Introduction

BACKGROUND

In this introduction, we explore some of the theory and evidence underlying both policymakers’ and scholars’ growing concern over the continuing weakness of economic growth in the West and the role innovation must play in strengthening it.

The great British economist A.C. Pigou once wrote that the goal of research is both fruit and light – light, meaning, better understanding of the world, and fruit, meaning, the ability to change the world in a meaningful way. The objective of this book is both light and fruit – to better understand the innovation process within countries and to provide a better basis for shaping pro-innovation policies. But first, we must ask, why is innovation so crucial to the wellbeing of the world and those who live in it? Why is innovation the first link in the causal chain whose end result is economic wellbeing?

PRODUCTIVITY, ECONOMIC GROWTH AND INNOVATION

The teleology (cause and effect) of productivity, economic growth, innovation and economic wellbeing is simple and clear. Economic wellbeing is measured by per capita consumption. Growth in per capita consumption must be driven by growth in per capita output, or output per labor hour, that is by productivity growth. Of course, consumption can outpace productivity, for a time, but only at the cost of growing budget and trade deficits, which is unsustainable in the long run. Productivity growth, in turn, is driven largely by innovation. We shall briefly explore each link in this chain in turn.

Productivity Growth

MIT Professor Robert Solow (1957), preceded by the Dutch economist Jan Tinbergen, have showed that between half and two-thirds of
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productivity growth, or more, stems from “total factor productivity (TFP) growth”, meaning, better, smarter, more creative use of resources (with the remaining part explained by growth in capital per worker).

A modest paper written by Tinbergen, published in 1942, revealed why innovation is so crucial to our wellbeing. Tinbergen was determined to maintain his research in Holland despite the Nazi occupation. He published an article almost nobody read at the time, in a German journal, *Weltwirtschaftliches Archiv* (Tinbergen, 1942). His paper has a fundamental equation, written as:

\[
t = y - 2/3 N - 1/3 K
\]  
(1)

where “y” is the year-to-year change in gross domestic product (GDP), or output, “N” is the year-to-year change in labor input (FTE, or man-years), “K” is the year-to-year change in invested capital; and “t” is free lunch productivity growth – the growth in GDP that cannot be explained by, or attributed to, growth in the basic factors of production, labor and capital, but rather is caused by better, smarter, more productive use of existing resources. (The weights, 1/3 and 2/3, reflect in turn the relative contribution of capital and labor to national income and output.)

The Tinbergen equation has undergone many transformations over the years, and Tinbergen’s “t” has been given various names: Total Factor Productivity (TFP, used in the US), Multi-Factor Productivity (MFP, commonly used in Britain), or, as it is sometimes called, Free Lunch Productivity (FLP). This equation has been revived and reframed by MIT Professor Robert Solow, who simplified the equation by adding and subtracting “N” from the right-hand side, to get:

\[
t = y - N - 2/3 N - 1/3 K + N = y - 1/3 (K - N)
\]  
(2)

\[
(3) \quad t = (y - N) - 1/3 (K - N)
\]

This simplified version says that TFP or total factor productivity growth is the residual, or what is left over, after the contribution of the growth in capital per worker (K – N) is subtracted from overall growth in GDP per worker. Put another way: (y – N) is the growth of gross labor productivity (the percent change in GDP per worker), and 1/3 (K – N) is the part of that gross labor productivity growth driven by higher capital intensity (higher capital per worker). What is left, then, must be the part of gross labor productivity growth caused by factors other than higher capital investment.

Tinbergen’s equation has found wide use at the national level, in measuring (TFP). Solow’s seminal 1957 paper reveals that for the US, for the
period 1900–49, “Gross output per man hour doubled over the interval, with 87.5 percent of the increase attributable to technical change (i.e. TFP) and the remaining 12.5 percent to increased use of capital.” (p. 320). This finding has since been replicated for many advanced nations. For 2005, a year chosen because it preceded the 2007–12 global economic downturn, TFP growth accounted for between 55 percent and 72 percent of overall growth in GDP per worker in the USA, India, China, Japan and UK (Cahill and Maital, 2012, p. 22). The inescapable conclusion is that overall growth in output per worker or per hour is driven not mainly by capital deepening (i.e. providing more equipment, machines, computers, etc. to workers), but by gains in knowledge, creativity, innovation and the cleverness with which we employ existing labor and capital.

**TFP Growth**

But what drives TFP growth? TFP growth, in turn, is driven largely by a combination of improvements in human capital and the creativity and innovation that human capital applies to its resources. Human capital and innovation are almost inextricable. People who are better educated, more skilled and more knowledgeable are by definition more able to do things differently, uniquely better, rather than do them as they always have been done.

Therefore, the teleology of economic progress in economic society is captured by a simple sentence:

Innovation and human capital drive productivity growth, which drives growth in output and consumption per capita and leads to improved economic wellbeing.

The first crucial link in this chain is therefore innovation. Hence, the growing importance both scholars and policymakers attach to their nations’ innovativeness.

**IS THERE A STRUCTURAL (PERMANENT) DECLINE IN INNOVATION?**

Strong evidence exists that the 2007–12 global economic and financial crisis may not be just another business cycle, albeit a very deep and difficult one, but may in fact reflect deep underlying structural problems, reflecting a secular (permanent) drop in productivity growth, in turn driven by declining TFP growth and declining innovation.
In his widely-discussed 2012 paper, and forthcoming book, Robert J. Gordon (2012) argues alarmingly that “future growth in consumption per capita” (for 99 percent of the US population) could fall below 0.5 percent a year for an extended period of decades” (p. 1). He cites six headwinds that afflict the USA (and, by extension, many other Western economies): “demography (aging populations), education (declines in the quality and quantity of human capital), inequality in the distribution of wealth and income, globalization, energy/environment and the overhang of consumer and government debt.” These “headwinds” are in fact global in nature, as shown by the 2013 World Economic Forum Global Risk Report. Gordon claims that “...the rapid [economic] progress made over the past 250 years could well turn out to be a unique episode in human history. ... Growth in the frontier [the technology-leading country – UK until 1906, USA afterwards] accelerated after 1750, reached a peak in the middle of the 20th century and has been slowing down since.” Gordon explains that the Third Industrial Revolution, 1960 to the present, featuring computers, the web, mobile phones, created only a “short lived growth revival between 1996 and 2004”, and was weak compared with the First (steam, railroads) and Second (electricity, internal combustion engines, communications, chemicals) Industrial Revolutions. Underlying this bleak picture is the secular decline of innovation – new products and services that change and enrich our lives.

Gordon’s arguments are summarized in Figure I.1. He is supported by the findings of Professor Tyler Cowen (2011), who argues that the global financial crisis is making a deeper and more disturbing “Great Stagnation”; as The Economist summarizes, “for all its flat-screen dazzle and high-bandwidth pizzazz, it seemed that the world had run out of ideas”.

Declining Innovation

Underlying Gordon’s worrisome research finding is evidence that the pace of innovation has slowed, perhaps permanently. Pierre Azoulay and Benjamin Jones (2006) have found that “The average R&D worker [in the US] adds only 15 percent as much to TFP in 2000 as the average R&D worker did in 1950. Why?” If the productivity of innovation investment itself has declined drastically, and is now 1/7 what it was two generations ago, it is inevitable that the innovation of productivity too will be dismal. Azoulay and Jones note that the share of resources allocated to R&D has risen by a third, since 1975, in the USA, to almost three percent of GDP, yet the results have met sharply diminishing returns. Many nations seek to expand R&D investment; yet if that investment itself is becom-
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One big wave
GDP per person, % increase on previous year

WATT'S STEAM ENGINE
STEAM Locomotive
TELEGRAPH
ELECTRICAL GENERATORS
INDOOR PLUMBING
BROADCAST RADIO
PC


Figure I.1 Growth in GDP per capita, 1300–2012, in the US and Britain

ing less productive, the result will not be the desired increase in fruitful innovation.

We can confront these research findings with our own pragmatic observations. The speed of traffic has barely increased in the past 60 years, and in city centers, it has greatly slowed. Supersonic air travel no longer exists. Life expectancy soared, as medical innovations prolonged life, but in the USA life expectancy of 78.4 years is just slightly above what it was in 1980. As a founder of PayPal once observed, instead of having flying cars, we have 140 characters (Twitter). And studies of individual self-assessed happiness show that happiness, if anything, has declined over the past decades (see White, 2007). Our own perception of wellbeing supports the claim that the fundamental drivers of wellbeing have stagnated.

The Theory of Stagnating Innovation

To this point, we have offered mainly empirical evidence supporting the concern that productivity growth, and the innovation that drives it, has declined structurally, not just cyclically, as a result of the 2008–12 global downturn. But is there solid economic theory that can explain this hypothesis?

According to Paul Romer (1987), in an influential paper published a generation ago, the decline in productivity growth is caused, perhaps,
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by Western companies offshoring their production to Asia. Once, rising wages forced companies to innovate, seeking labor-saving innovations to boost productivity and offset higher labor costs. But when inexpensive nearly-inexhaustible labor is available abroad, this incentive disappears. This theory was proposed long before offshoring became predominant. As Romer summarizes his theory, “an increase in the rate of growth of labor will be accompanied by a fall in the rate of growth of labor productivity” (Romer, 1987, p. 198). This may be true, even if the expanded labor supply is in another nation with which a country trades.

A related theory was put forward by MIT Professor Paul Samuelson, in 2004. Samuelson’s paper showed that technical progress in a developing country such as China had the potential to reduce welfare in the US. Samuelson’s model refutes the universal principle of comparative advantage, which states that all nations gain from free trade. He does this by creating a dynamic model in which China, say, specializes in an industry characterized by rapid productivity gains, and exports the fruits to, say, the USA; China thus captures the benefits of productivity growth, at America’s expense. This in part is precisely what has happened. In a sense, at least theoretically, America has exported its productivity gains, and the underlying innovation in production systems driving it, to China. Gordon (2012, p. 15) shows that USA output per hour of $53.70 in 2012 (in 2005 prices) was 60 percent lower than it would have been (i.e. $83.30), had the growth rate of productivity (output per hour) for 1948–72 prevailed in the period 1972–2012, in place of the much lower actual growth rate.

Some economists have argued that in the long run, this negative impact on productivity will be self-correcting, as wages rise in the offshore low-skill producing countries and makes innovation at home more attractive (see Acemoglu, Gancia and Zilibotti, 2012). There is some evidence that this is indeed occurring in China, where wages are indeed rising. But the result has not been to stimulate innovation in the West. Instead, other developing countries (Vietnam, Thailand, Burma, Sri Lanka) have taken China’s place at the bottom of the low-wage, low-skill value chain. There is an enormous amount of low-skilled labor that can be exploited in the emerging market nations, before Western countries and companies are pressed to the wall and forced to again seek labor-saving productivity-generating innovations.

Another secular cause of declining innovation, often cited, is that of the changing role of government and globalization. Globalization, and the accompanying rapid expansion of trade between East and West, created a massive imbalance, in which high-saving developing nations exported to low-saving Western nations, creating massive trade defi-
cits in the US in particular, and then lent their savings to the West to enable them to continue to purchase their goods, thus sustaining and deepening the trade deficits. This imbalance ultimately collapsed, in the 2008–12 crisis, as it inevitably had to. It has led to a demand for “rebalancing”, which will require a shift in emerging market nations in Asia from saving to consumption, to replace some of their exports, with a proportional and similar shift in the West from consumption to saving, to reduce their borrowing needs from Asia. Since a major source of dissaving in the West lies in government deficits, any rebalancing will require a major shrinkage in the amounts of demand injected by government budgets and a corresponding reduction in the role of government. Some see this as another cause of declining innovation. The stirring address of President John F. Kennedy, in 1962, at Rice University, announcing that “[America] will go to the moon” inspired a generation of young people to study science and engineering. In an age of austerity and shrinking government budgets, we are unlikely to see any similar project like Apollo, which led to a wave of innovation driven by those inspired by it.

CONCLUSION

Economists are notoriously poor at predicting the future. It may well be that the theory and evidence marshaled by some of this generation’s leading economists, suggesting that innovation and the resulting growth in productivity may be in permanent long-term structural decline, is completely wrong. But the theory and the empirical evidence are sufficiently reasonable and strong to cause major concern.

The world’s innovation machine, which drove three industrial revolutions and generated unprecedented increases in per capita income and consumption, first in Western nations and later and more recently, in emerging market developing countries, may be broken. It is no longer generating the breakthrough change-the-world innovations that it once did.

If the innovation is broken, it needs to be repaired. But how? Repairing a machine requires first that we understand fully how it works. The starting point, then, must be to take a fresh look at the innovation process, by defining and mapping national innovation ecosystems. In Chapter 1, we turn to defining and describing what we mean by innovation ecosystems, and then, in Chapter 2, we show how to visually create and map them.
NOTES
