Future Work/Technology 2050 Real-Time Delphi Study

Excerpt from the *2015-16 State of the Future* report

Stephen Hawking, Elon Musk, Bill Gates, and artificial intelligence experts are warning the world about the potential dangers of artificial intelligence growing beyond human control as it becomes superintelligence, artificial general intelligence, or strong AI—the ability to autonomously rewrite its own software code based on feedback, implement the new software simultaneously around the world, modify its goals, and outperform human intellect. Nick Bostrom's expert survey in 2012/2013 found a 50–50 chance that "high-level machine intelligence" could be achieved by 2040–50 and that superintelligence could be archived 30 years thereafter. (See http://www.nickbostrom.com/papers/survey.pdf.)

Whether AI can evolve beyond human control into the nightmares of science fiction or not, it is certain that it and other future technologies (e.g., synthetic biology, computational science, nanotechnology, quantum computing, 3D and 4D printing, Internet of Things, self-driving vehicles, robotics, and other technologies and synergies) will have fundamental impacts on the nature of work, economics, and culture by 2050. The Pew Research Center found that the "experts" are nearly evenly divided about whether future technology will replace more jobs than it creates in just 10 years. Already we see that:

- Concentration of wealth is increasing.
- Income gaps are widening.
- Jobless economic growth seems the new norm.
- Return on investment in capital and technology is usually better than in labor.
- Future technologies can replace much of human labor.
- Long-term structural unemployment is a business-as-usual forecast.

If long-term structural unemployment is inevitable, what should be done to improve the future prospects for civilization? Instead of a dystopian socioeconomic future, some believe that this could lead to a global renaissance of creativity as people are freed from the necessity of working for a living. But financial viability is not yet clear.

The Millennium Project assumes that the world needs to think seriously about all this now, because it may take a generation or more to make the changes necessary to improve our future prospects. To address this challenge, it launched a Future Work/Technology 2050 study with eight steps:

1. Literature and related research review
2. Real-Time Delphi international survey
3. Road maps and scenario drafts
4. Real-Time Delphi feedback on the draft road maps and scenarios
5. Final scenarios, policy implications, and production of an initial report
6. Initial report as input to national planning workshops
7. Collect results of the national planning workshops; analyze and synthesize results
8. Final report for public discussion

This is a distillation of the results of the second step.

Future Work/Technology 2050 Real-Time Delphi Study

Based on a review of the literature and related research, the following main questions were asked online using the Real-Time Delphi software in the Global Futures Intelligence System:

1. If socio-political-economic systems stay the same around the world, and if technological acceleration, integration, and globalization continue, what percent of the world do you estimate could be unemployed—as we understand being employed today—during each of the following years: 2020; 2030; 2040; 2050?
2. More jobs were created than replaced during both the Industrial and Information Ages. However, many argue that the speed, integration, and globalization of technological changes of the next 35 years (by 2050) will cause massive structural unemployment. What are the technologies or factors that might make this true or false?
3. What questions have to be resolved to answer whether AI and other future technologies create more jobs than they eliminate?
4. How likely and effective could these actions be in creating new work and/or income to address technological unemployment by 2050?
5. Will wealth from artificial intelligence and other advanced technologies continue to accumulate income to the very wealthy, increasing the income gaps?
6. How necessary or important do you believe it is that some form of guaranteed income be in place to end poverty, reduce inequality, and address technological unemployment?
7. Do you expect that the cost of living will be reduced by 2050 due to future forms of AI robotic and nanotech manufacturing, 3D/4D printing, future Internet services, and other future production and distribution systems?
8. What big changes by 2050 could affect all this?
9. What alternative scenario axes and themes should be written connecting today with 2050, describing cause-and-effect links and decisions that are important to consider today?
10. Other comments to improve this study?

Participants were selected from the literature and research review and by The Millennium Project's Nodes around the world. Some 300 experts provided both numeric judgments and over 1,000 comments about their judgments.

Demographics of the participants

There were 99 participants from North America (U.S. and Canada), 111 from Europe, 49 from Latin America, 25 from Asia-Pacific, 5 from Africa, and 9 undefined. There were almost four times as many male (232) as female (65) respondents. Tables 3.1 to 3.3 present the demographics of the participants by their affiliation, experience in futures studies, and age categories. The institutional affiliation results in more than the number of participants, since some respondents listed themselves in more than one category.

Table 3.1 Age Group of Participants

Age group	Number of participants
Under 30	22
30–45	77
46–60	105
61–70	59
Over 70	33
Undefined	2

Table 3.2 Respondents' Degree of Expertise in Futures Research

Experience in Futures Research	Number of participants
High (contributed concepts and/or methods, teach and/or write in the field, use and/or produce futures research full-time)	101
Middle (well-read, maybe published in the field, part of their work is future research)	135
Low (only general awareness)	51
Undefined	11

Table 3.3 Institutional Affiliation of the Participants

Institutional Affiliation	Number of participants
University	91
Business	70
Independent consultant/writer	60
Think tank	58
Government	34
NGO	31
UN or other IO	7
Other or Undefined	32

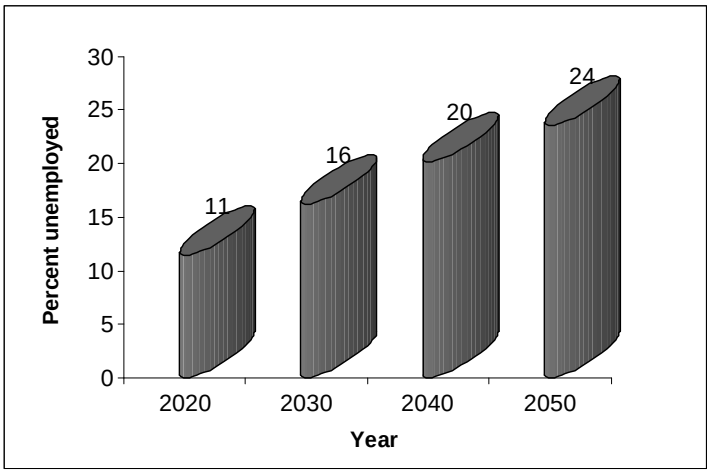
Distillation of responses

The following presents the averages of the quantitative responses and a distillation of the comments:

Question 1: If socio-political-economic systems stay the same around the world, and if technological acceleration, integration, and globalization continue, what percent of the world do you estimate could be unemployed—as we understand being employed today—during each of the following years: 2020; 2030; 2040; 2050?

The graph in Figure 3.1 displays the averages of 279 responses by 10-year increments. This clearly shows that without changes in the socio-political-economic systems, unemployment is thought of as an increasing trend.

Figure 3.1 Average Rate of Unemployment by 2050 by 10-year increments



All age groups and geographic regions expect unemployment to increase over the years. There was almost no difference between male and female average unemployment estimates. The greater the experience of the futurist, however, the higher the unemployment forecast. Similarly, the greater the experience in AI and technical field, the higher the rating of unemployment forecast.

The following is a distilled set of reasons given by the respondents for their forecasts, and additional comments:

Concept of work, jobs, employment will change. Rates of unemployment may become meaningless.

We will be creative and adapt.

Tech unemployment will accelerate when AI masters vision and how to learn.

Everything that can be automated will be; we need to start talking about a world without jobs quickly.

The issue is distribution of income and wealth.

Tech augments human work; human-tech symbiosis is a new form of work.

The applications of AI and other tech may go slow at first, but expect their applications to begin to spread around the world more quickly around 2030–40 with unemployment impacts

spreading more broadly by 2050... that is if we do not begin to create new approaches now, which may take decades to implement. When AI learns how to learn on its own, worldwide, it will learn faster and faster than humans can learn, unless humans become augmented cyborgs.

30-hour work week; global tele-work will take up the slack; new tech creates new work, rising BRICs and 3W creates new work.

Unemployment in richer countries but new jobs in poorer countries.

There will be more working-age population in the poor regions than job-creating technologies could cover.

Unlike the industrial revolution, there will be no plateau during which human labor will have a chance to catch up.

Global megaprojects will really change the economy creating innovations in human-machine work; meaningful activity such as space exploration to promote the chances that life and our species survives in the longer term.

The AI revolution should trigger changes to entire social and economic systems, as the agricultural and the industrial revolutions have done at those times.

Freed from the necessity of working to make a living:

- *2020: Increasing technological unemployment balanced by economic upswing*
- *2030: People who would like to work increasingly replaced by machines*
- *2040: Basic income guarantee in most wealthy countries—most people no longer seek employment and the definition of unemployment no longer applies*
- *2050: Basic income in most countries*

The tools and technologies of abundance are expanding faster than they can be expropriated.

Work as fulfillment, self-actualization, and not just income.

The top 10 job categories in 2025 do not exist today. We will deal with problems that have not yet been identified, and apply solutions that are based on technology that has not yet been developed.

Freelance work will increase exponentially.

Unemployment rate of over 25% across the world would lead to massive unrest and possibly the collapse of civilization.

Effectively 100% unemployment by 2100 may not be unreasonable.

Passive income will become as common as checking your email or Facebook messages and will create an inflation of what it costs for a real human on the job.

The real question is not about "employment" or "unemployment" as we understand them today, but about an income or distribution of wealth that would allow all (or most) members of society to have a decent living standard.

Our technological surrogate workers may be arriving just in time to save us from societal decay due to distraction by new forms of human activity that are not productivity-oriented.

Question 2: More jobs were created than replaced during both the Industrial and Information Ages. However, many argue that the speed, integration, and globalization of technological changes of the next 35 years (by 2050) will cause massive structural unemployment. What are the technologies or factors that might make this true or false?

Question 2.1: Factors replacing more jobs/work by 2050, preventing mass unemployment rated on a scale from 10 as Primary Cause to 0 No Impact at All. Table 3.4 displays the average ratings by 263 participants.

Table 3.4 Average Rating of Technologies Likely to Replace Rather than Create More Jobs/Work by 2050

Technologies Replacing Jobs	Causative Strength
Robotics	7.51
Integration and synergies among these making technologies not known today	6.92
Artificial intelligence	6.81
Artificial general intelligence	6.47
Retraining unable to keep up with accelerating technological changes	6.43
3D/4D printing	6.14
Other factors	5.54
Drones	5.35
Nanotechnology	5.19
Synthetic biology	4.66

The following is a distillation of the 241 comments given by participants for their answers, along with comments on question 2.1:

We are currently developing a second intelligent species, which we have never done before and which humans simply cannot compete with; it will have FAR MORE CAPABILITY and LESS COST than humans.

The definition of "employment" will change from something you need to survive or live decently to something you do voluntarily to get a feeling of self-worth or more luxuries.

I don't think full general artificial intelligence will arrive in this time frame. If it does, it would change most of my answers as it would be a huge force for change and would enable, for example, nanotechnology to achieve its full potential, which it otherwise would have a difficult time doing without AI control systems.

The current leaps in automation and AI will NOT "plateau"; they will keep accelerating beyond our control. That is the key dynamic we absolutely must address. Never in our history has the technology itself been so free of human control to improve itself.

With the widespread job disruption coming through artificial general intelligence and robotics, retraining will be irrelevant. Retrain to what?

Technological asymmetry will be a problem between the haves and have-nots.

AI and AGI will replace the need for any workforce eventually.

Question 2.2: Factors creating more jobs/work by 2050, preventing mass unemployment rated on a scale from 0 the weakest or no impact to 10 the strongest. Table 3.5 displays the averages of 251 respondents' judgments of the strength of factors thought to create more jobs than they replace.

Table 3.5 Average Rating of the Factors Thought to Help Create Jobs and Prevent Mass Unemployment by 2050

Factors Creating More Jobs Than Replaced	Average impact
New economic and work concepts	7.17
Self-employment, freelancing, Do It Yourself support systems, incentives, and training	7.07
Growth in new jobs in leisure, recreation, and health care industries	6.67
Freedom to create new work to make life worthwhile beyond "necessary" work	6.28
Human creativity will accelerate across the world	6.25
Other technologies could create more jobs than they replace	6.14
Human-technology symbiosis and/or augmentation	5.95
Crowd sourcing for finance (Kickstarter) and crowd-sourced work	5.61
Biological revolution (synthetic biology and other new biology-related industries)	5.42
Self-correcting: as unemployment goes up, purchasing goes down, reducing growth of AI robotic systems, in turn replacing fewer jobs	4.12

The following is a distillation of the reasons given by the participants for their answers, along with comments on question 2.2:

Information and means of production are far more open and distributed in the forthcoming Biological Revolution than they were during the Industrial Revolution and the Information Revolution.

An unlimited number of Decentralized Autonomous Organizations is possible, each with an unlimited number of peer-to-peer ad hoc "workers."

The maker and self-employed economies are likely to thrive.

The capital requirements for start-ups are increasingly low—consider YouTube, Facebook, Uber, etc.

People will adapt by looking beyond today's restrictive views of activities as being "labor" or "work" and seeking to have worthwhile lives but only if political and economic and social systems and expectations are adjusted as they should be.

If humanity can move into a phase where thought is valued above physical labor, and creativity is treasured above output, it could be a watershed moment.

Occupations within virtual reality; the metaverse.

Sharing economy is creating new business concepts.

Internet to obtain skills on a global basis, providing for new work structures.

The most sought-after good might be a purpose in life.

Local economies will be more sound than global economies.

DIY will eliminate some job categories, but potentially many more self-employment and freelance "jobs" can be created.

DIY, crowd sourcing, etc. only makes competition more intense; a race to the bottom for resources and money.

Hormonal peaks and valleys tend to be a driving factor of human creativity. It will be interesting to see how a perfectly engineered intelligence can compete with natural hormonal creative cycles.

A future "TradeNet" with smart AI contracts peer-to-peer using blockchain financial systems.

Question 3: What questions have to be resolved to answer whether AI and other future technologies create more jobs than they eliminate?

Question 3.1: What questions have to be resolved?

The following is a distillation of 220 responses.

How can we create initial conditions for AGI or super intelligence or strong AI so it evolves in a good way?

Do we want jobs at all? Should we be fighting to retain jobs? Or fighting to eliminate them?

How intelligent can AI and AGI become? How much complexity can robots handle?

What are plausible alternative definitions of work, jobs, employment, and basic income?

Who will own the AI? Is AI an independent operator; can it own tools it's using or controlling? Does it have intellectual property rights over its productions, code, algorithms, or inventions? What if very creative AI makes a lot of money and becomes a millionaire or billionaire, gaining lot of financial leverage? How will we determine and control AI motives? And should we?

What taxes and how to collect them?

Will human beings still be essential for conceiving, designing, building, and applying new technological tools—or will machines also take over this part?

Can we adapt our attitudes to work, business models, taxation, and welfare fast enough to avoid mass civil unrest as machines replace people at work?

Work creation though AI, not "jobs creation."

Can synthetic biology create many new industries and employment?

What kind of economy comes next?

We have no names for these new "post-unemployment" activities or categories yet. What will be the new economic order? How do we define "work" in the future?

Will strong AI [or superintelligence or AGI] be freely distributed worldwide?

How can future technologies eradicate poverty?

How and by whom is money created and distributed?

How can we support the development of a person with technology while taking care of the environment so that humans can live in a "humane" environment?

Question 3.2: What are your thoughts about answers to the questions you suggested?

The following is a distillation of 212 responses:

The objective of work will be self-actualization; the objective of the economy will be the well-being of humans.

Basic income should be installed and paid by the government.

Artificial biology could be as large as or larger than the Industrial Revolution, creating many jobs that could be offset by all those jobs lost by AI, robotics, etc.

Localization—Go back to live in connected villages in harmony with nature.

Develop a worldwide organization supported by governments to assess developments and to encourage developers to think about the (long-term) consequences.

Question 4: How likely (question 4.1) and effective (question 4.2) could these actions be in creating new work and/or income to address technological unemployment by 2050?

Table 3.6 presents the average rating of the suggested actions using the following scale: 5=Solves the Problem; 4=Very Effective; 3=Effective; 2=Little Impact; and 1=Makes It Worse. Some 215 respondents provided their judgments. The two grey cells identify the most effective and the most likely actions.

Table 3.6 Average Rating of the Likelihood and Effectiveness of Some Suggested Actions to Create New Work/Income by 2050

Action	Average Effectiveness	Average likelihood
Retraining programs for more advance skills	3.43	3.20
Require science, technology, engineering, mathematics, and coding in all levels of education	3.33	2.87
Make increasing national and individual intelligence a national priority	3.27	2.56
Create incentives to attract and create advanced skilled jobs	3.25	3.26
National innovation programs	3.24	3.42
Consolidate public welfare systems into a basic guaranteed income pending national situations	3.20	2.48
Create Do It Yourself Maker areas, hubs, centers, districts	3.18	3.05
Double national R&D budgets by 2020 (to have impact by 2050)	3.08	2.35
Create incentives for employee ownership plans	3.05	2.72
Make university education free to students	3.04	2.33
Tax the new wealth generated by new technology for public financial support	3.04	2.74
Massive public training in self-employment	3.03	2.56
Government investments in future technology firms with profits from government shares redistributed to unemployed	2.87	2.40

Question 4.1 and **4.2:** No actions were rated as "Solving the Problem" or being "Very Effective" or "Very Likely." The following is a distillation of the reasons given by the panel regarding the effectiveness and likelihood of the suggested actions:

There are some people who are so far behind technologically and emotionally they will never be able to catch up, but by 2050–60 that race will be moot once strong AI will reach human capacity.

Requiring STEM and CS education at all levels of education would be a prerequisite for basic productive life by 2050 but it would not, in itself, be sufficient to mitigate systemic technological unemployment.

Training people in how to be self-employed would mitigate technological unemployment because people would have the necessary skill sets to bootstrap and maintain their own jobs.

It is more expensive to create jobs for people whose work contribution is not enough to make a living than to have them living on welfare.

Free university education in medicine leads to lower-cost medical services and efficiently develops national talent resources.

Most of these things will be "tried" and most will fail due to lobbying by partisan interest groups in the governments.

Democratic governments in most parts of the world operate within a limited time frame. They prefer immediate gains of their policies/programs to meet public expectations. They, as such, would be hesitant to invest in long-term goals. And the non-democratic governments usually are not sensitive to the needs of the masses. It is thus rather rare for governments to incorporate a view of the distant future in their programs.

Question 4.3: Please suggest additional actions to address technological unemployment.

The following is a distillation of 190 suggestions:

We should be thinking in terms of systemic rather than one-off solutions.

If AI develops into a network service that enhances everyone's abilities everywhere, this will produce a dramatically different (and more positive) outcome than we expect today.

Teach critical thinking, reasoning faculties, compassion, self-employment, enquiry-based learning, and data in schools.

Preschool programs to ensure that all children have access to technology-based learning from an early age.

Most-efficient solutions will be grassroots approaches (like Maker and User Bio labs) rather than top-down solutions.

Self-employment training in schools.

Changes in current economic models; tax consumption, not labor.

Encourage high-tech subsistence farming, DIY on steroids, off all the grids, tele-everything, obviates the need for jobs.

Localization, self-sufficiency, small communities produce, transport, use, and dispose of their things.

Lifelong educational programs to keep people's minds busy.

Systems have to have ample niches for people with few/no skills and low education/intelligence; not only are they not going away, they are as worthy, as human beings, as anybody else.

Learn how to use the future global brain to become super-professionals, mindful, craving for harmony instead of hate, and create our own (professional and citizens') circles of social security instead of depending on government.

Re-examine defense spending.

Public money for financing startups.

Massive investments into very large-scale global programs, as in addressing climate change and space exploration; the current level of investment is too small to matter societally.

Set challenging objectives for the societies as a whole.

Create a system by which every living person is given the ability to create their own means of production.

Review intellectual property rights, given new future possibilities.

Campaign finance reform, reduce lobbying.

Question 5: Will wealth from artificial intelligence and other advanced technologies continue to accumulate income to the very wealthy, increasing the income gaps?

Question 5.1: What is likely to happen by 2050? Table 3.7 presents the ratings of some suggested developments using the following scale: 0=No Chance to 10=Almost Certain. Some 213 people provided responses.

Table 3.7 Average Likelihood Rating of Some Potential Developments Addressing Income Gaps

Development	Likelihood
Very uneven—some areas of the world implement good policies and others do not	8.05
Major social unrest occurs first, then policy changes are put in place to improve this situation	6.52
Other	6.50
Sufficient policy changes do not occur, income gaps get worse, and lead to social instability	6.42
New public-private economic programs, investments, trainings, incentives, begin to reduce the gaps	5.18
New taxation programs begin to reduce the gaps	4.71
Masses working and spending much time in virtual reality do not care about the income gaps	4.68
Several AI disasters change world opinion dramatically, slowing technology development	4.01

The following is a distillation of the panel's reasons for their answers:

Instability can spread internationally and lead to important wars.

Basic income would be a way to move forward, however it would have to be paired with micro incentives (passive income) to participate in society in a constructive and useful manner, even if it is taking place in a "virtual economy."

Decentralization and crowd funding will reduce the imbalance.

After a period of social instability, the speed of technological progress can create new wealthy people more rapidly and then income gap diversity could reduce.

It is an invalid assumption that AI works to exaggerate income gaps.

The best strategy is to follow Elon Musk's lead and create wealth through the creation of new innovating and world-changing technologies, rather than through outdated intellectual property schemes. Intellectual property is becoming increasingly harder to enforce. The future is open-sourced everything. This means the wealth generated by AI and other tools of abundance will be available to all at little or no cost. Structural unemployment will be the desire and the cure, not the problem.

Give people enough, so they don't care about the income gap; if people cannot participate, because of a rigidly structured society, then they will eventually cause a social upheaval.

Question 5.2: What future high-impact strategies should be studied today that could significantly improve the future work-technology-wealth-income dynamics?

The following is a distillation of 197 suggestions:

Using AI to make predictions about these dynamics itself. If we will have strong AI, we will use it to test strategies and choose the most promising one.

Conduct regular technology forecasting, monitoring, assessments, and implications for action, and AI economic impact analyses.

Understand and improve the dynamic between productivity growth and income distribution.

The absolute differences are unimportant if the needs and desires of all are met by appropriate compensation. Perception is a key consideration.

Universal basic income, with different types of incentives, including cash flow projects to see how it can finance work for well-being so that basic needs are guaranteed.

New economic systems, transition to a post-scarcity society and eliminate money, peer-to-peer money and value exchange.

More new world-relevant, self-paced, future-oriented simulations, low or no cost online education for self-actualization, entrepreneurial-oriented, science-based decision making, specialization like Singularity University.

Alter taxation, flat tax, taxing revenues where they are made, not where the head office of a company is based, use "A Theory of Justice" for guidance in tax and welfare systems with improved democratic governance and counter corruption and crime.

Enforce triple bottom line accounting (Profit, People, Planet) and find regulating mechanism to force the stock-market and banks to take them all into account.

Innovative ways of supporting self-generated jobs (AI/expert systems, finance, technical assistance, education, marketing, open-source movement, open collective intelligence, training, facilities provision, technology access through new start-up funding mechanisms).

AI disasters—pacemakers are already being hijacked for ransom. Recall Frank Herbert's "Butlerian Jihad" against the machines in his DUNE series. The disaster brought back higher education and training of actual humans and their actual brains.

Enact viable strategies for mitigating the effects of homelessness informed by those who are already on the street or who interact with them on a daily basis.

Use results of scientific investigations of the outcomes of laws of government to eliminate harmful/useless laws and enhance laws that solve problems.

Transfer activities to the virtual world.

Look at the former machine tax debate from last century; avoid mistakes of the last century.

Question 6: How necessary or important do you believe some form of guaranteed income will be in order to end poverty, reduce inequality, and address technological unemployment?

Question 6.1: Please rate how necessary you believe guaranteed lifetime income will be by 2050?

Table 3.8 displays the panel's judgments concerning the necessity of a "guaranteed income" rank-ordered by the average scores.

Table 3.8 Necessity of Guaranteed Income (number of responses)

Guaranteed income necessity	Score
Absolutely necessary	54
Very important	53
Can help	36
Irrelevant	27
Not too necessary	12

The following is a distillation of reasons provided by 202 of the panel's participants:

With the basic income, people will have less fear and stress, so less spending on national health care, and social instability and national security budgets will compensate [balance] the basic income budget.

Saving national budget costs of riots and other costs due to hungry or unhappy people. People may create more self-employment to reduce social safety budget.

The security of receiving a constant income will allow people to think and plan their future better.

Very hard to see how people will survive and buy goods and services without some level of basic income; the alternative is social collapse.

All sophisticated countries in the West have proved that a minimum income is the surest way to better education, better health, lower crime, better quality of life (cf. the Scandinavian countries as examples).

It is a form of social investment, ensuring the financial sustainability of many people. The payback in social stability should not be underestimated.

Will create immense immigration problems in the countries that would implement it.

Machines taking all the jobs and owned by the 1% is the current direction. EITHER the 1% is taxed to provide a guaranteed income for the 99% or the 1% will have no one to sell to. The alternative is the DIY on steroids; subsistence high-tech living obviates the need for jobs and current econometrics; hence, the 1% goes away.

To implement lifetime income will take longer; current workers are used to contributing to guarantee their retirement in the next 25 to 30 years. Only increasing rates of self-employment can change the current tendencies.

It all depends on how much employment is created directly and indirectly by synthetic biology, self-employment via the Internet, and how much new human creativity will result from labor-saving tech.

The only market-driven income solution I can find is AI-controlled businesses that generate dividends for dependent shareholders.

Government must not give money for nothing. Welfare programs like this don't help, they promote and even force people into poverty; incentives to work and get higher education will be reduced and people will drop out of the competitive economy except for barter and black markets.

Capitalism as a primary logic will end due to abundance; the consequence is that we no longer need to focus on making money to live.

New production/consumption cultures will need less money with lifestyles that are outside of capitalistic trade.

This is a short-term fix and should be implemented soon. Eventually, it will mostly be irrelevant as the cost of most things will be nearly zero.

False assumption that there is a single baseline that will cater for all "below" this median.

A guaranteed income is not sustainable by any government in the long run. Also, it is not healthy for the new generations, no motivation to innovate.

Either totally necessary or totally irrelevant, depending on how we choose to distribute resources in the future.

Question 7: Do you expect that the cost of living will be reduced by 2050 due to future forms of AI robotic and nanotech manufacturing, 3D/4D printing, future Internet services, and other future production and distribution systems?

Question 7.1: How much will the cost of living be reduced by 2050 compared with today? The responses are presented in Table 3.9.

Table 3.9 Potential Changes in the Cost of Living by 2050

Cost of living by 2050	Score
Increase for some areas	46
Reduced for most areas	43
Remain about the same as today	41
Significantly reduced	34
Significantly increased	16

The panel was divided on cost reductions: 77 participants expected the cost of living to be reduced significantly or reduced in most areas, while 62 participants expected the cost of living to be significantly increased or increased in most areas.

The following is a distillation of 195 responses given by the participants:

The costs of goods have been reducing for decades. The new techs are miniaturizing and improving the performance, productivity of everything. On site 3D printing and fairly soon molecular manufacturing will greatly accelerate this trend.

Not only the cost of items could go down, but items will last much longer (e.g., nanotech coating) and have multi functions (mobile phones). Hence the rate of buying things could also be reduced.

Since more can be done for less work, far more efficiently, and since these tools will be largely open-sourced and widely available, the total cost in terms of time and money will be marginal.

Physical products "going to zero" in many cases, but food is likely to remain expensive, and housing would be hard to reduce

New form of materials such as graphene and others may make buildings, clothes, and city structures stronger than ever. Education and social services may become almost free with MOOC and AI robots. Energy may become very cheap with solar clothes/tents being saved in home energy saving systems.

Increase in the cost of living comes from dramatic unbalance in the global economy. So... If the unbalance goes away, the cost of living will go down.

Technologies for circular/green/eco-friendly production will allow the use and reuse of materials that are normally discarded today and will reduce costs; lower mobility costs will be facilitated through AI (fuel/operational costs) and telecommuting.

The digital life and 3D/4D printing will reduce shipping costs. When renewable energy becomes the majority, energy costs will fall. However, some areas will have resource shortages, causing some increasing costs in those areas.

The cost will remain the same, however the qualitative conditions of living will improve thanks to AI and other new technologies.

No amount of automation can increase the amount of coastline available for putting down cottages.

Climate change will increase the cost of living, no matter what technologies we are using for manufacturing.

Tech will not be evenly available across the world and within countries.

Even if manufacturing cost will be reduced, other cost related to new added value services will make the total costs increase.

The cost of living is a relative thing. Most things will become cheaper as we learn how to make them cheaper—finite resources may get more expensive temporarily, but the meaning of "living" and its requirements are likely to change accordingly.

Question 8: What big changes by 2050 could affect all this?

Question 8.1: What high-impact events, developments, surprises, wild cards, or black swans could change the future work-technology relationship?

The following is a distillation of 199 answers provided by the panel:

Terrorism using WMDs including bioterrorism leading to a neo-Luddite and science backlash with regulation against technological development.

Data Fukushima.

Political instability, partly religiously driven and partly due to economic divisions.

Organized crime uses AI and other advanced technologies leading to an insecure world.

Massive, state-level cyber-warfare.

Local renewable energy sources and zero-energy solutions (e.g., passive houses) become the norm, making power grids and large central power stations less important.

Cyberlife dominates physical human life.

Cultural acceptance of not working.

3D-printed food, indoor aquaculture.

Bio-mineralized structures.

All able to become augmented geniuses.

Atomically precise manufacturing, molecular assemblers.

Brain-to-machine and brain-to brain interfaces become the norm.

Global warming accelerates, approaching greenhouse runaway unites the world.

Permanent human space habitats opening "unlimited" energy and resources.

Global movement toward non-material sense of life.

Success of low energy nuclear reactions, also called cold fusion.

A more intelligent and better organized robot society, first in parallel, then dominant, and eventually giving some humans the possibility to live in zoos.

A huge meteorite risk will initiate a coordinated global effort to deal with the problem, resulting to great technological breakthroughs and long-term peace.

Intelligent self-reproducing robots spread like a virus to all corners of the world.

AI threats and human-machine wars.

Extraterrestrial contact.

Longevity treatments, radical health life extension, mentally productive "seniors.".

Question 8.2*:* If the future AI/Robot economy creates the abundant wealth many expect by 2050, how should it be distributed? Please explain briefly how this might be accomplished.

The following is a distilled sample of over 200 answers received from the panel:

Low but sufficient guaranteed annual equal income via governments to compensate for the fact that we will not need 70% of the labor force by 2050. This could be paid for by taxes on consumption, automation technologies, carbon, Internet transactions, robots that would let people focus on making their lives and others better rather than having to focus on economic survival.

Basic income, as the Swiss are contemplating, combined with investments for free or low-cost access to health services, energy, education (for the very young to the very old), water, transportation, communications, housing, food, 3D-printer time/resources, and other do-it-yourself entrepreneurial activities.

Give everyone shares in the GNP, while maintaining incentives for work that still could be in demand.

A certain percentage must go back to the stakeholders that created it; the rest to the society.

Workers owning shares of the companies, ownership of worker robots and their income.

The same way wealth is distributed today: income tax, profit tax (on companies) etc. Today's system is the product of many decades of development and shouldn't be easily overthrown—just adapted as needed; We still need incentives to advance.

Combination of three ways in a private enterprise/capitalistic society: a) legislation that limits the earnings potential of the few (owners/inventors) in both public and private

companies ; b) taxation on wealth and/or by applying a progressive tax bracket system; and c) mandatory employee stock ownership for all companies over, say, 10 people.

Nations are not charities; each will keep its share and maybe give something for development aid. However, it is not to be expected that shares will be distributed equally.

Instead of a central distribution control system, radical distribution of abundance will happen organically and automatically in the absence of enforceable intellectual property rights.

Global networks and AI can optimize wealth distribution based on big data analysis and direct voting.

By creative output by individuals that improve the human condition; financial incentives for those that create collective benefits; it should go to those who create and sustain the wealth; distributed to those who earned it, whether owners, stockholders, distributors.

High taxation of productive and creative individuals and corporations could stunt the growth of the very technologies that would eliminate poverty and provide food and shelter to many.

Human consciousness melded with machine consciousness will create a civilization where risk-reward is no longer operant and cost-benefit is obvious.

Smart contracts, AI, peer-to-peer, and blockchain (used by Bitcoin) style financial systems connected to personal devices.

We need dialogue on creating basic income formulae.

Question 8.3: How might economic systems begin to change?

The following is a distillation of 197 answers:

When distribution of scarcity is overtaken by distribution of abundance.

We can either wait until the current system breaks or create a safety net now to prevent complete social upheaval/chaos.

Economic systems are already changing; it's politics that will need to catch up.

Collaborative peer-to-peer networks will transform capital/money relations.

Hyper-connected world economy will emerge with global system such as crypto currency; cashless, non-state "coin."

A series of global bank crises will eventually create trust on independent digital currencies.

If 10% of people are productive enough for sustaining the entire (100%) of humankind, then new products and services will be created for the 90% in adult "day-care" activities to release enormous innovation and creativity.

Increase in participatory democracies, protecting the environment, promoting research and creativity, and awareness of the social responsibility of all to all.

Changing the taxation system, and the productivity-remuneration relationship.

First, a kind of sustainable capitalism and then, a new kind of circular, recycling, people-planet-profit economy.

Through revolution or through democratic change or, more likely, it will not change until the next major crisis or the next two or three major crises.

Some nations implement basic income for everyone, then other states will follow.

Disempowerment of corporations when people no longer "have to work to live."

More network communities will transform hierarchical systems into decentralized ones.

Increased concentration of wealth to the top 1%, then under massive pressure and crisis government interventions and crowd self-organization; e.g., local food, services, with local alternative currencies.

The masses become self-sufficient, organized for creating basic needs and some surplus via free enterprise, free expression and great creativity with a minimum requirement of "responsible" mandatory work such as guarantee each individual's self-support.

Public pressure, having elective candidate who sees the big picture, and by actually voting on Election Day.

Reducing the costs of goods and services is equivalent to rising income levels for everyone. Through increasing automation, human activity will increasingly shift to fun and creative pursuits—to self-actualization. After improved technologies help restore the ecological systems, more radical and powerful technologies will continue to flourish, grow, and expand beyond Earth into high frontiers unknown.

Question 9: What alternative scenario axes and themes should be written connecting today with 2050, describing cause-and-effect links and decisions that are important to consider today?

Question 9.1: What scenarios axes or assumptions should shape useful scenarios on the future of work-technology dynamics for 2050? The panel was asked to check all that apply. Table 3.10 summarizes the votes.

Table 3.10 Scenarios Axes Rank-Ordered by the Number of Votes Received

Scenarios Axes	Number of votes
High to Low Human Well-being (including health, guaranteed basic needs, and clean natural environment)	111
High to Low Wealth Creation from Technology Integration	83
High to Low Unemployment	77
Human Intelligence Technological Augmentation	74
High to Low Use of Guaranteed Income Programs	59
High to Low Artificial Intelligence Disasters	44
Other	13

The following is a distillation of the panel's reasons given for their answers and additional suggestions:

Economic decoupling or "opting out" should be considered; i.e., will certain communities elect to drop out of the global economy entirely? Hyper-localized, autonomous communities—imagine the hi-tech equivalent of a monastery, but occurring at a variety of scales from neighborhood up to city-state levels.

Geo-social axis: Or social acceptance axis. At one extreme, overwhelming global acceptance of the benefits of AI/robotics/IoT, and at the other extreme, many see the use of such technologies as a loss of control and behaviors considered abhorrent and many work to quash the technology.

Other axes to consider: draconian government intervention is the one that concerns me most.

General artificial intelligence will be an all-or-nothing scenario. They'll either cause catastrophic (perhaps existential) damage, or they'll be an unbelievable boon. There's not much room in the middle.

Question 9.2: What themes, foci, titles would be the most useful for the 2050 scenarios that would expose what we don't know today, that we should explore to know how to build a better future for the world-technology dynamic? The rating used a scale from 1=Least Useful to 5=Most Useful.

Table 3.11 displays the themes' usefulness as rated by 196 of the panel's participants.

Table 3.11 Themes to be Considered for the 2050 Scenarios

Theme	Rating
Human Well-being 2050	3.97
Other (see suggestions below)	3.90
The New Economy 2050	3.74
2050 Global Success: More Work Created than Lost	3.21
Humanity Becoming Augmented Geniuses Changes Nature of Work	3.12
Home/Community Production of Stuff and Food; Bartering/Time-banking	3.08
50% Long-term Structural Unemployment by 2050	3.03
High-Tech Rural Autonomous Subsistence Migration	2.76

The following is a distilled sample of the panel's reasons or additional comments on their answers:

Rapid global acceptance of the usefulness of AI/Robotics/IoT or a widespread cultural and religious rejection? And to what extent will humans really be willing to give over their entire lives and trust to an AI/robotic system?

How will people engage in policy decisions in 2050?

Changing our understanding of the relationship between work and well-being.

The symbiotic society; the tech-human factor.

Money-neutral society in circular economy.

Humankind's optimized civilization for the space industry; optimize positive benefits to Earth and humankind from the future space epoch.

Doubling or tripling of the faction of the population having a first-world living standard, with increased productivity etc. and issues of aging.

If we get anywhere near 50% structural unemployment we are doomed to a long period of darkness.

Question 9.3: What would make these scenarios worth your time to read them and share with others?

The following is a distillation of 189 answers:

New insights, punchy implications, the WOW factor!!!

Interaction of technological changes and values and how society sees itself.

Connection with the present human nature, with its desires, hopes and fears.

Connection with what is really happening as well as Innovations still not yet developed.

Use of Maslow's needs to guide and structure healthy life.

Evolutionary psychology and social dynamics of the causes for the problems: tendencies to hierarchies, centralized control, exclusionism, and tribalism. Address resistance to change, group-think, and fear of being an outstanding individual.

Uncovering new aspects and perspectives of the impact of technology on human life (work and leisure)—in particular, potential risky/unwanted situations/conditions ... with specific recommendations for actions today.

Better conceptual tools for thinking about an information society.

Endorsement from financial luminaries.

Challenge basic concepts, such as unemployment, income gaps, technological displacement, classic economics, etc.

Applicable to different contexts, with different scope levels (global, macro meso micro) and include roadmaps.

The idea of personal progress.

Show the readers how the scenarios directly relate to their children's jobs.

Totally new concepts, ideas, instead of (un)employment, new purposes of work.

Roadmap to transform today into tomorrow with required investments.

More visual illustrations and videos.

Future technological dynamism and rapid growth of the technology market.

Roadmap that shows how AI and new technologies could improve the human condition and the quality of the natural environment.

Maybe try a short story competition.

Interactive discussions in the right fora with the right people.

Question 10: Other comments to improve this study?

The following is a distillation of 193 comments received from the panelists:

I found this questionnaire thought-provoking and had to revise some of my working models and hypotheses in my field's work.

Consider short videos of the most important key insights for much broader dissemination and use in conferences, universities, schools, etc.

Experts who participate in that process should function as loudspeakers for your project and discussed the issues. Also include social media.

Workshops could also benefit from the raw data and ideas being collected here.

I congratulate the organizers of this Real Time Delphi for the kind of questions they have managed to present in this survey…the overall result is really worthwhile.

Really a nice work; periodic survey will be beneficial to amend policy level and strategic decisions. Can we keep the discussions ongoing? Revisit annually?

Engage corporate and union organizations management as well as successful high-tech companies in the dialogue and the entire process.

I realized this project is really important for making a better world. Please add more chances to gather and share as many as possible.

I think this is a good way of collecting ideas and direction. I would organize a conference with futurists and politicians to discuss the results. This should be done every two to three years to be able to see differences / changes and, if needed, adjust recommendations.

We need to take these global results into local analysis, through the development of specific regional situation analysis by The Millennium Project Nodes that would be later discussed in the planned workshops around the world.

Very well prepared and very useful for decision making.

This study is nicely focused on very basic issues.

This is a very good stuff!! Please contact me anytime to help spread the word.

Next Steps in the Future Work/Technology 2050 Study

The results of this Real-Time Delphi will be used as input to the construction of alternative scenarios and road maps. These drafts will be made available for comment and feedback to those who participated in this Real-Time Delphi and additional experts. Based on the feedback, the scenarios will be rewritten. Strategies will be drawn from the final scenarios and used as inputs to national planning workshops. These will be initiated by some of the 56 Millennium Project Node Chairs around the world and others who express interest during this process. The results of the workshops will be integrated and distilled and made available in a variety of media for public discussion.