective policy has attained a position of manufacturing and commercial supremacy can (after she has attained it) revert with advantage to a policy of free trade."[1]

List reached back to record how Britain's emergence as "the first industrial nation" at the end of the eighteenth century depended on prior

[1] F. List, *The National System of Political Economy,* trans. Sampson S. Lloyd, 1885 ed. (New York: Augustus M. Kelly, 1966 [1841]), p. 11.

state policies to promote British industry, from the sixteenth century Tudors through the seventeenth century Commonwealth. As List wrote: "Had the English left everything to itself…the Belgians would be still manufacturing cloth for the English [and] England would still have been the sheepyard for the [Hanseatic League],"[2] exporting wool to Flanders and buying it back in the value-added form of woolen textiles.

Coherent programs to accelerate economic catch-up are relatively straightforward. But the transition from follower to leader at the frontier of the innovation economy is more challenging and elusive. The very programs that work for the follower compromise the achievement of leadership at the frontier. As one prime example, the designation of "national champions" may prove effective when the path forward has already been well marked. When the need is for competitive exploration at the frontier, designated national champions have served to block progress, as they did in Britain, France and Germany in the formative years of the computer revolution.

Moreover, even while celebrating it as the essential force for economic development, Mariana Mazzucato – champion of the "entrepreneurial state" – is right to urge us not to romanticize the state in that role.[3] Political leaders who are devising programs to sponsor infant industries are also serving the economic interests of those in the market economy who thrive on protectionist policies, at the expense of the mass of consumers who suffer at the margin from the adverse shift in the terms of trade with the external world. The intensely focused interest of the few whose wealth buys access to political power always tends to trump the

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[2] *Ibid.*, p. 25.
[3] M. Mazzucato, *The Entrepreneurial State: Debunking Public vs. Private Sector Myths*, (Anthem Press, London), p. 195.

diffuse interests of the many. From the scandals that infested American subsidies to railroad promoters 150 years ago to the trial of Bo Xilai, corruption is the handmaiden of state-driven development. The entrepreneurial state is both an agent of economic growth and a channel for the distribution of economic rents.

As we attempt to comprehend the transition from follower to leader, a certain humility is appropriate. Whether one follows Carlota Perez in identifying five great waves of technological innovation[4] or Professor Robert Gordon, who sees only three over the past 250 years,[5] the sample in either case is limited. Further, in either case, the process in which we are interested has involved only three nations to date: Britain from the first industrial revolution through the age of the railways; Germany and the United States as they competed for leadership of the second industrial revolution; and the United States alone for close to 100 years. This is hardly a data set from which statistically reliable laws of motion can be derived. Yet I will offer a few generic observations.

At the frontier, economic growth has been driven by successive processes of trial and error and error and error: upstream exercises in research and invention, and downstream experiments in exploiting the new economic space opened by innovation. Each of these activities necessarily generates much waste along the way: dead-end research programs, useless inventions and failed commercial ventures. In between, the innovations that have repeatedly transformed the architecture of the market economy, from canals to the internet, have required massive investment to construct

[4] C. Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Cheltenham, UK: Edward Elgar, 2002).
[5] Gordon, R., "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," NBER Working paper 18315, August 2012.

networks whose value in use could not be imagined at the outset of deployment. This is the messy environment through which Schumpeter's "gales of Creative Destruction" sweep. This is why an innovation system is required that can tolerate what I call necessary Schumpeterian Waste.

Consequently, innovation at the frontier depends on sources of funding decoupled from concern for economic value. At the frontier, calculation of the net present value of the expected future cash flows from investment in innovation range from highly uncertain to simply unavailable. All who choose to practice at the frontier - or to theorize about those who do - are on notice to heed Keynes' canonical statement of 1937:

> By "uncertain' knowledge" . . . I do not mean merely to distinguish what is known from what is merely probable . . . The sense in which I am using the term is that in which the prospect of a European war is uncertain, or the price of copper and the rate of interest twenty years hence, or the obsolescence of a new invention, or the position of private wealth owners in the social system in 1970. About these matters there is no scientific basis on which to form any calculable probability whatever. We simply do not know.[6]

Thus, the processes that drive Creative Destruction cannot be reduced to the optimal inter-temporal allocation of resources. The conventional production function of neoclassical economics, that is to say, offers a dangerously misleading lens through which to understand frontier innovation. The vision of the theoretical "optimal social planner" and of state officials in the real world striving to harness the magic of frontier

[6] J. M. Keynes, "The General Theory of Employment," *Quarterly Journal of Economics,* February 1937, in E. Johnson and D. Moggridge (eds.), *The Collected Writings of John Maynard Keynes*, vol. XIV (Cambridge University Press and Macmillan for the Royal Economic Society, 1973 [1937]), pp. 112–113.

innovation for economic growth – as of the entrepreneur and her venturesome financier - is necessarily clouded to the point of blindness.

In this context, two sources of capital have been available to underwrite investment in fundamental innovation. The first is financial speculation. Investment bubbles have arisen wherever liquid markets in assets have existed. The objects of speculation challenge the imagination: tulip bulbs, gold and silver mines, real estate, the debt of new nations, corporate securities. Occasionally, decisively, the object of speculation has been one of those fundamental technologies – Canals, Railroads, Electrification, Radio, Automobiles, Micro-electronics, Computing, the Internet - for which financial speculators have mobilized capital on a scale far beyond what "rational" investors would provide.

The history of financial capitalism demonstrates the need to distinguish between bubbles along two different dimensions. One dimension is defined by the object of speculation. Only occasionally have speculators focused on fundamental technology instead of such assets as gold mines or houses that do not contribute to system-wide increases in productivity. The second dimension concerns the locus of speculative activity, distinguishing between bubbles that remain confined to the capital markets versus those that transcend the capital markets to suck in the institutions that accept deposits and provide the credit that fuels the ordinary workings of the market economy.

In the immediate past, the contrast is instructive between the respective consequences, positive and negative, of the dotcom/telecom bubble of 1999–2000 and the credit bubble of 2004–2007. When the $6 trillion of nominal financial wealth created in the former and concentrated in equity securities was liquidated, the economic consequences were within

the bounds of postwar experience, leaving the technological foundations and business models in place for the newest new economy. The great credit bubble will be remembered precisely for its destructive economic consequences and not for any physical legacy, least of all the abandoned tract houses scattered along the coastal regions of the United States and from Ireland and Spain to the emerging lands of Central and Eastern Europe.

Complementing the role of speculation, activist states have played multiple roles in encouraging innovation at the frontier. They have been most effective when pursuing politically legitimate missions that transcend narrow economic calculation: national development, national security, conquering disease. Indeed, more than 50 years ago Richard Nelson and Kenneth Arrow separately identified the market's failure to allocate sufficient resources to scientific research and technological development as offering a prima facie case for state intervention.[7] But "correcting market failure" has proved capable of mobilizing only limited resources for narrowly defined purposes. Of critical importance, invoked in order to *increase* the efficiency of resource allocation where the market has failed, correction of market failure offers no defense whatsoever against the waste that state investments in frontier innovation will necessarily generate.

The U.S. managed the transition from follower to leader between roughly 1880 and 1930, combining the professionalization of management with a speculative taste for new technologies – electrification, automobiles, radio – and state tolerance of the great industrial monopolies spawned by the second industrial revolution that invested their excess profits in

[7] K. Arrow, "Economic Welfare and the Allocation of Resources for R&D," in K. Arrow (ed.), *Essays in the Theory of Risk-Bearing* (New York: American Elsevier, 1971 [1962]), pp. 144–163. R. R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy,* 67 (1959), pp. 297–306.

scientific research and technical invention. From the onset of World War II, investment in science became a core instrument of national security. Its continuation into the post-war Cold War decades was historically unprecedented. Quantitatively and qualitatively, the Federal Government drove the extension of America's leadership to the array of technologies that constituted the digital Information and Communications Revolution. In turn, invocation of a new politically legitimate mission – conquering disease – broadened its scope to the life sciences. President Nixon's declaration of "war on cancer" was more than a play on words.

Today, contrary to the techno-pessimists, the digital new economy that was "made in America" exhibits ample momentum in the private sector. Speculation-worthy innovations are visible across multiple dimensions:

- Rendering the fourth generation mobile/cloud computing architecture enterprise-ready
- Deploying "the internet of things" to link large-scale sense-and-control networks
- Advancing from automatic speech recognition to natural language understanding
- Extracting actionable information from big unstructured data.

But when we turn to the next new economy – the low carbon economy – a fog of strategic uncertainty engulfs us. America is suffering the consequences of a generation-long effort to render the state illegitimate as an economic actor. Moreover, America is uniquely distinguished by widespread denial of the reality of climate change and rejection of global warming as a motive for aggressive state action of any sort. And Europe,

where climate change and the need for state-sponsored response are both generally accepted, remains mired in its self-contradictory commitment to "expansionary fiscal austerity."

Can China take the lead? Daron Acemoglu and James Robinson in their book *Why Nations Fail* have read the history of economic development to argue that leadership in economically significant innovation turns on prior institutional evolution from "extractive" to open, "inclusive" political institutions. In consequence, they express extreme skepticism about China's potential to lead "until there is radical reform of political institutions."[8] Yet as noted, the relevant historical record is short and sparse. And consideration of the manner in which Britain emerged as the first industrial nation suggests that, as usual, it is not that simple.

Let us reach back almost two hundred years, to consider the state of Britain's political economy when the First Industrial Revolution was gathering steam, as one might put it. England in 1820 was governed by a corrupt oligarchy whose authority was exercised across the country in intimate collaboration with a national religious establishment. While limits on the arbitrary authority of the sovereign had been established by the Glorious Revolution of 1688, for the great mass of the people draconian repression was the rule: under the "Bloody Code" of criminal justice, more than 100 felonies were definitionally punishable by death or transportation. The patent system was notoriously expensive and inaccessible. The aristocratic elite were insulated from legal exposure and enjoyed enormous rents: both actual from their ownership of land and virtual through political and social institutions. Legitimacy was validated by the fear of anarchy, the

[8] D. Acemoglu and J. Robinson, *Why Nations Fail: The Origins of Power, Prosperity and Poverty* Crown Business, New York).

terrifying reality of which had been observed in Paris, just across the English Channel, within living memory.

Those who ruled England were seeking to hold the lid on the greatest explosion of economic energy and financial wealth in human history. And, over a long generation from roughly 1830, England was transformed along multiple dimensions, from the "Old Corruption" derided by William Cobbett to the High Victorian order celebrated by Anthony Trollope. From the Great Reform Act of 1834 to repeal of the Corn Laws in 1846 and on to the Northcote-Trevelyan civil service reforms initiated in 1853 and the radical Representation of the People Act of 1867, Britain followed its own unique path towards a relatively stable and sustainable democratic capitalism that could survive the disruptive consequences of successive waves of Creative Destruction.

Did "inclusive" political institutions enable the industrial revolution, or were they in good parts its consequence? Or are both question misconceived? In the complex and contingent process of social evolution, is it possible to abstract *any* causal law on which it is useful to rely when seeking to interpret – let alone anticipate – the outcome of another such evolutionary process, itself comparably complex and contingent?

Just how uncertain the dynamics of transition from Follower to Frontier are is demonstrated by the history of that other challenger to Britain's leadership. At the end of the 19th century, when mechanical tinkering had definitively yielded to scientific discovery as the source of technological innovation, Germany – not the United States – was the emergent winner. Not only was Germany the pre-eminent host of the first truly science-based industry – chemicals – and fully competitive in the transformation of the phenomenon of electro-magnetism into the

infrastructure of a comprehensively "new" economy. Germany had already invented the research university and uniquely educated American students to the doctoral level while providing the model for educators in the US to emulate. Germany was the home of the world's most comprehensive system of primary education and technical schools had been. What's more, under Bismarck its paternalistic state had pre-emptively initiated the first ever elements of a social safety net.[9]

The late historian David Landes, considering Germany's success in overtaking Britain at the end of the nineteenth century, identifies "one of the strangest paradoxes in history":

> that on the one hand, a liberal society standing out from all others for equality and mobility of status, should have lost something of these during the very period of its progressive political democratization; while on the other, a far more authoritarian society, characterized in its pre-industrial period by a clearly defined, fairly rigid hierarchy of rank, should have developed a more open structure, without corresponding political change.[10]

In the language of Acemoglu and Robinson, Britain's economic institutions became less inclusive even as its political institutions became more so; Germany's economic institutions became more inclusive even as its political institutions remained substantially extractive.

For Germany, there then followed 30 years of destruction from 1914 on: Two World Wars, a hyper-inflation, the Great depression and the Third Reich. The succession of political, military and financial catastrophes

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[9] D. S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*, 2nd. ed., (Cambridge University Press, 2003), pp. 346-7.
[10] D. S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present*, 2nd. ed., (Cambridge University Press, 2003), p. 348.

trumped the economic momentum derived from scientific discovery and technological advance.

Any attempt to construct a transcendent framework in which to force-fit human history can be expected to confront such extreme discontinuities as this. Yet we may extract a few significant lessons – not laws – from the experience of those who have driven innovation at the frontier. The "national champions" that are the vehicles for economic development during the catch-up phase can be expected to mobilize all their resources, political as well as economic, to resist any opening to competitive assault, even as Britain's East India Company did once it had succeeded in ousting the Dutch and the French from their positions of strength in South Asia and as – some two hundred years later - the American telecommunications monopoly, ATT, did when it fiercely opposed the Defense Department's sponsorship of the Internet. Contrariwise, state sponsorship of trial-and-error experimentation and toleration of entrepreneurial failure – upstream in the domain of scientific research and downstream in the deployment of novel technologies - will be subject to fierce criticism – and not only from economists -for the necessary waste thereby generated.

Yet innovation at the frontier turns on engendering a host of "hopeful monsters" seeking commercial reward…most of which will fail. This explains the need for access to speculative finance in liquid capital markets, where failure of any project has limited economic consequences and is decoupled from political patronage or penalty. In fact, as noted, financial bubbles are both extraordinarily common and – occasionally - extraordinarily productive. The state can step in when the core banking system that provides working capital to the mainstream economy is

infected. But it can also step back from curbing apparent excess in the stock market.

Again, let us refer back to Britain's industrial emergence in the 18th Century. A generation before the initial mechanization of textile production, the City of London had demonstrated a propensity for speculative mania in the South Sea Bubble of 1720. The promise of profit from attacking the fading Spanish monopoly of trade to South America was sufficient to ignite a bubble that spilled over to float an array of schemes entirely irrelevant to the triggering story and devoid of sustainable economic content. The waste and misery engendered by the South Sea Bubble became – and remains – deeply embedded in the folk culture of Britain and, indeed, of the world. Yet it was the Canal and Railway Manias, financial bubbles which seized the City of London before and after the Napoleonic Wars, that transformed Britain's economic architecture and established the logistical base for the Industrial Revolution.

Two other issues stand out. First, if the debilitating "corruption tax" is not curbed, as it was in Britain during the nineteenth century and America during the twentieth, it is difficult to imagine how new players with new ideas and minimal prior connections will succeed in gaining the running room needed to make a difference. Second, progress on the path from imitation to innovation is unlikely without some degree of protection for original intellectual property, even while one must recognize that an excessively burdensome patent system can stifle invention as surely as the absence of any system will.

In my book, *Doing Capitalism in the Innovation Economy*, I characterized innovation as the outcome of a Three Player Game whose participants are the state, the market economy and the owners of financial

capital. In every nation, the relative weight and reach of each of these institutions at every moment of historical time is unique and their interactive evolution indeterminate. Like the Three Body Problem in physics, the dynamics of the Game are inevitably unstable and unpredictable. No schematic, however powerful the mathematics deployed to express it, can define its future state. No doubt China's own path forward will be as distinctive and path-dependent as were Britain's and America's and as were the processes through which China itself reached this extraordinary time of opportunity and challenge.