# CREATIVE DESTRUCTION
## Economic Meaning of Technological Change

An Address to
The MBA Student Association, UNBSJ
February 28, 2012

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Publisher, Compiler Press
Intellectual & Cultural Property
in the Global Village

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## Introduction

*Business Warriors & the Art of War*

Welcome business warriors! Business, as in competition between rivals like Apple and Samsung, has often been compared to war. In fact in East Asia, and elsewhere, business students study Sun Tzu's *The Art of War* written in the sixth century Before the Common Era during the time of Confucius, Cyrus the Great of Persia and Thales, the first philosopher of ancient Greece. It was one of the few books, along with the *I Ching - The Book of Changes* (Wilhelm, 1950: xlvii), of a literature continuous for almost 2,500 years to survive the great book burning of 213 B.C.E. ordered by the first emperor of China, Ch'in Shih Huang Ti who declared: Before Me, No History! Knowledge can be lost, not just found.

Among other things Sun Tzu argued a battle can be won before it is fought. Among the important factors is the terrain. Unlike the warring kingdoms of Sun Tzu's time, however, business warriors today compete on a battle field or fitness landscape that is constantly changing and mutating. Blithely, we call this 'technological change'.

But what do we mean by technology? The word 'technology' entered the English language only in 1859 according to the *Merriam Webster Dictionary* deriving from the Greek *techne* meaning Art and *logos* meaning Reason, *i.e.*, reasoned art. The *Oxford English Dictionary* (OED, technology, 1 b) reports it was re-coined at that time by Sir Richard Francis Burton, Victorian explorer and translator of the *Kama Sutra* (1883), the *Arabian Nights* (1885) and the *Perfumed Garden* (1886).

It was Karl Marx, however, (1818-1883) who produced the first true philosophy of technology combining 'the means of production' with a humanist critique rather than simple glorification of Victorian progress. It is important to realize that the technological imperative drives Marxian analysis. Class warfare is collateral damage. This Marxian connection tainted reception of all subsequent philosophies of technology especially in the English-speaking world or Anglosphere. Arguably, it was the work of Martin Heidegger (a purported Nazi) specifically his 1954 essay 'The Question Concerning Technology' that finally led in 1983 to founding the American Society for Philosophy and Technology (Idhe 1991, 4). Please see the journal, *Techne*. Physical technology, to paraphrase Heidegger, is the enframing and enabling of Nature to serve human purpose.

In Economics, as you will see, measurable technological change only entered the mainstream in 1962. In this address I will examine definition of technological change within the orthodox or Standard Model of Market Economics and within heterodox economic thought, specifically my own, to describe the perennial gale of creative destruction.

*Creative Destruction & the Solow Residual*

In 1942, economist Joseph Alesoph Schumpeter published *Capitalism, Socialism and Democracy*. Schumpeter, like Marx, considered technological change the driving force of capitalism and human society in general. For Schumpeter creative destruction is the:

> … process of industrial mutation - if I may use that biological term - … that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new … Creative destruction is the essential fact about capitalism. It is what capitalism consists in and what every capitalist concern has got to live in. (p.83)
>
> … Every piece of business strategy acquires its true significance only against the background of … the perennial gale of creative destruction; it cannot be understood irrespective of it or, in fact, on the hypothesis that there is a perennial lull. (pp. 83-84)

From this observation, and other evidence, Schumpeter concluded that the Standard Model of Market Economics missed the point. Competition was not about long run lowest average cost per unit but rather about innovation and surviving the perennial gale of creative destruction.

In 1962, economist Robert Solow published "Technical Progress, Capital Formation and Economic Growth" in the *American Economic Review*. In it he presented what is known as the Solow Residual. It begins with a symbolic equation for the production function: $Y = f(K, L, T)$ which reads: national income (Y) is some function ($f$) of capital (K), labour (L) and technological change (T).

Technological change in the standard model of Market Economics refers to the impact of new knowledge on the production function of a firm or nation. The content and source of that knowledge is not a theoretical concern; what matters is its mathematical impact on the production function.

Over the last hundred years, depending on the study, something like 25% of growth in national income is measurably attributable to changes in the quantity and quality of capital and labour while 75% is the residual Solow attributed to technological change. Yet we have no idea of why some things are invented and others not; and, why some things are successfully innovated and brought to market and other are not. The Solow Residual is known in the profession as 'the measure of our economic ignorance'. It is why I became an economist.

I will first review the orthodox, mainstream or standard model definition of technological change. Second, I will then expand the definition to include my own heterodox economic thought.

## Orthodox

As stated, technological change in the Standard Model refers to the impact of new knowledge on the production function of a firm or nation. The content of such that knowledge is not a theoretical concern, only its mathematical impact on the production function.

In response to technological change, the production function may shift upwards or downwards. The quantity and/or cost per unit output may increase or decrease. Alternatively, an entirely new production function may emerge with innovation of new products, processes and techniques. Technological knowledge does not just accumulate; it also withers away if not transmitted to subsequent generations. This is most apparent with the fall of Rome and contemporary loss of traditional craft methods (White & Hart 1990). The process has been compared to speciation and extinction in biology (Kauffman 2000, 216).

Furthermore, in the Standard Model knowledge is considered a public not a private good. When new knowledge is published or otherwise made known, others cannot be easily excluded from acquiring it, *i.e.*, it is non-excludable in consumption. Furthermore, when shared knowledge is not reduced, *i.e.*, it is non-rivalrous in consumption. In fact, the more knowledge is shared, the more knowledge is created. In this sense, knowledge exhibits increasing returns to scale. Put another way the public domain of knowledge is where, to paraphrase Isaac Newton: We all stand on the shoulders of giants.

The effects of technological change in the orthodox model can be broken out into two dichotomous but complimentary categories: disembodied & embodied and endogenous & exogenous technological change. In addition New Growth Theory attempts, in my opinion unsuccessfully, to treat knowledge as 'bit strings' of digital ones and zeros And at the very edge of orthodoxy are two neologisms not yet integrated into the disciplinary lexicon: enabling and disruptive technological change. I will examine each in turn.

*Disembodied/Embodied*

Implicitly disembodied technological change dominated economic thought since the beginning of the discipline. It refers to generalized improvements in methods and processes as well as enhancement of systemic or facilitating factors such as communications, energy, information and transportation networks. Such change is disembodied in that it is assumed to spread out evenly across all existing plant and equipment in all industries and all sectors of the economy. It is what Victorians would have called 'Progress'.

Also implicitly, the concept of embodied technological change traces back to Adam Smith's treatment of invention as the result of the division and specialization of labour (1776). It refers to new knowledge as a primary ingredient in new or improved capital goods. The concept was refined and extended by Marx and Engels (1848) in the 19th and by Joseph Schumpeter in the 20th century with his concept of creative destruction (1942). No attempt was made, however, to measure it until the 1950s (Kaldor 1957; Johansen 1959). And it was not until 1962 that Solow introduced the term 'embodied technological change' into the economic lexicon, and by default, disembodied change was recognized (Solow May1962).

Formalization of embodied technological change arguably emerged out of 'scientific' research and development (R&D) during the Second World War followed by the post-war spread of organized industrial R&D. This demonstrated that new scientific knowledge could be embodied in specific products and processes, *e.g.*, the transistor in the transistor radio. Conceptual development of embodied technological change has, however, "lost its momentum" (Romer 1996, 204). Many theorists, according to Romer, have returned to disembodied technological change as the *force locomotif* of the economy meaning: "Technological change causes economic growth" (Romer 1996, 204).

*Endogenous/Exogenous*

While embodied/disembodied refers to form, endogenous and exogenous refers to the source of technological change. The source of exogenous technological change is outside the economic process. New knowledge emerges, for example, in response to the curiosity of inventors and pursuit of 'knowledge-for-knowledge-sake'. Exogenous change, with respect to a firm or nation, falls from heaven like manna (Scherer 1971, 347).

By contrast, endogenous technological change emerges from the economic process itself - in response to profit and loss. For Marx and Engel, all technological change, including that emanating from the natural sciences, is endogenous. Purity of purpose such as 'knowledge-for-knowledge-sake', like religion, was so much opium for the masses cloaking the inexorable teleological forces of capitalist economic development. The term itself, however, was not introduced until 1966 (Lucas 1966) as was the related term 'endogenous technical change' (Shell 1966).

Endogenous change is evidenced by formal industrial research and development or R&D programs. It therefore includes what are usually minor modifications and improvements – tinkering - to existing capital plant and products called 'development' (Rosenberg & Steinmueller 1988, 230). In this way industry continues the late medieval craft tradition of experimentation. R&D varies significantly between firms and industries. At one extreme, a change may be significant for an individual firm but trivial to the economy as a whole. On the other hand, 'enabling technologies' such as computers or biotechnology may radically transform both the growth path and the potential of an entire economy. How to sum up the impact on the economy of the endogenous activities of individual firms remains, however, problematic.

With respect to the Nation-State, endogenous and exogenous technological change has a different meaning. They refer to whether the source is internal, *i.e.*, produced by domestic private or public enterprise, or external to the nation, *i.e.*, originating with foreign sources.

*New Growth Theory*

Out of a decade long debate over embodied vs. disembodied and endogenous vs. exogenous technological change, a new theory emerged in the 1980s called New Growth Theory. Initiated by Paul Romer (1986), it is explicitly endogenous and implicitly embodied.

Like other 'new' forms of economics such as the New Institutionalism (Coase 1992), New Economic History (North & Thomas 1970), New Economic Geography (Krugman 1983; Martin & Sunley 1996) and the New Economics of Science (Dasgupta & David 1994), New Growth Theory appears, at least to this observer, as an exercise in re-calibrating the Standard Model to include descriptive, empirical, institutional and historical evidence previously excluded because it is qualitative rather than quantitative in nature.

While welcomed, the professional urge remains to fabricate such new evidence into quantitative proxy indicators to be plugged into mathematical models. Romer thus calls for more sophisticated mathematical modeling without expectation of testing because "these kinds of facts tend to be neglected in discussions that focus too narrowly on testing and rejecting models" (Romer 1994, 19-20). So much for Positivism in econometrics!

Beyond admitting additional sources of evidence, New Growth Theory introduces the concept that technological change involves non-rival 'ideas' that can "be stored in a bit string" (Romer 1996, 204), implicitly referring to computer programs, a form of soft-tooled knowledge. His concept, however, presents, to my mind, a confusion between information (measurable) and knowledge (immeasurable) and a failure to acknowledge the distinction between the short-run and long-run with respect to intellectual property, *i.e.*, between knowledge residing in the private domain in the short-run but entering the public domain in the long-run.

With respect to information and knowledge, the 'bit' abstracts from content and fails to provide a homogenous unit measure of knowledge, or what Kenneth Boulding called 'the wit' (Boulding 1966, 2). With respect to intellectual property, in the short-run knowledge is rivalrous and excludable to the degree that copyrights, patents and other state-sponsored intellectual property rights provide protection. In the long-run, however, all intellectual property rights expire and knowledge enters the public domain. Given new technical knowledge is continually being copyrighted and patented, one faces an ever moving horizon between rivalrousness and non-rivalrousness, a horizon that can never be reached. Applying Lord Keynes' aphorism: "In the long run we are all dead" (Keynes 1924).

*Disruptive/Enabling*

In Economics, two additional terms are slowly entering the lexicon migrating from business and technology literatures: disruptive/enabling technologies. The term disruptive technology was, according to Adner & Zemsky (2005), introduced by Christensen in 1997. In turn, the Adner & Zemsky article was the first and only one to include the term 'disruptive technology' in its title according to a JSTOR search of 173 economic journals published between the 1880s and 2008. A disruptive technology is one that disrupts existing markets displacing earlier technologies, *e.g.*, the automobile displacing the horse and buggy.

On the other hand, the term 'enabling technology' has, according to a similar JSTOR search, not yet been the titled subject of any economics article. An enabling technology is one that dramatically increases the capabilities of consumers and/or producers. They are often characterized by rapid development of derivative or complimentary technologies, *e.g.*, the IPod and complimentary goods such as docking stations. Another example is convergence of telecommunication, the internet and software permitting creation of JSTOR that dramatically enhances the capabilities of scholarly researchers. Similarly an emerging enabling technology, 3D printing, threatens to upset traditional mass production manufacturing by enabling small firms to produce cost-efficient small runs.

It is important to note that a new technology may be both disruptive and enabling at the same time. The internet or worldwide web is an example. On the one hand it has enabled creation of 'social media' such a Facebook; on the other hand, it has been extremely disruptive of pre-existing business models in the entertainment industry.

## Heterodox

By heterodox I mean outside of the mainstream. In fact the *Journal of Economic Literature* recognizes a distinct sub-discipline called Heterodox Economics, subject classification B - History of Economic Thought, Methodology, and Heterodox Approaches. Such Economics generally begin with premises different from the orthodoxy. In my case there are three differing premises. First, I believe that not all significant factors can be quantified and unquantifiable ones deserve equal attention. Second, I use inductive logic, *i.e.*, generalizing from a specific example. This contrasts with the mainstream that applies deductive logic, *i.e.*, applying a general principle to a specific case. Third, I believe the appropriate metaphor for the economic process is to be found in biology rather than mechanics as in the Standard Model.

In what follows I summarize some of my observations which are more fully explored elsewhere in "10 Ways to Know the Knowledge Based Economy" (Chartrand 2012) and presented in detail in my dissertation: *Ideological Evolution: The Competitiveness of Nations in a Global Knowledge Based Economy* (Chartrand 2006). Such summaries are used so I can, within the time available, focus on Evolution of the Production Function. I would be happy, however, to expand upon these summary observations during Q&A.

*Emergent Technologies*

With respect to technology, the Standard Model is *ex poste*, *i.e.*, after the fact. Thus it considers new technology only after it has fully impacted the production function. There are, however, emergent technologies whose transformative effects will not be fully felt for years if not decades to come. Today, there are arguably two such emergent yet complementary technologies that promise to radically alter the economic process. In my opinion, it is critical to anticipate their impact *ex ante, i.e.,* before the fact.

These two emergent technologies can alternative be characterized as dryware/wetware or biotech/nanotech. Dryware/wetware is a neologism coined by science fiction writer Rudy Rucker (1988). Dryware refers to silicon-based technologies, *e.g.,* computers, while wetware refers to carbon-based or organic technologies including genetically modified organisms.

When Rucker wrote in 1988 he did not anticipate the emergence in the late 1990s of nanotechnology which in many cases also uses carbon. Graphene, for example, is a made up of pure carbon atoms arranged in a regular hexagonal pattern in one-atom thick sheets. Its application to flexible video displays is just one of its emerging applications. 3D printing, previously, referenced is another example of nanotechnology. What nanotech and biotech share in common is the manipulation of matter/energy at the molecular and atomic levels. These complementary technologies promise to be enabling of new ways of doing existing things as well as doing new things entirely. They also promise to be extremely disruptive of existing industries from electronics, health care and even the construction industry.

*Epistemology Summary*

Epistemology is the study of knowledge which, for my purposes, emerges from three distinct knowledge domains. The Natural & Engineering Sciences generate physical technology, *i.e.*, the ability to enframe and enable Nature to serve human purpose. The Humanities & Social Sciences generate organizational technology, *i.e.*, the ability to shape and mold human personalities, communities, enterprises, institutions and societies. The Arts generate design technology, *i.e.*, the ability to make the best looking thing that works. In effect the Arts provide the technology of the heart.

*Legal Summary*

Law takes a public good called knowledge and for a limited period of time converts it, if fixed in material form, into a private good that can be bought and sold – copyrights, patents, registered industrial designs and trademarks. Eventually, however, all knowledge returns to the public domain where, to quote Newton, we stand on the shoulders of giants.

*Morphology Summary*

Knowledge takes three forms. Codified knowledge is fixed in matter/energy as meaning. Sender and receiver must both know the code. It is protected by copyright, registered industrial design and trademark. Tooled knowledge is also fixed extrasomatically in matter/energy as function. The user must know what button to push. It is protected by patent. Personal knowledge is fixed in the Natural Person as neuronal memory and reflexes of muscle and nerve. It is protected by non-disclosure and/or confidentiality clauses in commercial contracts as well as contracts of employment as 'know how' and trade secret. Ultimately, however, all knowledge is personal. Only the Natural Person knows how to decode and push the right button for tooled knowledge to function.

*Evolution of the Production Function*

The production function is arguably the most elegant contribution of Economics to human thought. In its symbolic form, *i.e.*, without numeric value ascribed to the variables and function, it sums up the economic process. It can also be used to illustrate the evolution of the economy. Exhibit 1 illustrates my view of this evolution. It is important to note that over time factors of production accrue additional, extended meaning as well as new factors being recognized.

The first school of modern economic thought, Mercantilism of the 16$^{th}$, 17$^{th}$ and early 18$^{th}$ centuries, believed national income (Y) resulted from accumulating capital (K) in the form of gold and silver (or bullion) as well as land and slave labour. Spain was the exemplar economy. The huge quantities of bullion accumulated by the Conquistadores, however, fed inflation and destroyed much of the domestic economy. It became cheaper to buy abroad than produce at home.

The Classical School of Economics beginning with Adam Smith in the late 18th century argued that in addition to bullion, national income was generated by a new form of capital: manufacturing plant and equipment. In addition free rather than slave labour (L) through division and specialization was recognized as a significant contributor to national income. England was the exemplar economy.

**Exhibit 1**
**Evolution of the Production Function**

| Exemplar Economy | Sector | Production Function | Accreting Factors of Production |
|---|---|---|---|
| **Spain** 16th, 17th & early 18th centuries | *Primary* farming, fishing, forestry & mining | $\mathbf{Y = \mathit{f}\,(K)}$ | K = gold, silver, land & slave labour |
| **England** late 18th and mid-19th centuries | *Secondary* manufacturing | $\mathbf{Y = \mathit{f}\,(K, L)}$ | K = manufacturing plant & equipment<br>L = division & specialization of free labourers |
| **U.S.A.** late 19th to mid-20th century | *Tertiary Services* communication, energy, financial, transportation | $\mathbf{Y = \mathit{f}\,(K, L, T)}$ | K = private financial capital & limited liability corp.<br>L = organized labour<br>T = disembodied, endogenous |
| **Japan** mid- to late 20th century | *Government* | $\mathbf{Y = \mathit{f}\,(K, L, T)^{G}}$ | K = public & private capitalization<br>L = automated labour<br>T = embodied, exogenous<br>G = government coordinates public & private sectors through macro- & micro-economic policies |
| **Global** late 20th & early 21st centuries | *Quaternary* copyright, patent, registered industrial design, trademark, ‘know-how’, trade secrets | $\mathbf{Y = \mathit{f}\,(K, L, P, O, D)^{G}}$ | K = knowledge capital<br>L = knowledge workers<br>P = physical technology<br>O = organizational technology<br>D = design technology<br>G = national innovation system ensures rapid commercial exploitation of academic or pure research to grow GDP |

In the late 19th century the Neoclassical School of Economics arose and with it another change in the nature of capital: the limited liability corporation. Proprietorship and partnership models imposed fully liable for all losses of a firm. With the limited liability corporation investors could buy and sell shares with liability limited to the value of those equities. Capital markets were expanded to include equity markets and, *contra* Marx, capital ownership was spread into more and more hands.

Also as the scale of industrial production soared in critical sectors, *e.g.*, communications, energy, transportation, there were fewer and fewer yet larger and larger firms. This was the Age of the Robber Barons. Labour, however, was also unleashed from constraints imposed under the Conspiracy Act and allowed to organize and negotiate terms of employment.

In addition, a new factor of production was introduced, *i.e.*, technological change (T) in the guise of disembodied, endogenous technology. Technology was endogenous in this age of Morse, Bell and Edison all of whom sought new technologies for commercial application. Technology was, however, disembodied and generally described as capital 'p' Progress! The U.S.A. is the exemplar economy.

In the mid-20th century the Keynesian School of Economic arose and a new factor of production emerged: Government (G). Capital again expanded to include publicly funded infrastructure like the American Inter-State Highway System seen as an investment in economic growth and expansion. Government also assumed responsibility for macroeconomic management of the overall economy and microeconomic management of selected industries through anti-trust, anti-combines policies first introduced in the previous period.

Labour was also transformed from unskilled or semi-skilled workers into automated labour, *i.e.*, labour assisted by increasingly intelligent devices, *e.g.*, the word processor and the robot. As automation spread throughout the economy employment increasing shifted into the service sector.

Technological change also morphed into embodied, exogenous technology. Specific natural science research became embodied in new devices such as the transistor in the transistor radio. Whole new industries emerged, *e.g*., electronics. Technological change was also increasingly exogenous in that research findings increasingly came out of the University. Corporate efforts focused on development, *i.e.*, tinkering, with existing products and processes rather than 'pure' research. In fact, the biotech revolution began and continues to centre round the University with academic researchers partnering with commercial enterprise (Zucker 1998)..

Technology was also embodied with respect to innovation, *i.e.*, how to successfully bringing an invention to market, *e.g.*, the fax machine, the Walkman, the VCR. It is especially in this regard that Japan as in 'Japan Inc.' serves as the exemplar economy of the period.

In the late 20th century and early 21st century the production function changed again. In 1995 the World Trade Organization (WTO) began operations and a new global economy was born. Today, virtually all member states of the United Nations (UN) belong to the WTO. This was possible only because of the triumph of the Market over Marx.

For the first time virtually all Nation-States agreed to abide by common rules of trade recognizing the WTO as final arbitrator of disputes and authorizing it to sanction countervailing measures against offenders of its rules. Ideologically its rests on the Standard Model of Market Economics.

The WTO is a 'single diplomatic undertaking', *i.e.,* it is a set of nearly 30 instruments constituting a single package permitting only a single signature without reservation. One of these is the *Trade-Related Intellectual Properties and Services Agreement* (TRIPS) that constitutes, in effect, a global treaty on trade in knowledge, or more precisely, in intellectual property rights (IPRs) including copyrights, patents, registered industrial designs and trademarks.

TRIPS marked the beginning of a new geo-economic order. Just as Second World command economies melted into a single global marketplace under the WTO, the First World shifted from a manufacturing to a knowledge-based economy. Thus in 1996 the Organization for Economic Cooperation & Development (OECD) – the First World club - published: *The Knowledge-Based Economy* (KBE) which rationalized the transition. Then in 1997, it published a survival guide: *National Innovation Systems* (NIS). This was accompanied by transition to financial capitalism (knowledge-based) and de-industrialization or rather de-manufacturing of most Anglosphere Nation-States while Germany, Japan and the Nordic countries maintained their manufacturing base. It also, of course, saw China become the workshop of the world.

Creation of the WTO (especially TRIPS) and recognition of the knowledge-based economy initiated an avalanche of change. A new private sector specialty emerged called 'knowledge management'; governments created knowledge ministries, departments and agencies; 'knowledge audits' were conducted by firms and Nation-States. See, for example, (Malhotra 2000), (ANSI/GKEC 2001) and (Bouthiller & Shearer 2002). The mandate of the University was transformed from generation to commercialization of new knowledge (Chartrand 2008) as it was welded into the government inspired National Innovation System (NIS).

The definition of capital again expanded to include knowledge capital as intellectual property rights, statutory – copyright, patent, registered industrial design and trademark, and contractual – 'know how' and trade secrets. Labour too transformed particularly with the decline of organized labour into knowledge workers, increasingly working on contract or self-employed.

The definition of technology also expanded. A knowledge-based economy has three primary sources of new knowledge and hence technology. As noted above, the Natural & Engineering Sciences generate physical technology (P), *i.e.*, the ability to enframe and enable Nature to serve human purpose. The Humanities & Social Sciences generate organizational technology (O), *i.e.*, the ability to shape and mold human personalities, communities, enterprises, institutions and societies. The Arts generate design technology (D), *i.e.*, the ability to make the best looking thing that works. In effect the Arts provide the technology of the heart.

## Conclusions

In the same year – 1962 – that Solow revealed the enormous technological residual or hole in the production function, philosopher of science Michael Polanyi published his seminal *Personal Knowledge: Towards a Post-Critical Philosophy* and Thomas Kuhn published *The Structure of Scientific Revolutions*. While Kuhn focused almost exclusively on scientific thought, Polanyi expanded the spotlight to embrace technology. With respect to physical technology, what Heidegger defines as enframing and enabling Nature to serve human purpose, Polanyi considered it extension of human *being*. He argued we 'indwell' in our tools and toys. They extend not just our senses but our sense of self. As did Heidegger, Polanyi used the example of a simple hammer. Where does one feel the impact of the hammer hitting the nail? Is it in the palm of one's hand or at the point of impact?

We indwell in our physical technology taking the computer game, light switch and automobile as black boxes extending our sense and abilities. They become subsidiary to our focal consciousness; they are background; taken for granted. Someone from centuries passed would call them magic or tools of the devil! For us they form and format the human built environment.

Such indwelling can, however, be both blessing and curse. It can breed dependency. What happens when the lights go out? We grow comfortable with our toys and tools, especially how to use them. How many people spent years learning to use WordPerfect before forced to WORD? How many knowledge workers struggle daily to keep up with ever changing software versions, updates, *etc*.?

Yet physical technology – what I call hard and soft tooled knowledge (Chartrand 2006) – is only one contributor to the perennial gale of creative destruction. We also indwell in our organizations from family to neighbourhood, community, city as well as workplace. We become embedded within organizations reflecting the dominant ideology of the age. We routinely play out our appropriate roles until the management model changes. From Planned Program Budgeting

Systems to Management by Objectives to Zero Based Budgeting, the management fashion cycle goes on and on and on. Our organizational technology is also in constant flux.

Furthermore, our sense of ‘the best looking thing that works’, our design technology too is in constant flux. Styles change. Keeping up is a constant struggle, especially for the young. After about 30 one generally gives up and locks into a personal style, the cultivated self-image one projects to the world. What of the Yahoo employees who worked from home? Now they must go into the office. How will their style change?

So business warriors, the ground under your feet is not solid. Physical, organizational and design technologies keep changing and mutating. What is one to do? One approach is to contrast competitiveness and fitness. I do so at the level of the Nation-State, *i.e.*, macroeconomic perspective.

There is no doubt that competitiveness results from the division and specialization of labour in a larger market. But competitiveness as comparative advantage has its limits. In sports, the preferred metaphor used in discussing competitiveness, it is the opposing team that is the challenge. The playing field, the environment itself, is generally fixed, invariant and subsidiary to the consciousness of players at play. In biology, however, natural selection involves not just an opponent but also an ever changing environment or 'fitness landscape'.

Given an active environment, autonomous agents, organisms or institutions, constantly adapt, adjust and evolve or go extinct. They adapt by experimenting with mutations called preadaptations or exaptations. According to Kauffman, these come from the adjacent possible - the realm where possibilities one step away from being realized reside. Creativity, inventiveness and imagination are required to see them and courage and confidence to grasp them.

New products and processes generated by R&D in the Natural & Engineering Sciences; new methods emerging from the Humanities & Social Sciences including management sciences; and, new aesthetics, forms and designs thrown up by the Arts, this is creative destruction. Biological systems expand or explore the adjacent possible filling all possible niches as quickly as possible subject to timely selection of the fit and unfit, *e.g.*, going out of business. Such timely selection is called ‘early visibility’ and ‘fast failing’ in the innovation literature.

If selection takes too long, then fitness may decline or simply melt away. Arguably, this explains ‘de-industrialization’ of Anglosphere Nation-States. They maintained existing plant and equipment, *e.g.*, in steel production, until fully depreciated through voluntary (and sometimes involuntary) quotas on imports from developing Asian producers who invested in the best new technologies emerging from the adjacent possible. The fitness of the West fell, at least in terms of the traditional manufacturing-based economy.

A balance must be struck between fitness defined as the ability to adapt to a changing environment and competitiveness defined as optimal adaptation to the current environment. This balance includes conserving and preserving the best of the Past. More dramatically it means maintaining some minimum domestic capacity in case of interruption to international trade, *e.g.*, caused by a deadly world flu pandemic. For 3 to 6 months international shipping may stop. Competitiveness means being the best in the current environment. Fitness means surviving environmental change. Sustainability means staying fit through time.

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## Eve of Destruction

Lyrics
Barrie McGuire, 1965

The eastern world it is explodin',
violence flarin', bullets loadin',
you're old enough to kill but not for votin',
you don't believe in war, what's that gun you're totin',
and even the Jordan river has bodies floatin',
but you tell me over and over and over again my friend,
ah, you don't believe we're on the eve of destruction.

Don't you understand, what I'm trying to say?
Can't you see the fear that I'm feeling today?
If the button is pushed, there's no running away,
There'll be no one to save with the world in a grave,
take a look around you, boy, it's bound to scare you, boy,
but you tell me over and over and over again my friend,
ah, you don't believe we're on the eve of destruction.

Yeah, my blood's so mad, feels like coagulatin',
I'm sittin' here, just contemplatin',
I can't twist the truth, it knows no regulation,
handful of Senators don't pass legislation,
and marches alone can't bring integration,
when human respect is disintegratin',
this whole crazy world is just too frustratin',
and you tell me over and over and over again my friend,
ah, you don't believe we're on the eve of destruction.

Think of all the hate there is in Red China!
Then take a look around to Selma, Alabama!
Ah, you may leave here, for four days in space,
but when your return, it's the same old place,
the poundin' of the drums, the pride and disgrace,
you can bury your dead, but don't leave a trace,
hate your next-door-neighbour, but don't forget to say grace,
and you tell me over and over and over and over again my friend,
ah, you don't believe we're on the eve of destruction.