Economics of the future: plus ça change

Melanie SWAN
MS Futures Group, Palo Alto, California USA

"Modern methods of production have given us the possibility of ease and security for all; we have chosen, instead, to have overwork for some and starvation for the others. Hitherto we have continued to be as energetic as we were before there were machines; in this we have been foolish, but there is no reason to go on being foolish for ever."
– Bertrand Russell, In Praise of Idleness (1935)

Abstract. Technology innovation continues to expand the current economy and further technology advances could create a long-term future in which substantially all material goods needs are met at extremely low cost. Despite this potential revolution in material freedom, the overall social climate would not likely change for two main reasons. First, there have been many historical precedents of technological advances (e.g.; steam engine, railroad, telegraph, electricity) that significantly improved the quality of life but did not alter societal dynamics. Second, it is likely that the technological changes will occur in the current context of evolution-shaped human society, with human drives dominating technology use. This paper assumes the technical feasibility of such technologies and explores what a post-scarcity material goods society might be like together with a scenario roadmap for its attainment.

Keywords. Economics, future economy, post-scarcity economy, scarcity, material goods, material freedom, natural resources, affinity-directed capital, multi-currency society, roadmap, foresight matrix

1. Status of the Present Economy

The seeds of the future economy are present in the current economy. Three key trends have been unfolding: disillusionment with traditional institutions and processes, a shift in cultural attitude towards responsible capital use, and the ongoing expansion of technological capability.

Disillusionment with traditional institutions and processes comes from the continuing inadequacy of financial markets to provide both capital and accurately-represented non-fraudulent investment products. Cyclic taxpayer bailouts of banking and Wall Street malfeasance (1980s Savings & Loan crisis, 2000s mortgage crisis) are eroding trust. Simultaneously, market volatility has been increasing in the last few decades and is complicated by the human inability to accurately perceive risk, especially high-magnitude infrequent black swan events.[1] Entrepreneurs and other change agents are striving to improve existing financial institutions and introducing alternative models such as peer-to-peer finance.

At the same time, a great attitude shift toward sustainability and social responsibility is underway, including with regard to capital flows. The ability to have more granular attribute knowledge about all economic transactions (investment, donation, purchase and income-generation) has triggered the demand for affinity-directed capital, the ability to target resources specifically to end recipients or causes of choice. The idea of blended return or double/triple bottom line returns has arisen. This is having multiple investment

outcomes, financial, social and environmental. This democratizing of finance is a significant step forward in increasing transparency, individual agency and self-expression, and utility for the participants on both sides of the transaction. Every transaction matters and its impact can be seen.

The inexorable expansion of technological capability and the entrepreneurial ideas that exploit it is also having tremendous influence on the evolution of the economy. Technology has improved efficiency in most industries and the Internet era allows increasing numbers of businesses to digitize. Costs of storage, bandwidth and processing have become so low that goods and services relying on them can be provided for free or at very low cost. Indirect monetization of attention and reputation become the business model. The cost of starting a business asymptotes to the cost of having good ideas via the LAMP (Linux, Apache, MySQL, PHP) software bundle that provides free technology infrastructure, the APIs that replace business development and the blogs, social networks and user forums that replace marketing.

These current economy trends are building the base for the next economic steps by engendering debate about financial institutions, codifying the notion of capital as a resource for achieving a variety of objectives and entrenching the idea of technology-triggered evolving business models.

2. Definition of the Future Economy

One notion of the long-term future economy is that of a post-scarcity economy (PSE) where substantially all material and natural resource needs are easily met at low cost or for free. The term post-scarcity is a misnomer since even if the scarcity of material goods and natural resources recedes, scarcity as an economic dynamic is likely to persist. At any moment of fulfillment, human focus tends to shift quickly to whatever is not yet realized, usually in the tiered order of Maslow's Hierarchy of Needs. Scarcity could be perceived in whatever material resources are not yet plentifully available and in the finite resources of time, attention, reputation, quality and other factors. The term future economy is used here to denote this concept of an economy, where material goods needs are met at low cost.

Is a future economy without a post-scarcity economy for material goods possible? Yes, however it would be a status quo or incrementally changed economy, not a future economy as defined above. The point of this analysis is to assume that such a future economy is technically feasible and explore how it could arise and what it would be like.

3. Phases of the Future Economy

The future economy is likely to be realized in phases relative to its constituent components: material goods and natural resources, services, public services (police, fire, military, courts) and new goods and services.

Material goods and natural resources would likely be the first focus. Some material goods could be replaced or provided at near-zero cost in the first phase, perhaps certain classes of items like fuel. The harbingers to this are already in place with concerns about global warming and peak oil sponsoring an upwelling of financial resources and entrepreneurial focus on establishing alternatives. In subsequent phases of the future economy, additional goods such as food and household items could be provided at minimal cost to consumers and ultimately all material goods could be provided at low cost. Fancier items like high-end designed objects and medical treatments would probably not be available in the earlier phases.

The obvious model would be the present and historical model of continuing "utilitization" where more goods become utilities over time and costs continuously drop. Currently water, electricity, gas and heating oil are utilities in many countries. Internet

access is or is becoming a utility. Transportation energy could be the next utility, followed by home-delivered CHON streams (carbon, hydrogen, oxygen and nitrogen) for on-demand food and goods production.

What will happen to services as material goods are increasingly provided at low cost? Initially services would be unchanged, but over time, nearly all current services could be replaced by technology-advanced zero cost alternatives. Nanobots could provide daily hair-trimming and nano-foglets could create new hairstyles on demand.[2] Robots are already available for lawn-mowing upkeep. Partially-automated telemedicine could be used for medical diagnostics and treatments. Artificial intelligences may be consulted for tax and stock advice.

Eventually, public services such as police and fire protection could be provided by trusted artificial intelligence networks and other mechanisms. The presence of wireless sensor networks and cams may shift the nature of crime and policing activity. Future building materials may be impervious to fire and possibly self-protect or self-reconstruct following earthquakes or other damage.

The new technologies will probably drive demand for new goods and services. The ability of anyone to generate any physical object puts a premium on object designs. There would be demand for applications sitting on top of the new technologies such as effective telemedical diagnosis and intervention. Expanded leisure time would increase demand for entertainment, hobbies, learning and productive activities. Other new services such as those relying on intelligent attention with artificial intelligences or human minds for interaction, counsel and therapy would also be in demand.

4. Future Economy Enablers

The future economy could arise from a series of ongoing incremental improvements in technology over time or from one or more dramatic increases in the ever-growing ability to control matter. The onset timeframe is more likely to be gradual but some aspects could be rapid. Many areas including biotechnology, nanotechnology and computing could contribute to the development of the future economy.

4.1 Biotechnology and Cleantech

The natural contribution of biotechnology and clean technology to the future economy would be in helping to understand and manage all human and non-human biological processes. Biofuel advances are already beginning with more efficient coal processing and Craig Venter's fourth generation fuels made by bacteria from $C0_2$ and other synthetic formulations. Bioremediation is another area. Synthetically generated or stimulated substances could consume environmental and other waste including greenhouse gas emissions. Biofood is bioengineering mechanisms that could be used to create abundant inexpensive healthy food and water. Finally, human biotechnology, managing all human genomics, proteomics, and other biological processes for repair and enhancement could substantially improve human quality of life.

4.2 Molecular Nanotechnology

Molecular nanotechnology is the spatial placing of atoms in 3D to build precise structures from the bottom up atom-by-atom, the next generation of the 3D printer. A molecular assembler is the idea for a countertop-based home appliance supplied by water, element canisters and electricity.[3] It would make items on demand such as food, clothing or other objects personally created or generated from designs found on the Internet. Such designs can be found now from Ponoko, the Open Architecture Network and other design-sharing websites. The advent of molecular synthesizer could revolutionize how goods are produced and have a bigger impact than the industrial revolution.

4.3 Computing and Artificial Intelligence

Artificial intelligence has already proven more capable than humans in specific applications such as chess, checkers, fraud detection and oil exploration data analysis. The breadth of areas where artificial intelligence can contribute is likely to grow and one day become the most efficient means of outsourcing a large variety of tasks. It is possible that most of the current human workload could be offloaded to artificial intelligences freeing humans in new and unexpected ways. Not only could artificial intelligences replace many current information economy data collection and analysis jobs, the depth and range their capability could be improving much faster than with humans. Advances in robotics are also accumulating with Boston Dynamics' quadruped walker BigDog and improvements in the ROOMBA, PackBot, Robomow and DARPA Grand Challenge winners.

5. Delivery Model: Utility vs. Public Good

There are two main supply input delivery models by which the future economy could be realized: direct and indirect. The direct model is that of a utility where consumers would pay for metered or flat-rate usage in the familiar electricity and telephone utility model. Payment could be monetary or via another resource, such as by signing the community contract, agreeing to comply with local covenants. To some extent, motorhome campgrounds have this type of arrangement now, providing water and utility hookups as long as visitors pay the entrance fee and abide by facility rules.

The indirect model is the public good model where material items or inputs would be so inexpensive and easy to provide that ostensibly they would be free and any cost to provide them would be borne by the community via tax revenues. For example, implicit in the "free" right to "life, liberty, and the pursuit of happiness" in the United States is the cost of the taxation and court system to provide and enforce these rights. Even if inexpensive advanced technology like molecular synthesizers and artificial intelligences were used to provide near-free material goods, they would still need to be maintained and upgraded, and probably operated with some sort of back-up system in case of failure, all of which would entail some cost.

The utility model seems better than the indirect model since it both avoids the welfare moribundity problem of the public good model and encourages more efficient usage as individuals are cognizant of their directly-paid consumption. A utility model may also render people more literate about the issues when voting or making policy decisions. Following wide spread adoption, there may be little practical difference between the utility and public good models; also it could be possible that some inputs would be too cheap to meter. However, it could be useful and practical to use traditional metaphors such as the utility concept during the roll-out phase for public acceptance and to finance the implementation.

Other policy issues aside from agreement on the utility vs. public good input delivery model might include network management/traffic shaping of input streams, network delivery grids and most importantly, taxation. Integrating community element supply systems into nationally fungible grids could be anticipated for supply streams in the same way that has been done with electricity and is starting to be contemplated with water. Taxes based on income, consumption (sales tax) and property would make little sense in a world where people have a minimal need to work and can build and recycle buildings and objects at will, perhaps including land, so an alternative means of taxation such as a poll tax would likely need to be established for whatever public services are still needed.

6. Future Economy Overview: Plus ça change

6.1 Smooth political and social transistion

One framework for considering the continuing evolution of economics is the record of history. In the most basic articulation, in 1800, the majority of the populace was working sixteen hours a day, had little or no leisure time and needed to spend the majority of their resources on survival needs. Fast forward 200 years to 2008 where, again in gross generalities, the majority of the industrialized world populace works eight hours or less per day, has eight hours a day for other activities and has some percentage of their resources, perhaps 25-50%, available for saving or luxury consumption (expenditures beyond basic survival).

As with technology advances such as electricity, some of the most dramatic changes have already occurred, there has been a halving of the amount of time worked by many people in the developed world. Any further time reductions could result in no detrimental political and social change and in fact could have an overwhelmingly positive impact as people are able to focus on higher Maslow tiers. Also, despite a decrease in the amount of time required to work, there would likely be an ongoing need to work as low-cost and non-free items will continue to require payment.

A politician's fear and a sociologist's curiosity is how people would spend their non-work time. There would probably be little surprise as people would likely spend their non-work time as they do now, in some mix of active and passive activity: relaxation, family/friends interaction, hobbies, entertainment, volunteer work and all manner of productive projects.

Absent biological editing (despite some likely simultaneous development), human needs and behaviors, and therefore culture and established society, are not likely to change significantly from the way they have evolved over hundreds of thousands of years. A desire to live in communities, reproduce, compete for status and mates, own land, learn new things and belong to groups with shared interests are likely to persist and keep society structured as it is now.

6.2 Multi-currency society

Economy as a construct and tool would likely continue to be useful. Economies are an efficient means of assigning, creating and exchanging value, discovering price and allocating resources. The offerings and currencies may change but the mechanism for their transfer, the economy, seems likely to persist.

The current trends towards a multi-currency society could become more engrained. At present, many web-based businesses provide free services, indirectly monetizing user traffic (attention) and activity (reputation/content relevance-marking). A multi-currency society could have many factors behaving as currencies: money, reputation, time, intention, ideas, etc. Already many people organize their actions around or at least with a heavy weighting towards reputation and status over money. Academia and open-source communities are examples, as well as Amazon and eBay user willingness to absorb short-term transactional losses in favor of keeping reputation ratings high. Bhutan measures gross national happiness (GNH) as a more important metric than traditional GDP.

6.3 People keep working

There are many reasons why people are likely to keep working. First, there will still be a number of costs: whatever low cost is required for material items, the cost to buy whatever goods and services are not yet provided at low-cost and the ability to purchase specialty offerings. Second, people are likely to keep working for a variety of other reasons including for social status competition, for security as the new system remains unproven, out of interest and opportunity as work will be shifting in reflection of the new technologies, out of habit and in need for normalcy and emotional comfort in the face of change.

There would likely be demand for a variety of new product and service offerings as people have more time and tools to focus on providing meaningful offerings in niche

areas. Both monetary and non-monetary incentives could encourage people to participate in creating new goods and services. There could be more tiers of offerings, the basic/free level plus many varieties of increasing refinement and personalized customization. In an era of material abundance, consumption could be driven by values and interests rather than resource limits to a far wider extent than today.

6.4 Global economic improvement

Concurrent with the trend to increased leisure over time is the increased economic improvement in all economies. The poorest economies, comprising the 4 billion people in the bottom of the pyramid have been realizing both relative and absolute economic gains in the last several years and this is likely to persist.[4] Parts of the bottom of the pyramid could reach full sustainability before additional technological advances occur which could have multiplier effects trickling up to all world economies. Immigration demand bubbles could arise as different areas of the industrialized and developing world apply technological advances heterogeneously.

6.5 New Technology Rollout

A final reason suggesting that a smooth transition to the future economy could be realized is that the rollout of new technologies is not likely to be overnight. Governments will probably attempt to regulate with at least some degree of success and economics will naturally regulate with expensive initial price points and S-curve adoption patterns. In the case of fuel, new offerings will likely continue trying to make use of existing infrastructure. With a goods generator like the molecular synthesizer, the first ones might make use of CHON cartridges readily available at traditional food distribution outlets and electronics stores. Eventually, direct-to-home element supply lines or other delivery mechanisms could emerge.

7. Future Economy Roadmap

This section extends the overview of the future economy into a more rigorous analysis. Predicting the future economy, in the year 2050 for example, is like predicting the economy next year or in ten years and adding more time and uncertainty. It is hard to make a linear forecast and estimate, even for next year. A futurist technique called foresighting or scenario planning is applied here to the question of what the future economy will like in 2050. The foresighting technique involves brainstorming a list of key driving forces and shaping the two most important into four quadrants denoting four possible states of the future world.

7.1 Key Driving Forces

The many possible driving forces that could shape the future economy of 2050 are distilled into two main drivers: participants and their level of participation, and the degree of technological innovation and adoption that occurs.

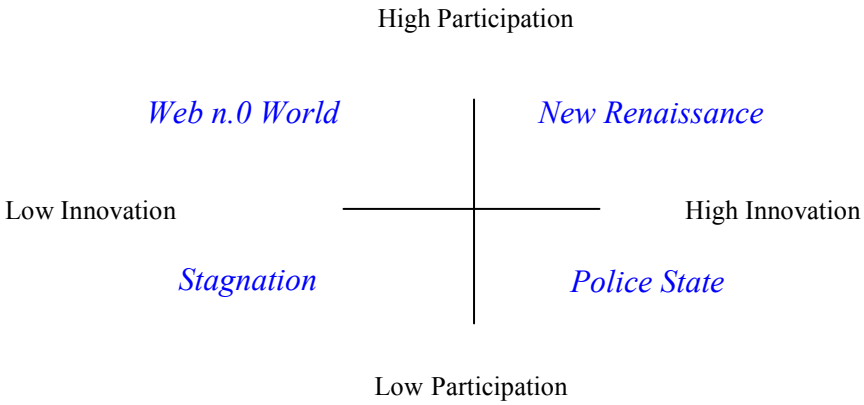
The participants driver concerns the specifics of future economy actors and their ability to participate. Who will be the future economy actors (humans, augmented humans, multiple levels of artificial intelligences, robots, intelligent corporations, etc.)? What portion of the population do they comprise, what are their needs, perceptions, actions and participation capabilities as goods and services providers and consumers? Politically, what capability do individual agents have to act on opportunity? To what degree has the current bottom of the pyramid been fully integrated into the world economy? How are any non Earth-based regions included in the economy? Does politics or economics have more influence on resource distribution? How have nation-states and alliances evolved?

Are there trustable market mechanisms and infrastructure enabling markets; e.g.; payment transfer, escrow, authentication, security, protocols, accessibility and recourse (contracts and enforceable legal regimes)? What levels of transaction transparency exist? To what degree are participant actions transparent?

The rate of technological innovation and adoption driver concerns the many direct and indirect factors that influence technology innovation and adoption. Are there sufficient financial, reputational and intrinsic incentives for individuals and groups to develop innovative technology? Is support infrastructure in place such as public and private capital markets and technology commercialization programs? How have world cultures evolved? Has the political, regulatory and social climate hampered or encouraged innovation and technology development? What degree of open public debate has accompanied technology issues, allowing for democratic and informed implementation? Have humans effectively managed potential large-scale catastrophic/existential risks such as climate change, energy resource management, bioterror and politico-religious conflicts?

7.2 Foresight Scenario Matrix

A matrix is drawn from the logical extremes, high and low, of the two key diving forces and scenarios are named. The driver extremes are intended to create a large enough canvas such that all possible future scenarios are captured. The present moment can be plotted and the actual path may shift through different quadrants.



New Renaissance: High Participation/High Innovation
The New Renaissance is a world with high participation and high innovation. All possible agents are able to contribute and be part of the economy. Appropriate trust-enabling market mechanisms are in place. There is an abundance of product and service offerings. Society is technically literate and makes informed decisions regarding technology development and implementation. An early indicator that this world is developing could be all children at early ages being automatically gene-modified to correct for potentially debilitating diseases such as Parkinson's.

Web n.0 World: High Participation/Low Innovation
The Web n.0 World is closest to an extension of the current world. Increasing numbers of people worldwide are participating in the global economy and changing it slowly from the bottom up. Technology innovation has been sluggish with few incremental improvements and no new paradigm breakthroughs. The hard problems of science, for example environmental management, quantum mechanics, artificial intelligence and gene therapies have been too difficult to crack. Governments attempt to control and regulate

technology and populaces are generally uncaring and illiterate regarding science and technology. An early indicator that this world is developing could be Intel and AMD merging over inability to compete with graphics processors, Moore's law is dead.

Stagnation: Low Participation/Low Innovation
Stagnation is a world of governmental oversight coupled with low participation in the economy and little generation of new technology. Participation may be constrained by a variety of factors including law, lack of market infrastructure, offering paucity, lack of education, and intolerant (anti-technology) thought regimes. Politico-religious conflicts, bioterrorism attacks and fears of new technology getting out of control could drive world views into extreme conservatism and technology rejection. Early indicators that this world is developing could be worldwide governments restricting travel due to fear of bioterrorism; water prices climbing to new highs.

Police State: Low Participation/High Innovation
The Police State is a world with a high rate of technological innovation which is strictly sponsored and controlled by governments and corporation titans; new DARPA toys never leave the military. Corporate monopolies squelch private innovation. Wisdom of crowds and bottom up democratic change models have been squelched. Governments engage in big brother-type surveillance. An early indicator that this world is developing could be China threatening Iran, or a successor rogue state, with its bioterror weapons stock.

7.3 Roadmap

Near-term economy: 2008 - 2020
On the Foresight Matrix, present-day 2008 is somewhere in the Web n.0 World quadrant, a world with growing worldwide participation and slower than possible technological innovation. There could be a near-term shift to the New Renaissance quadrant with greater participation, higher-impact technological breakthroughs and more mature political and social regimes stimulating useful technology development. Some governments have taken a proactive stance towards science and technology development such as Singapore and Dubai but the majority path is likely one of growth pockets tempered by governmental reaction to adverse events like a bioplague. A technology backlash could push the world into Police State or Stagnation.

A near-term Police State future could arise but it is unrealistic to think that it could contain the spread of new technology given the challenges of surveillance, the ease of Internet-based information transfer, the increasing power of individual agents, the high demand for new technologies by individuals and organizations and simultaneous discovery of new technologies. Governments should include traditional Police State control aspects in their strategic plans as one possibility but should also include other scenarios including the opposite, that new technology is completely open and universally available. Governments and entrepreneurs should spend time generating appropriate defensive responses to open technology. For example, if bioterrorism is impossible to prevent, biosensors and substance neutralizers would be a response and should be developed simultaneously.

Interim economy: 2020 - 2035
The key steps in the interim timeline for the future economy are the "utilitization" of one or more key areas such as energy for residential, commercial and transportation use, clean water and air, and production feeds for on-demand food, clothing, shelter and other goods generation. The initial simple molecular assemblers may only be able to provide for basic survival needs but are starting to see new generations that will eventually be god-machine assemblers that could produce health diagnostics and remedies, nanotechnology, sophisticated electronics including self-aware robots, copies of themselves and any other required or requested objects, and recycle all unwanted material.

Long-term economy: 2035 - 2050

The long-term future economy has seen a full transition to having many low cost utilities that provide for all material goods and natural resource needs. Existing land would still be somewhat scarce, but it might be more feasible to live in a wider range of areas and to create additional land or stable novel residential structures in oceans, rivers and bays. For example, the Pacific Garbage Patch could be recycled into a foundation for a vacation and conference hub between the U.S. and Asia. A sample headline could be "The PGP Convention and Visitors Center is pleased to host CES 2035."

Molecular assemblers and super strong nano structures could create much denser comfortable habitation on existing land (for example, kilometer high skyscrapers) allowing existing and new cities to flourish and grow. The improved technology could also be used to easily build and inhabit many more environments. Removing physical proximity requirements for work and education could allow people to fan out across the globe and eventually into space.

8. Conclusion

Having all material goods needs met at low cost is an economic construct, not a fully practical one, as surplus resources immediately create demand for higher than sustenance consumption. However, being able to meet all material goods needs at low cost is an important human milestone to achieve. It should also be noted that "low cost" is a relative not absolute measurement, it could be that societies become so rich that the percent of resources required for sustenance is effectively zero.

The future economy, a post-scarcity goods economy, would likely not be as revolutionary an occurrence as one might think initially. If it happens, it would likely occur in distinct phases over time, have a heterogeneous worldwide rollout, and be implemented in the current context of evolution-shaped human society where technology enables man rather than controls man. Historical trends are likely to persist, trends toward increasing leisure time, worldwide economic improvement, incremental and revolutionary technological advancement and the persistence of economies. The capital and labor resources currently focused on biotechnology, cleantech and materials science suggest that these fields will be the first to deliver advancements towards such a future economy.

References

[1] N. Taleb, *The Black Swan: The Impact of the Highly Improbable*. Random House, 2007.
[2] J. Hall, *Nanofuture: What's Next For Nanotechnology*. Prometheus Books, 2005.
[3] K. Eric Drexler, *Nanosystems: Molecular Machinery, Manufacturing, and Computation.* Wiley, 1992.
[4] D. Coyle, *The Soulful Science: What Economists Really Do and Why It Matters*. Princeton University Press, 2008.