Principles and Patterns of Economic Era Development

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Abstract

The proposition tendered here maintains that historic economic era developmental patterns reveal principles that can be used to forecast oncoming economic eras. This article commences with a brief introduction of the past and present "Big Four" economic eras that have dominated human history. Drawing upon patterns associated with the "Big Four," the author presents some "lessons learned." The "pacing parameters" presented prove useful in gauging progress and status of the "Big Five" waves of economic change the author projects will dominate the millennium.

In total, nine successive waves of economic activities—past, present and prospective—already have swept or soon will sweep across the world. Changes in sector dominance do not mean that previous economic activities will disappear. Undertakings in waning sectors simply become less important, as the onus shifts elsewhere. One after the other, each impending era is projected to become the economic center of gravity generating the major source of jobs, livelihoods and gross domestic product in country after country.

Global economic development, so far, has involved four successive waves of economic change. Advanced economies have progressed through the first three of these basic development stages: 1. Agricultural Revolution (sector peaked in the US during 1880s); 2. Industrial Era (US peak, 1920s); 3. Service Era (US peak, mid-1950s). So-called post industrial economies are engaged in the Information Era which reached dominance (measured by workforce majority) in the US by the late-1970s. Undertakings involved in this fourth stage sector include knowledge, information, education, communications and computers. Sooner or later, every nation seems essentially destined to progress through this same general pattern of sequential economic development.

The previous Big Four economic eras that advanced incrementally over thousands to millions of years portray the course, content and timing of technological milestones that gird economic development. The momentum of such long term evolutionary developments entail a sequence suggesting tempo and timing. Continuation of further similar change is strongly deterministic, not fatalistic. These patterns of the past can be used to size up the nature and timing of the impending "Big Five" economic activities projected to dominate this millennium:

1. Leisure Era, acquiring dominance beyond 2015;
2. Life Sciences Era, attaining dominance by 2100;
3. Meta-Materials Era, achieving dominance between 2200-2300;
4. New Atomic Age, acquiring dominance between 2250-2500; and
5. New Space Age, commencing around 2500-3000.

The Big Four

1. Agriculture

Agricultural jobs wresting sustenance from nature peaked in the US during the 1880s, and radically declined from then on. Soon after the founding of this nation, as many as 90 percent of all workers were engaged in agriculture. By 1880, less than 49 percent were so engaged. The proportion plummeted to 27 percent by 1920, to 6 percent by 1960, and a mere 2.5 percent by 1994. By 2010, a miniscule 1 percent will be directly engaged in farm operations. Currently, this component of the agri-business system is fully accomplished by a miniscule percent of all workers in advanced industrial nations.

At the outset, massive human inputs are applied to specific economic undertakings. Technology, institutional arrangements, organized structures, and increasingly efficient inputs enable more and more to be produced or provided using less and less human input.

The genetics revolution, for example, already is radically altering and increasing food productivity. Potential increases suggest that boosting global food output 10-fold is a cinch, 100-fold boosts will not be terribly difficult to realize, and 1000-fold increases are possible. Advances in the development of synthetic sweeteners provides an inkling of such seemingly preposterous increases. Synthetic sweeteners, ranging from hundreds to thousands of times the sweetness of sucrose (table sugar) have been developed and are used throughout the world. Some of them have been used for over 100 years. Among the growing family of synthetic sweeteners is a dipeptide that is 55,000-times sweeter than sucrose! Millions of acres now devoted to traditional sweeteners—sugar cane, sugar beets, corn sweeteners and other starch-based sources—along with millions of jobs may be lost as consumers switch to alternative sweeteners.

2. Manufacturing

Modern Industrial Era undertakings entailing mass production of fabricated goods engaged 53 percent of all US workers in 1920 and declined to 29 percent in 1976. Likewise, the proportion of GDP generated by manufacturing plummeted from 34 percent in 1950 to a mere 13 percent in 2002. These long term declines are contrary to what most casual observers might think. Putting this plunge in perspective, Bureau of Labor Statistics notes that goods-producing industries will generate 1.3 million jobs during the first decade of the 21st Century while service sector jobs will add 20 million new jobs!

Productivity of all kinds is enhanced by knowledge. Driving economic forces of science and technology represent practical application of the state of knowledge and understanding. Somehow and someway, human inquisitiveness and endeavors always find new ways of doing things better, faster, cheaper, utilizing fewer resources, and markedly reducing human labor inputs.

Huge central steam engines that used to run the earliest American factories have long since been supplanted by miniaturized dedicated electric motors which run individual pieces of industrial equipment. Miniaturized equipment not only takes less energy to run, occupies less space, and represents a smaller capital investment, but it also does the job more efficiently. Giant vacuum tubes used in electronics have given way to the very large scale integrated semiconductor chip which soon may include as many as one billion transistors, each performing the function of the old giant vacuum electronic tube. Should extra-sensory perception become finely honed and widely used, communications will be transformed into totally new and different dimensions.

Clocks, a forerunner of mechanical invention, initially occupied entire temples. Pocket watches, ponderous and thick at the outset, steadily diminished in size. By 1700, the average thickness slimmed down to 1.5 inches, trimmed to one-half that thickness (0.75 inch) by 1800, and shrank to 0.25 inches by 1850. Today, LED display timepieces measuring the thickness of a sheet of paper and molecule-thick versions have been developed.

Sand, to demonstrate another extension of value-added use, has been employed for a succession of commercial applications. This abundant resource was used in glass making (beads back in 3400 BC, and more intricate beakers by 1500 BC), for cement (300 BC, Pompeii), followed by concrete (240-190 BC, Rome). Currently, its most valuable use involves computer, communications, and electronic applications that utilize silicon dioxide-sand in a purified form-as the basic building block. All these uses for sand prevail to this date.

3. Services

Service Era undertakings-activities involving third party providers rendering assistance or specialized expertise that consumers could not do for themselves or choose not to perform-peaked in the US during the mid-1950s. Service sector dominance was short-lived. Many accounts of economic eras skip over the so-called Service Era. Job counting, of course, depends on what is tabulated. The service sector came and went quickly as it was surpassed by the rapid rise of communication technologies.

4. Information Era

The fourth and present stage of economic development in post-industrial societies includes in its vast sweep and swath: knowledge, education, entertainment and information undertakings (plus all associated support activities). Anchored on communication and computer technologies, US employment in this sector has been dominant since the late-1970s. Estimates of US workforce engaged in Information Era jobs currently are pegged at 67 percent! Still heading toward its zenith, this current economic wave continues to predominate in post-industrial societies. It is likely to begin waning, however, in as few as 13 years (2015) as it begins to be overtaken by another surging wave of economic activities associated with advent of the Leisure Era.

During the Stone Age, early ancestors communicated at the rate of about one visual or audible message per second. Back then, they relied upon simple gestures, grunts, and body language. Today, mind-boggling terabit per second communications usher in rates of speed that transcend human capabilities. Considered as computational devices, computers can be traced back to the abacus that was invented over 4000 years ago in Egypt (others credit Babylon or China). The abacus itself represented only an improvement over notching sticks or other forms of counting and tabulating. Each stride ahead represents considerable improvement in a seemingly never-ending succession of upgrades.

The first programmable computer (ENIAC, 1946) was capable of 5,999 instructions per second. In 1994 a DEC computer was capable of processing 1 billion instructions per second. Wavelength division multi-plexing of photonic signals tilted the entire field. Transmission rates skyrocketed from 20 billion bits per second using 8 channels in 1995; 40 billion using 8 channels in 1996; 400 billion utilizing 40 channels in 1977; to 800 billion using 80 channels in 1998; to a capacity of 1 trillion using the highest rated commercial cable available mid-2000. Bell labs achieved speeds of 3.28 trillion bits per second utilizing 82 different wavelengths in early-2000. In 1998, laboratory demonstrations achieved transmission rates of 10 trillion bits per second. Transmission rates of 10 trillion bits per second require some perspective. At 10 trillion bits per second, the 24 million books in the Library of Congress-assuming one megabyte per book (and 8 bits per byte), amounting to a total of 193 terabits-could be transmitted in 18-24 seconds! As of 2002, the world's fastest supercomputer—the NEC-built Earth Simulator (Institute for Earth Sciences, Yokohama)—operates at 35.86 trillion (floating point) operations per second.

While these mind-boggling speeds have come a long way, a further road yet to be traversed is clearly discernable. Alastair Glass (Bell Labs) speculated in 1998 that rates of 200 trillion bits per second would soon become possible. Speeds of 100 trillion bits per second (or performing 16 trillion calculations per second) will be achieved by "ACSI White" (at Lawrence Livermore Laboratory), when that supercomputer becomes operational in 2004. The following year, it will be surpassed by another IBM-built supercomputer, "Blue Gene," that is designed to operate at one quadrillion operations per second! Breakthrough potentials of on-going research into quantum computers theoretically capable of transmitting in the range of quadrillions of bits per second stand in the offing. Nor is it likely that transmission speed increases will end there. Current thinking regards the speed of light as an absolute constant, a universal barrier that cannot be transcended. A growing base of observations and experiments refute this boundary limitation. During the 1990s, for example, Nicholas Gisin, a Swiss physicist, conducted experiments indicating that entangled photons produce signals speeding along at least 10 million times the speed of light!

Lessons learned from the "Big Four" patterns

What can the lessons of history involving the Big Four lend to better understanding the advance of the Big Five economic engines of impending growth? Lots. "Patterns from the past" provide insights into how succeeding economic eras develop that can be used to plot the status, content and timing of the approaching Big Five.

Central importance of economic activities

Viewing unfolding panoramas of human progress and historical evolution has many different lenses, levels of analysis, intellectual approaches, and perspectives. Theories of change and techniques for predicting it are numerous: great man, scientific and technological determinism, cyclical trend analysis, logistic curves, and economic determinism, to name just a few among the hundreds devised. Each of these approaches and methods can yield valuable insights. This article series is premised on assumptions associated with principles of economic determinism. The basic premise maintains that it is the dominant economic activity, triggered by new technological developments, that shapes nations, their socio-economic situation, and ultimately alters values and lifestyles.

Technological advance, the very mainspring of civilization and culture, builds to points of critical mass that characterize new economic eras. Economic development involves a timing and tempo. Dominance of a particular economic era marks from the time when it becomes a nation's major source of employment. Soon thereafter, that sector will account for the ordinate share of gross domestic product. Transformations wrought by economic era undertakings create waves of effects that pervade and alter the social-political rubric of nations. Just as changing components of a delicately balanced Calder mobile throws its pattern askew, altering the relative weight of a key element in a nation alters and then requires readjustment to entire structural arrays.

Workforce distribution: leading indicator

The key indicator for assessing essential features and conditions in socio-economic settings is workforce distribution. Societal conditions and prospects are overwhelmingly influenced by the dominant lifetime activity pursued by its members. For most people, their occupation and livelihood constitute that central activity. Individuals must find some kind of gainful employment (or other means such as inheritance or stealth) to earn their keep for sustaining themselves and dependents. Nations, as structured and ordered, also are dependent on jobs. Work and its fruits are fundamental to mutual support in interdependent societies. Undertakings that provide goods and services have to be performed for society to function smoothly.

Earliest beginnings of technological underpinnings

Studying the evolution of economic eras reveals that they do not emerge suddenly. Not by a long shot. Milestone scientific and technological accomplishments giving rise to a dominant economic era trace back hundreds, thousands, and even millions of years. Cycles of development, dominance and decline of economic eras through which nations, so far, have progressed entail very long timeframes to run their course. All the oncoming Big Five economic "centers of gravity" already are well underway in early stages of their continuing development. The trend and nature of each can be plotted and relative dominance projected. Drive toward economic dominance in the Big Five sectors will spread across the course of the millennium.

New understandings open up entirely new realms

Gateways to new levels of manipulating matter rise to new and higher levels as abilities to "see" or image materials unfold. Magnifying glasses (1250 AD) opened the door to new phenomena never before seen. Simple lens microscopes magnifying objects 20X (1505 AD), followed by compound lens instruments (1590) opened up and made possible new realms of medical and public health breakthroughs. Discerning bacteria in 1683, boosted health care delivery to an entirely new phase of development. Contemporary imaging systems such as the laser force probes developed in the 1950s enlarge images 5 billion-fold. Atom cavity systems are projected by 2200 to boost magnification to levels capable of discerning individual atoms. Increased magnification probing, visualizing and imaging matters at sub-atomic levels entails new power and abilities to manipulate matter and the ways if forms itself. In like manner, entirely new dimensions of the universe will unfold in 2010 when the James Webb Space Telescope, successor to the 12-year old Hubbell Space Telescope, is boosted into orbit. This new telescope with six-fold the sky-piercing capability of Hubbell will enormously expand human understanding of the cosmos.

Doing more with less: human and physical resources

Lessons of the past reveal that economic centers of gravity, as they mature and better ways are found, generate prodigious output requiring increasingly fewer workers. In like manner, same or similar tasks, over time, are accomplished using ever smaller inputs of raw materials. Atom-thick deposits of chemical elements achieve what rooms full of material once were needed to accomplish.

Current capabilities and limitations

Establishing the ceiling limits and metes and bounds for "the realm of what is possible" defines the outermost constraints within which new technologies can be developed. Within the ambit of these limitations, a structure for plotting the direction and pace of oncoming change can be achieved by: tracking knowledge of impending breakthroughs, following the status of experiments on the leading edge of change, gauging time lags from conceiving ideas to developing prototype inventions, and taking cognizance of the time required to achieve mass market penetration.

Key resource that characterize epochs

Epochs of world history often are characterized by a major material or article of value that became vital to commercial undertakings and needs of the times. Over the millennia, a succession of key resources described the capabilities and dominated the economic ventures of individuals, economies and societies.

Stone Age dwellers relied upon nature's bounty as they found it. Stones strewn about were used to pound, scrape, bludgeon and hurl. As tool making advanced, ways of chipping, shaping and forming stone and minerals augmented and advanced effective uses. Special shapes gave rise to additional functions such as grinding. Certain materials were found that could be chipped and fashioned into cutting blades or spear and arrow points. Brightly hued rocks and minerals self-evident in outcroppings or upon terrain eroded by wind and water—azurite, jade, malachite, opals, and crystals among them—attracted attention. Initial uses were largely for adornment and aesthetic effects. This long and protracted period in the development of civilization, actually extended over millions of years characterized by at least three defined periods:

> Old Stone Age: 3,000,000- 8000 BC (Paleolithic Period);
> Middle Stone Age: 18,000-7000-2700 BC (Mesolithic Period);
> New Stone Age: 2700-1900 BC (Neolithic Period).
> The Stone Age did not end because the world's storehouse ran out of stones. New materials were found that did the job far better.

Much later, nearly 10,000 years ago, a succession of metals proved so crucial that major historic eras were ascribed to them. Distinctively hued and structured materials were easy to spot. Natural deposits of durable minerals, easily detected because of unique color or form, included: copper, gold, silver, and lead. Metallurgy may have began when ores (perhaps pyrites with relatively low melting temperatures) placed near or in firepits melted, and the value of the "transformed" material was recognized. The Copper Age arose. Malleability by hammering and sculpting the metals soon followed. Metals represented major improvement over crudely fashioned stone. Working with those materials steadily enhanced knowledge of metallurgy, refining, mining and extraction. Casting into more intricate shapes developed. Later on, melding of several metals gave rise to the Bronze Age. Much later, the ability to "blow" iron impurities out of iron, gave rise to higher strength steel and the Iron Age.

Technologies transforming early materials-based periods moved from the Stone Age (3,000,000-1900 BC), to the Copper Age (6400 BC), to the Bronze Age (3000-500 BC), which, in turn, gave way to the iron Age (1700-51 BC). The tempo of change has picked up speed since then. In more recent times, bursts of scientific invention tend to occur in 55 year cycles, more or less.

Somewhat similar successions of key materials and processes can be discerned in the patterns of change accompanying other economic sectors. The key point is that commercial activities and institutions do not remain static. They respond to changing conditions and environments, especially the prevalent technologies of the time and the know-how in manipulating them to secure the utmost benefit.

Precursive patterns and diffusion

One basic principle in cross-cultural and historical time series is that some jurisdiction has to be first and others follow. Throughout history a few centers of influence always have led the way. There will be early and late adopters in these cycles of diffusion. Human activities of any kind do not flow evenly. They never have, and they never will. Nations do not move all at once in lockstep fashion. Jurisdictions first to adopt and test new concepts are termed precursor jurisdictions. Sometimes, they are characterized as bellwethers, pacesetters or leading jurisdictions.

Impending Big Five undertakings and the drive of each to relative dominance will commence in precursor post-industrial nations. Precursor jurisdictions are the most venturesome, experimental, and progressive. They also are most likely to develop and implement longer ranged visions and accomplish them. Implementation moves proposals from theory to practice, from concept to reality. Practical experience tests the mettle of new concepts, and weeds out unsound ones. Proven successes encourage emulation by others.

Nations positioned later in this continuum of developmental stages have opportunities to assess and alter the sequence and course of their destiny. Successive waves of economic activities, each in its own turn and time, will become the economic center of gravity in all other nations. Some countries may be able to skip over and bypass eras not suited to local capabilities and conditions. Instead, they may be able to manage their development by vaulting ahead to economic undertakings more appropriate to their situation. Each center of influence and every nation moves at its own pace.

Clash of opposing viewpoints

Introduction of new industrial technologies historically has been greeted with enthusiasm as well as with dark forebodings and despair. Technologies, at root, often entail inherent opportunities to be applied for good or evil purposes. Like the Roman deity, Janus, with two faces placed back-to-back so that he might look in two directions at the same time, technologies also can be viewed from two opposing viewpoints.

Struggles between optimism and pessimism

Incessant and eternal tinkering with constructs of civilization involves a never-ending dialogue over its predicaments and prospects. Optimists view technology positively, and hail its achievements and benefits for mankind with awe and hope. Pessimists see technology as evil, wrongdoing, an interference with nature. Both views play important roles. Interplay between these forces and their bearing on socio-political influences-that can foster, stymie or halt progress-indicate the timing of possible advances or setbacks. Outcomes depend upon human perspective and willpower.

What pessimists see as problems, optimists see as challenges to be overcome by conscious, deliberate, and well-planned effort. Optimists are not totally disillusioned with runaway technologies, excessive economic growth, population explosions, entropy, or any of the other dreary disasters that have been fretted over by doomsayers. Optimists welcome technology's new productive efficiencies, increased output of goods and services, and reduced prices in the name of progress. Without technological progress, stagnation and decline set in.

Civilization's landscape is packed with promise and peril. For the most part, it is filled with reassurances. This article series stressed that technological advances confer new capabilities improving upon nature's handiwork and enhancing human progress. The promise of making the world a better place through advancing knowledge and its myriad technological feats is important enough to explore every valuable opportunity.

Optimistic mindset

The optimistic viewpoint is positive and typically prevails over the long run. The reason for that outcome is based on the fact that scientific soundness invariably is anchored upon the beneficial nature of new technologies. Optimism is consistent with the rational tradition of Western intellectual history and the scientific method associated with logically ordering affairs in advanced industrialized nations. Optimists share an abiding belief in the perfectibility of mankind. They relentlessly pursue something better. They view the future neither as inflexible and predetermined nor as unordered and chaotic. The optimistic outlook welcomes the opportunity to invent the future. This upbeat view considers people in control of their destiny, instead of being its hapless captive. They perceive society as open to intelligent directions and management.

Americans generally agree that technology has contributed more good than harm. Despite the constant carping, complaint and criticism that permeate the commonweal, the plain fact is that people live longer, work less, are healthier, have more leisure and recreation opportunities than ever, and enjoy better housing, clothing and food. The list could go on at great length. Virtually everywhere one looks, living conditions and the lot of human beings are better than they once were. In fact, the average person today eats better and enjoys amenities far superior to those enjoyed by reigning monarchs and royal families a few centuries ago.

Optimists consider that alarms raised by doomsayers, pessimists, and negativists generally serve a useful, though bothersome, purpose. Criticism often bares imperfections and shortcomings that set the stage for optimists to respond. Dire concerns about future prospects galvanize others to overcome most problems. On balance, these challenges regird efforts maximizing the best and minimizing the least desirable aspects of ongoing development. Human consensus is achieved by tempering the dichotomy between optimism and pessimism.

Pessimistic mindset

Pessimistic perspectives, intemperate doomsaying, and tales of woe have confronted humanity throughout recorded history. Pessimism has a dark and foreboding cant to it. Negative attitudes ranging from alienation, cynicism, disillusionment, helplessness, resignation, despair to passivity and apathy, are among those that creep into confrontations accompanying many aspects of progress.

Predictions of doomsday persist throughout history. Peddlers of gloom and doom, doomsayers, pessimists, and negativists include influential thinkers such as Jacques Ellul, Lewis Mumford, Herbert Marcuse, Jean Jacques Rousseau, and Henry David Thoreau. Contemporaries like Paul Ehrlich, Jeremy Rifkin, Ralph Nader, and Barry Commoner represent similar mindsets. They champion causes and crusades encompassing anti-technology quests of every imaginable sort.

Doomsayers often play on fears of the uncertain and unknown to stir up angry and emotional responses. Their conclusions tend to be premature and bereft of scientific certitude. They typically fail to properly estimate the capacity of the human will to alter circumstances, and redirect final outcomes.

Anti-technology and pessimism

Technological progress typically is besieged by diametrically opposed viewpoints between optimists and pessimists. Key technologies essential to each of the oncoming Big Five eras already have begun to engage and work their way through these clashes.

Pessimists fear that technological developments invade and interfere with nature. They see much of this progress likely to subjugate and further submerge workers as mindless cogs of vast industrial-technological machines. Perhaps most of all, they fear losing jobs, livelihoods and traditional ways of life. Since the onset of the Industrial Revolution, if not before, anxiety over job displacement by automata and machines has been a persistent concern involving anti-technology thrusts.

Optimistic utopians envision work eventually disappearing in the steady onslaught of advancing technology. They foresee outcomes leading to a Leisure Era and lands of plenty. Freed from the bondage and burden of labor, individuals ultimately will be enabled to pursue individual pleasures and preferences. Utopian views of automation and technological advance sometimes transcend reality. A report published in the *United States Review* in 1853 predicted that within 50 years "machinery will perform all work—automata will direct them. The only tasks of the human race will be to make love, study and be happy."

Instead of dislocating effects, optimists view automation providing the solution to society's problems, individual salvation from demeaning labor, and relief from the squalor and suffering of poverty. Thousands of years of experience actually show ever-increasing job opportunities as technological advances create more jobs than were destroyed. Far from cutting off job availability, the development of new disciplines and support activities opens up numerous new avocations and avenues of pursuit. Ultimately, jobs seem to be far more dependent upon rates of economic growth than upon technological innovation and change.

Containing and controlling technologies

Following development and detonation of atomic bombs during World War II, a deep sense of disaffection with technology began to set in and become widespread. Although there always has been a fear of the unknown, the magnitude of this particular threat suggested the need for new restraint. These new urgencies suggested that limitations of some sort had to be interposed.

Widespread protests against nuclear power persist and curtail its adoption. A growing number of nations have gone so far as to terminate further development and shut down existing nuclear fission facilities.

While there may be a downside to developing a new technology, save in rare instances, that alone should not be sufficient reason to discourage or block it. However, the mere fact that a particular technology could be developed increasingly is considered insufficient justification to proceed. Efforts to control technologies takes the stance that science no longer should be allowed to carry humanity wherever it might. Technology no longer is likely to just be harvested. It also will have to be pruned. Trial and error and muddling through have become too costly a course. Unintended repercussions and second-order consequences—sometimes catastrophic in their sweep—need to be contained, if not avoided. Risks of new technological undertakings may be too great, as in doomsday weapons, for example. Costs, monetary as well as social, may be too high, e.g., the supersonic transport development. Ecological imbalances or improper conservation inherent in certain undertakings may prove disastrous, e.g., rainforest depletion. Irresponsible maximum development of finite resources may prove unwise, e.g., fossil fuel depletion. Moral and ethical dilemmas may entail potentially catastrophic potentials, such as genetic engineering that discards "misfits" and creates a cloned "master race." Debate involving conquests over nature rage interminably between scientists and humanists over such issues. Society is striving toward deliberate control of technology.

Trade offs and balances between good and bad results, optimistic and pessimistic assessments will play a growing role in controlling introduction of new technologies. In the final analysis, the culprit is not technology itself, but its application and use. Balance is the key resolving force to perpetual controversies involving anti-technology and pessimism. Human progress, slowly but steadily, heads toward the up-side and avoids or strives to minimize the down-side.

Major technologies inherent in the impending Big Five economic drivers, already gathering momentum, will radically alter, enhance and extend human life. Denying the promise and potential inherent in each of the Big Five emerging technologies discussed in this series means closing one's eyes to the obvious benefit of scientific and technological advances long underway. Scientific breakthroughs imposing epoch setting dimensions already have begun to change lives. On-going commitment and effort will bring all these wondrous possibilities to fulfillment. Criticism and complaint will restrain reckless pursuits. Competing and countervailing attitudes toward new technologies will materially affect the outcome of the Big Five economic engines of growth discussed in this series:

Controlling "blueprints" of life

Decoding genomic patterns and discerning nature's blueprints of lifeforms opens up new possibilities for: controlling disease, dysfunction, and disablement; extending life expectancy; designing lifeforms to specification; expanding food production; and enhancing the quality of life overall. Complexities of biochemistry eventually will unlock intricate blueprints of the human brain and enable similar control over mental health and unleash new potentials for intellectual enhancement. These genetic engineering capabilities of the impending Life Sciences Era also raise qualms and fears. Looming specters of mutant lifeforms, uneasiness over humans assuming control of evolution, objections to aborting less that perfect fetuses, fears of creating a master race, and worries involving have/have-not discrimination on a vast and unprecedented scale engender reactions pro and con. Such responses are to be expected. Science and reason are most likely to prevail over the long run.

Controlling "blueprints" of matter

In much the same manner, blueprints of sub-atomic matter and particle physics—keystones of the oncoming Meta-Materials Era—open up opportunities for constructing inanimate matter to specification, using infinitesimally small quantities to meet all manner of needs, and developing "miracle" materials. Power to deconstruct and reconstruct the building blocks of matter at infinitesimally small quantum scales will stretch out the use of matter. Guided by principles that matter can neither be created or destroyed, these new found capabilities will satisfy Earth's needs into eternity. Worrywarts who have fretted over thousands of years that resources will run out, will have to take a different line as these developments confer their prodigious bounty.

Together, the blueprints of the Life Sciences and the Meta-Materials Eras establish new opportunities for human control over animate and inanimate matter, organic as well as inorganic materials. The ability to understand and to manipulate the blueprints of what amounts to this sum total of creation involves "god-like" control of all things. Considering humanity's "dark side," the tasks will not be easy.

Controlling limitless nuclear energy

Manipulating plasma and photonic energy unleash a New Atomic Era which relies upon the development of thermonuclear fusion to supplant rapidly diminishing fossil fuels, and provide limitless and low-cost energy. These technologies also provide life-giving benefits ranging from radiation healing therapies to irradiation of pathogens that make food safe. On the other hand, nuclear fusion that harnesses the enormous energy output of stars like our sun, can be used to annihilate mankind, and excessive radiation can cause illness and death.

Controlling development of outer space

Most any thing has an upside as well as a downside. Space vehicles, for example, pose a darker side that includes intercontinental ballistic missiles interposing a globally omnipresent "balance of terror," the possibility of unleashing a "nuclear winter," and huge losses of life-if not obliteration of life itself. The upbeat outlook views space vehicles, exotic propulsion systems, and the possibility of transcending the speed of light being crucial to the promise of exploring galactic grandeur and cosmic wonders.

Visionary perspectives

Why should anybody be interested in what the world might look like in 1000 years? For one thing, long range perspectives help draw attention to visionary thinking. Discerning horizons 1000 years distant holds great promise to alter, speed up or slow down, outcomes. On a grander scale, 1000 year perspectives suggest opportunities for inventing new worlds, either utopian or dystopian.

Mapping out visions and defining goals opens the way for planning and building a better Tomorrow. Perspectives rendered will guide decision makers to avoid the pitfalls and capitalize upon the positive aspects to secure civilization's ascent. Detailing new vantage points sharpens assessment of crucial steps required if specified goals are to be realized. Focused in this manner, human willpower and conscious direction can influence, if not actually determine, outcomes.

William James affirms the capacity to alter the future, if only that potential is exercised: "Man alone, of all creatures on earth, can change his own patterns. Man is the architect of his destiny." To get on with the job, Ernest Boyer implored that "Dreams can be fulfilled only when they've been defined." Oliver Wendell Holmes emphasized the importance of the right pathways: "The great thing in the world is not so much were we stand as in what direction we are moving." Acknowledging that the future requires hard work, Robert Kennedy asserted: "The future is not a gift, it is an achievement." Not to be overwhelmed by too many possibilities, Richard Nixon cautioned against "Too many visions and not enough vision." Without getting carried too far away with anecdotal advice of the Greats, it is well to keep in mind the cautionary advice of Proverbs 29:18: "Where there is not vision, the people perish." It is high time that somebody took up the task with meaningful resolve.

Architects of destiny, unfortunately, are few and far between. Few leaders ever seize the opportunity to plot visionary courses and plot the goals to fulfill dreams for a better Tomorrow. If we do not now summon these possible, probable, and preferable futures, who will? If not now, when? If not here, where?

Visionary thinking about economic change

Benjamin Franklin hit the nail on the head when he chose the Latin phrase inscribed on the dollar bill: *Annuit Coeptes*— "*Be* favorable to bold enterprises." Another inscription, also found on the dollar bill, implies and captures the spirit of the succession of economic eras: *Novus ordo sedorum*— "A new order of the Ages." Statesmen, by encouragement, helped create a favorable economic climate that boosted American enterprise into a paramount position during the Industrial Era. America's share of global industrial production, virtually nil at the outset of the 1800s, rose to 20 percent by 1860, and soared to 40 percent by 1913. The US, taking the lead away from Great Britain, became the dominant industrial power throughout most of the Twentieth Century.

This article described promising technological developments, called "the Big Five," forecast to dominate and drive a vibrant US economy through the new millennium. To sustain that growth, each of these promising economic sectors, as well as others that may come along, require proper nurturing. Bringing them along to highpoint can be facilitated by establishing visionary perspectives.

National economic goals

Accomplishing the substance of visionary potentials requires specifying long-term goals as well as the strategies for realizing them. Japanese national planning provides a late-20th century example of deliberate economic goal setting and specific strategies. Fully executed, those goals boosted Japan into a globally vibrant economic position during the 1980s. Government policies bolstered "sunrise" industries that included: micro-electronics, machine tools, computers, communications, robotics. Policies sheltered these designated new growth technologies. Trade restrictions discouraged or even shut out foreign competitors, until a domestic base could be solidified. Thinking beyond the short term and immediate strong growth opportunities, government planners also designated "new frontier" technologies, ones with longer term timeframes including: advanced ceramics, nuclear power, non-oil energy sources, bio-technologies, and laser products. These new frontier technologies are prominent core competencies of the impending Big Five economic eras. Japan's prolonged current economic slump has "taken the bloom off the lily." Time will tell how longer range encouragement and support of new frontier technologies plays out.

Japanese economic planners, spearheaded by Prime Minister Kakuei Tanaka, also tagged so-called "sunset" industries, ones in substantial and inevitable decline. Rather than lending further encouragement and support for these waning industries, governmental programs were aimed at easing the economy away from such undertakings. Declining industries included: aluminum, cardboard, cotton and wool spinning, electric-furnace steel, ferro silicon (a steel alloy), fertilizers, shipbuilding, and synthetic fibers. Mature industries, such as those just enumerated, had been diminishing in economic importance for decades.

Perspectives, principles and patterns of the past

Description of the past and present Big Four economic eras through which all advanced countries have progressed, so far, was presented in this article to highlight recurring patterns and principles. Principles gleaned from the "patterns of the past" can be used to track and monitor the status of the impending Big Five economic drivers that will dominate the next 1000 years. Sizing up these "signatures of change" can be utilized to help establish the trend, direction and timing of oncoming eras. Premised on the overarching significance of economic determinism, several parameters signaling these changes were described:

Workforce allocation characterizes key economic eras

The key indicator establishing the relative dominance of an economic era is the share of workforce engaged in such undertakings. Dominance is reached when a majority or modal share of jobs fall within a particular sector. Sector share of GDP follows some years later. New centers of employment are created by echelons of underlying technological change which, cumulatively, characterize the new era.

Deterministic timelines of major economic eras

Evolutionary trendlines of technologies undergirding new economic eras are strongly deterministic. Timelines plotting past and present milestone events and achievements often span hundreds to millions of years. Sheer momentum of these evolutionary developments indicate the range and potentials of possible future developments and breakthroughs.

Prospective developments bounded by ceiling limits

The realm and dimensions of further potential progress in a given technology is the void between current levels of performance and outermost scientific ceilings or limits. Previous trends, their direction and timing, provide a sense of incremental steps toward the outmost boundaries of potential performance. By applying knowledge of research efforts and potential breakthroughs of scientific technologies, keener insights into the path of continuing progress can be mapped out. Knowledge of prospective developments and potential breakthroughs indicates the trend, direction and timing of further incremental developments. Bounded by "ceiling limits" beyond which current science cannot transcend, these deterministic trends elucidate likely patterns of prospective developments.

New investigative tools open up new realms of understanding

New levels and dimensions of understanding set new boundaries that open up new frontiers of what is possible. Microscopic magnification enables ever keener and ever smaller levels of discernment that opens up entirely new echelons of understanding and potentials for further control.

Perpetual pursuit of bettering what has gone before

Driving forces behind these evolutionary trendlines of progress involve ceaseless efforts to perform any given task or feat better than what has been accomplished so far.

Doing more with less

Patterns inherent in the constant striving to "do more with less" are one of many incremental indicators for gauging the verve of a particular evolutionary trendline.

Corroborating complementary technologies

Complementary technologies that support a given economic sector, provide additional supporting evidence that can be used to track prospects of the principal technology. For example, energy availability and substitution trends influence prospects for growth or decline of energy-dependent technologies.

Precursor or bellwether jurisdictions

Precursor nations, jurisdictions continually in the vanguard of change, are a major indicator of changes likely to be emulated by others. Actual experience with a particular phenomena moves it from abstract and theoretical concepts to practical application and tests its mettle. Successes are quickly emulated elsewhere and mistakes are avoided.

Contrariety of viewpoints

Introduction of most novel technology is accompanied by positive and negative views. Antitechnology and pessimistic attitudes may deter but seldom if ever, ultimately prevail. Evidence stolidly supported by scientific principles and findings eventually triumphs over the long run.

Visionary goals

Visionary goals and national planning can play important roles in speeding up or slowing down the pace of change. Visionary perspectives and goal setting provide the inspiration. Sizing up the political and psychological climates of opinion help to gauge support or disapproval. Execution measures success. Results depend on how well stewards and supporters understand, plan ahead, and execute essential steps that have been set.

Superabundant outputs

Ultimately, the output of goods and services will become superabundant. So much so, that the needs of everybody, everywhere will be able to be met. Changes of this magnitude suggest that nobody will get left behind. Utopian sounding? Surely it is. Impossible? Hopefully, no!

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