

Technology, collapse, development

1. Does the future of globalization depend on the future of technology, namely, on what is technologically possible? Is globalization a means by which the limits, and the nature, of human technology will be revealed/discovered/reached/tested?
2. The level of intelligence of human beings is not the highest that physics allows. There is then room for us to create beings that will surpass our intelligence probably by far: contrary to human intelligence, which essentially fixed, the intelligence of artificial beings could be recursively improved. [Intelligence: "ability to solve problems with limited resources."]
3. Since these new beings may pursue their our goals and interests, it is to be expected that they will eventually take control of humanity.
4. To achieve their goals, these intelligences may need to monopolize vast amounts of planetary resources. Human beings would end up being considered mere resources.
5. Will we be able to encode human/humaine values into artificial intelligences? Or does greater intelligence lead to better morals? How much room is there for moral progress?
6. Is human progress exponential? Is human-created technology accelerating, so that the power of technology expands exponentially? Are we now starting to experience the *knee* of the exponential growth curve, the point of the curve where the exponential nature of growth is noticeable? Will intelligent machines be the definitive invention of humanity?
7. Law of accelerating returns (Ray Kurzweil). The rate of evolution inherently accelerates, shows continual acceleration (every stage in evolution uses the capabilities and results from the previous stage and, for each stage, going from one stage to the next takes a shorter time).
8. Six epochs of evolution (Ray Kurzweil). These epochs express the continued evolution of information: physics and chemistry (information captured by patterns of matter and energy); biology and DNA (self-replicating mechanisms created: life); brains (mechanisms to acquire and process information biologically); technology (human creations); merger of human technology with human intelligence; and "the universe wakes up" ("the 'dumb' matter and mechanisms of the universe will be transformed into exquisitely sublime forms of intelligence, which will constitute the sixth epoch in the evolution of patterns of information. This is the ultimate destiny of the Singularity and of the universe", Kurzweil, 2005, ch.1).
9. The Singularity (Ray Kurzweil). It is the era defined by intelligence becoming nonbiological and countless of times higher than the current level of human intelligence as a result of rapid technological change. The impact of this change will transform human life: biological limitations will be transcended out, creativity will be amplified, humans and machines will become integrated, we could occupy different bodies and all human problems will be solved (aging, illness, pollution, hunger, poverty... even death). Nanotechnology will make it possible to produce anything inexpensively. The Singularity culminates the merger of biology with technology: it is the time when machine intelligence merges with, and surpasses, human intelligence.
10. It seems that exponential growth can become explosive only if there is room for explosive growth: is exponential growth of outputs possible without exponential growth of inputs?
11. The law of accelerating returns and related 'laws' work until they stop working (Paul Allen). Are such laws simple, not guaranteed extrapolations of past regularities and trends? What ensures that end of a technological paradigm (vacuum tubes) is followed by a new one (transistors)?
12. How and why is human technology different from the technology created by other species? Aunger (2010) suggests that the difference lies in that human technology is cumulative: that only humans produce capital, instruments only helpful to produce other instruments. This has

allowed humans to increase the complexity of technology and even to accelerate its increase. Side effect of this potential: humans can create a global catastrophe (like climate change or biodiversity loss). Humans make things and things make humans: there is a coevolution between humanity and technology.

13. Phases of technological change (Joseph A. Schumpeter). (1) Invention: process by which new technologies come to exist, typically as combinations of existing technologies. (2) Innovation: the commercial introduction of new technologies. (3) Diffusion: the spreading of new technologies.
14. A conceptualization of technology (W. Brian Arthur). A technology is a means to fulfill a purpose or need by reliably exploiting some natural effect or phenomenon. A technology puts together assemblies, which work together on the grounds of some base principle of the technology (for instance, counting the beats of a stable frequency is the base principle of a clock). The base principle of a technology is the idea of using a phenomenon to accomplish some purpose. In sum, a technology involves a purpose, an architecture of components and a phenomenon exploited by some base principle: technologies take advantage of predictable and replicable events. Innovation can be seen as the discovery of new links (base principles) between purposes and phenomena that can be exploited to meet the purposes. Invention is then a process connecting a purpose with a principle that can satisfy it.
15. General approaches to the relationship between technology and society. (1) Internalist approach: technology develops in isolation from society. (2) Technological determinism: certain inventions or innovations cause major changes in society (social development is related to the development of techniques). (3) Dialectical approach: technological and social changes interact mutually.
16. African societies as example of the lack of adoption of superior technologies (resistance to foreign ideas). (i) Tools from Eurasian preindustrial technology (cart, plow, potter's wheel) were not adopted, despite contact with Eurasia. (2) Advanced industrial technology was imported but not successfully integrated with existing locally-based economic structures. African economies remain based on human energy and linear-reciprocal motion (non-human energy sources and technologies based on rotary motion did not spread). Despite exposition to presumably more advanced technologies, material and cultural reasons led to a general rejection of the technologies. The technological gap with Eurasia reinforced rejection: the introduction of more advanced production technologies in precolonial Africa failed to generate transformations in the rest of the economy (failed to create an economy where those technologies could thrive and develop). The benefits of the new technologies were appropriated by ruling elites, which reinforced their privileged position. Precolonial Africa illustrates the possibility that technology spurs economic growth but not development (innovations can be transferred without the technological capacity embodied in those innovation being simultaneously transferred).
17. Even after 1960, African growth has been characterized by the divergence of African incomes from incomes in other developing regions.
18. The five most important trends in the next 50 years (Watson, 2012). (1) Ageing. (2) Power (economic, political, military) shifting from West to East. (3) Greater, global connectivity. (4) Convergence of technologies (GRIN technologies = Genetics + Robotics + Internet + Nanotechnology). (5) The environment (planetary conditions, resource exhaustion).
19. The five most important trends that will transform societies in the next 50 years (Watson, 2012). (1) Globalization: everything to become hyperlinked. (2) Localization: countertrend to globalization because not everyone will like globalization or homogenization. (3) Polarization: middle classes will tend to disappear, either going up or down on the income scale (upwards to a new managerial elite or downwards to a enslaved working class or to the unemployed). (4) Anxiety, resulting from greater uncertainty and vulnerability. (5) Search for meaning: will science become the new religion or will traditional religions be reinforced?

20. Arthur C. Clarke's laws of prediction. (1) "When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong." (2) "The only way of discovering the limits of the possible is to venture a little way past them into the impossible." (3) "Any sufficiently advanced technology is indistinguishable from magic."
21. Amara's Law (Roy Charles Amara, 1925-2007): "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

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22. History is an opportunity to learn from past mistakes. The greatest risk to humanity in coming decades is the continuous damage to the environment to a degree incompatible with the current standard of living, or even incompatible with the existence of humanity.
23. All pre-industrial societies were vulnerable to collapse: a local intense decrease in human population and/or in political, economic, or social complexity.
24. Easter Island is a spectacular historical example of collapse. When humans settled, the environment was rich; eventually, forest were completely cleared and most bird species become extinct. Other examples: Mangaia, Mangareva, Rapa, low Marquesan islands, parts of New Caledonia, parts of Fiji. In some islands in the Pacific the result was complete abandonment. Some Native American societies (like the Anasazi) in the U.S. Southwest before 1492 constitute another example of collapse.
25. Despite the fact that societies apparently tend to approach the margin of what the environment can support, in the past collapse was not the necessary outcome: many societies have existed continuously for thousands of years without any signs of collapse (Japan, Java, Tonga, Tikopia, Tahiti, Rarotonga). Are modern (technological advanced societies) immune to collapse?
26. Why, when environmental disaster seems apparent, measures are not always taken to avert disaster? How to differentiate environmental factors (deforestation, salinization, soil nutrient exhaustion, drop of water tables, drought) behind collapse from cultural/social factors?
27. Jared Diamond's (2000) explanation of collapse: "people living in fragile environments, adopting solutions that were brilliantly successful and understandable in the short run, but that failed or else created fatal problems in the long run when confronted with external environmental

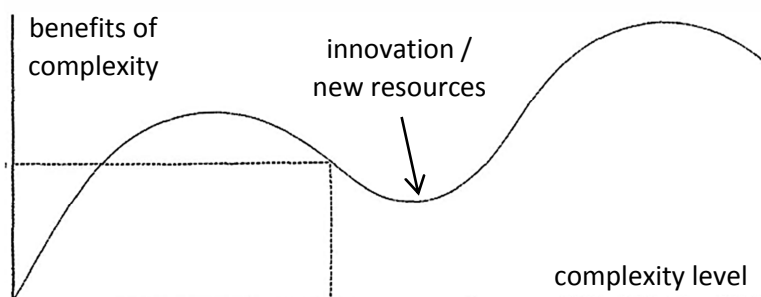
changes or human-caused environmental changes that people without written histories or archaeologists could not have anticipated.”“Past societies faced frequent ecological crises of small amplitude over small areas. Modern global society faces less frequent but bigger crises over larger areas.”

28. Are non-ambiguous the lessons of the past? The response to the environmental crises in Western Europe between the 14th and 18th centuries was innovation and intensification. This response was flexible, broad, decentralized and protracted. Based on this experience, is alarmist the claim that, under the current pattern of global resource exploitation, the future of humanity is at risk? Butzer (2012) contends that one should not ignore the resilience and the capacity of readaptation of societies. Social stress creates the conditions and incentives to try new ideas and solutions, above all in societies favouring bottom-up options, in contrast to the authoritarian strategies characteristic of pre-industrial societies.
29. According to Tainter (2006), the big question at present is whether intensification can continue indefinitely. The view of orthodox economists is that new technologies and new resources to address all kinds of problems will always be found: the future is always promising. The alternative view is that the present global civilization is like any other previous civilization, in the sense that no civilization can survive the destruction of its natural base. Economies depend on ecosystems. What is the future of an economy shrinking forests, eroding soils, depleting aquifers, collapsing fisheries, raising temperature, melting ice sheets...? Collapse in the past was typically preceded by the spread of hunger (hunger at the global scale has not yet disappeared).
30. Modern societies rely on a continued improvement of technology. This makes economies increasing complex and all its components more interdependent. As a result, economies are more vulnerable to shocks. The infrastructures required to maintain the stability and complexity of modern economies (electrical power, water and food supply, communication, transportation, health care, defense, finance) are increasingly intertwined, so that troubles in one component more easily may spread to other components.
31. X-events are high-surprise, high-impact events. In a society, the source of X-events is the ‘complexity gap’ between the complexity of the control system (the government) and the increasing complexity of the controlled systems (the citizens). The gap must be bridged: either the government forces a reduction in complexity in the population (repression) or raises its own complexity to match the population’s higher complexity (free elections are held, civil rights and liberties granted, social mobility allowed, openness accepted). An X-event is the default path of bridging the complexity gap, the vehicle that narrows the different complexity levels of two interacting systems. When a government is not able to bridge the gap, a revolution (an example of an X-event) is likely to break out. Examples of X events: supervolcano explosions (Toba, 74kya, probably responsible for the near extinction of humanity), the 1918 Spanish influenza epidemic, high magnitude earthquakes, bees massively dying off, 9-11 terrorist attack... Societies today are more vulnerable than ever to X-events: the complex structures of modern societies are extremely fragile.
32. Law of requisite complexity: to regulate a system, the complexity of the controller has to be at least as great as the complexity of the system to be controlled.
33. The 2011 revolts in the Arab world are examples of X-events. Modern communication and social-networking services (Google, Twitter, Facebook) have increased social complexity (citizens become more empowered, self-aware, informed, connected). Governments responding by restricting access to those services, or shutting them down, made the complexity gap widen to unsustainable levels. A complexity gap is synonymous with trouble and the political expression of trouble is revolt/revolution. The result in the Arab world was regime change in some countries (Tunisia, Libya, Egypt) and challenge to ruling elites (the Assad dynasty in Syria, the monarchy in Bahrain).

34. Manufacturing sectors in developed economies have become more complex (minimum-wage laws, health and safety standards, unionization) than those from developing economies. When both sectors interact through globalization, with a complexity gap becoming too large to be sustainable, the gap is closed by an X-event: outsourcing (manufacturing jobs transferred from developed to developing countries). This X-event downsizes by force the comparatively excessive complexity of the most developed sector. In this respect, globalization creates new X-events and magnifies the consequences of existing X-events.
35. The rules for dealing with normal events (for which there is abundant past experience) are different from those for handling X-events (which are rare and unexpected).
36. The increasing complexity of the global society is the direct cause of X-events. The complexity is expressed in many ways: integration, interdependence of systems and infrastructures; accumulation of bureaucratic layers; mismatch in complexity levels between interacting systems (national and foreign economies; governments and citizens; economies and ecosystems)...
37. Streeck's (2016) apocalyptic horsemen of contemporary capitalism that are devastating the economic and political landscape: stagnation, debt and inequality. Is a capitalist economy compatible with a democratic polity? Is capitalism socially dysfunctional?
38. Some complexity principles. (1) Emergence: the whole is not just the sum of its parts. Even if the characteristics of the individual components of a system are perfectly known, its interaction may give rise to systemic properties that are difficult to predict from the individual properties. (2) Red Queen hypothesis: one must run to stay in the same place (do the same is a recipe for failure). A system consisting of adaptive, evolving organisms forces the players to adapt and evolve fast and continuously just to remain in the game. This permanent race between the players tends to increase the overall complexity of the system. (3) No free lunch. To increase the efficiency with which a system operates, its resilience (to shocks or changes) must be reduced. Conversely, survival in an uncertain environment demands efficiency sacrifices. (4) The Goldilocks principle (food cannot be too hot not too hold). In an open, dynamic and competitive environment, systems can operate only within a limited range of conditions: the 'edge of chaos'. Policymakers, for instance, must select the right mix of market freedom and market regulation: too much regulation may harm growth; too much *laissez-faire*, may be destabilizing. (5) Undecidability: deductive reasoning (logic alone, rational argumentation) is not always enough to handle problems. (6) The Butterfly effect (ripple, domino, snow-ball effect). Complex systems tend to be very sensitive to apparently minor changes: small changes may have large effects. (7) Law of requisite variety: the control system has to be at least as complex (sophisticated) as the system to be controlled (higher complexity is required to manage lower complexity). Complexity gaps do not tend to last and its involuntary adjustment is likely to be traumatic for the system.
39. Is Isaac Asimov's psychohistory possible? Would it be possible to predict the evolution of a large population of individuals having information regarding those individuals? Can laws of evolution of some macrovariables describing the population be found? Sociophysics is a new discipline concerned with the capabilities of predicting (and controlling) human behaviour (mainly, qualitative tendencies), though the presumption is that it is specific events rather than the future of societies that is amenable to prediction: humans do not behave like atoms.
40. Punctuated equilibrium (Stephen Gould, Nils Eldredge). It refers to a theory of evolutionary processes according to which evolutionary processes do not occur slowly and gradually, but quickly and suddenly. Long periods of apparent stability and lack of significant change are suddenly followed by a period of radical, dramatic evolutionary changes take place (like the Cambrian explosion, 650 mya, where animals with shells and external skeletons appeared).
41. How similar are the biological and the historical evolutionary processes? Historically, societies appear stable for long periods. Constant adaptation goes unnoticed until societies "go critical".

42. Is Western civilization trapped in the grip of two inhibiting ideologies, positivism and market fundamentalism (Oreskes and Conway, 2014)? Is the ultimate paradox of neoliberalism that this ideology is meant to ensure individual freedom above all but eventually requires large-scale government intervention?

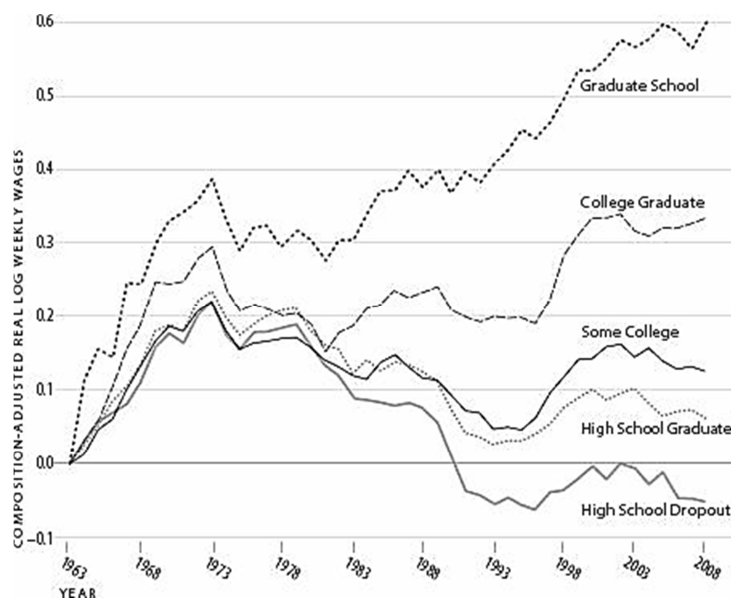
43. Tainter's (1988) theory of why societies collapse. Collapse means that a society experiences a rapid and significant loss of sociopolitical complexity. Tainter's explanation is based on four ideas. (1) Societies are problem-solving organizations. (2) The sociopolitical organization of societies requires energy for its maintenance. (3) Higher complexity levels of a sociopolitical organization correspond to higher per capita costs: a rising complexity is increasing costly for each member of the more complex system. (4) Solving social problems by investing in sociopolitical complexity has diminishing marginal returns: each complexity upgrading is less capable of solving problems. The productivity (the benefits) of the investment in complexity is eventually declining. Given (1)-(4), collapse arises when the benefits of investing in complexity are insufficient to cover its costs. Collapse is the natural mechanism to downsize a complexity level whose maintenance is excessively costly. Innovation or discovery of new resources (energy subsidies) are common ways to overcome the diminishing returns to investment in complexity.



44. Moravec's paradox (paradox of robotic progress). "The discovery by artificial intelligence and robotics researchers that, contrary to traditional assumptions, high-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources." (Wikipedia). "It is comparatively easy to make computers exhibit adult-level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility." (Hans Moravec)

45. Digitization. One of the most important recent phenomena is that almost everything is being digitized: documents, books, news, statistical information, music, photos, video, maps, social networks, requests for information, responses to those requests, data from sensors, personal information, purchases, services...

46. Skill-biased technical change. Digital technologies (big data, high-speed communications) have increased the demand for abstract and data-driven reasoning, and this has risen the value of the workers with the right engineering, creative or design skills. The result is a fall in the demand for less skilled workers and a surge in the demand for the more skilled. The chart on the right shows evidence of the winner-take-all phenomenon: skill-biased technical change favours people with more human capital (mainly obtained through formal education).



47. A by-product of technological progress is that technologies become overcomplicated and more incomprehensible. The current technological level has accelerated the metabolism of the planet, complicating the flow of materials and information.

48. Magdoff and Foster (2011, p. 7) corollary to Herman Daly's Impossibility Theorem of unlimited economic growth in a limited environment: "The continuation for any length of time of capitalism, as a grow-or-die system dedicated to unlimited capital accumulation, is itself a flat impossibility". "We are constantly being told by the vested interests (...) that capitalism offers the solution to the environmental problem: as if the further growth of capital markets, green consumption, and new technology provide us with miraculous ways out of our global ecological dilemma. Such views are rooted in an absolute denial of reality."

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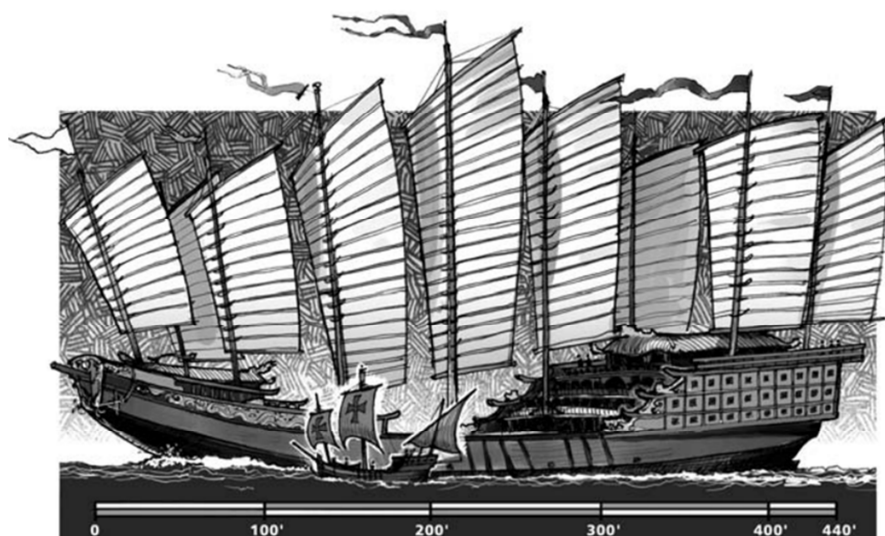
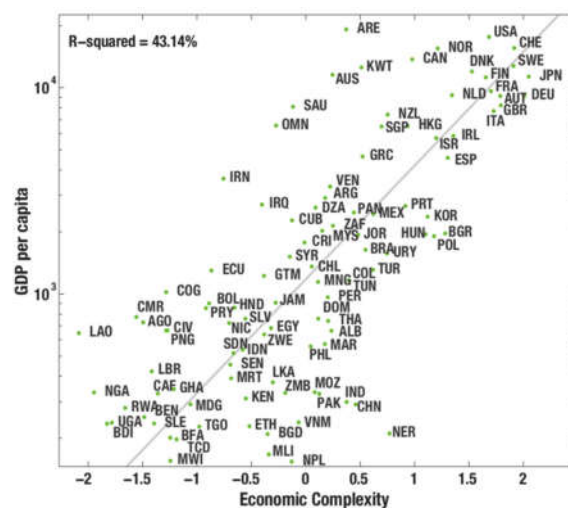
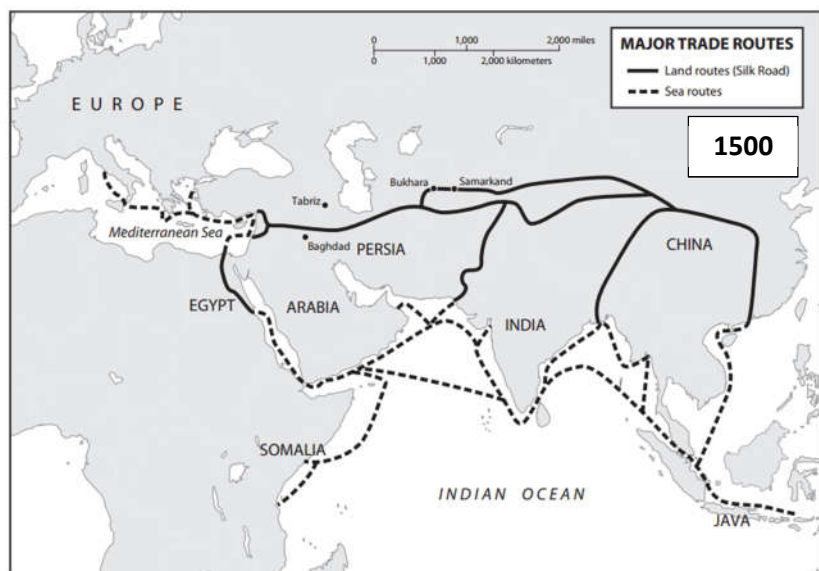
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49. The paradox of development (Morris, 2010). "Rising social development generates the very forces that undermine further social development." An unintended consequence of success is new the emergence of new problems, whose solutions lead to additional (probably, more serious) problems. Social development stagnates or declines when the challenge of temporary success is not met: every society races against itself under an unstoppable Red Queen effect.

50. Two views on development. View 1: W. W. Rostow (1960). Economies pass through similar stages of development that lead to a common final state. View 2: Alexander Gerschenkron (1962). The path of development of an economy depends on the development gap with respect to the developed economies. Gerschenkron observed that scale economies were greater for later industrializers and that demanded new institutions to raise more capital. Additional, more recent factors that modifies the challenges and opportunities for late developers are the changes in transportation and communication technologies and the new patterns of global trade. Hirschman (1968) identified the differences between late industrializers in Europe (based on heavy industry and capital goods) and early stages of industrialization in Latin America (light industry and consumer goods).

51. Shirky principle (Clay Shirky): "Institutions will try to preserve the problem to which they are the solution." Institutions tend to develop a self-preservation instinct.

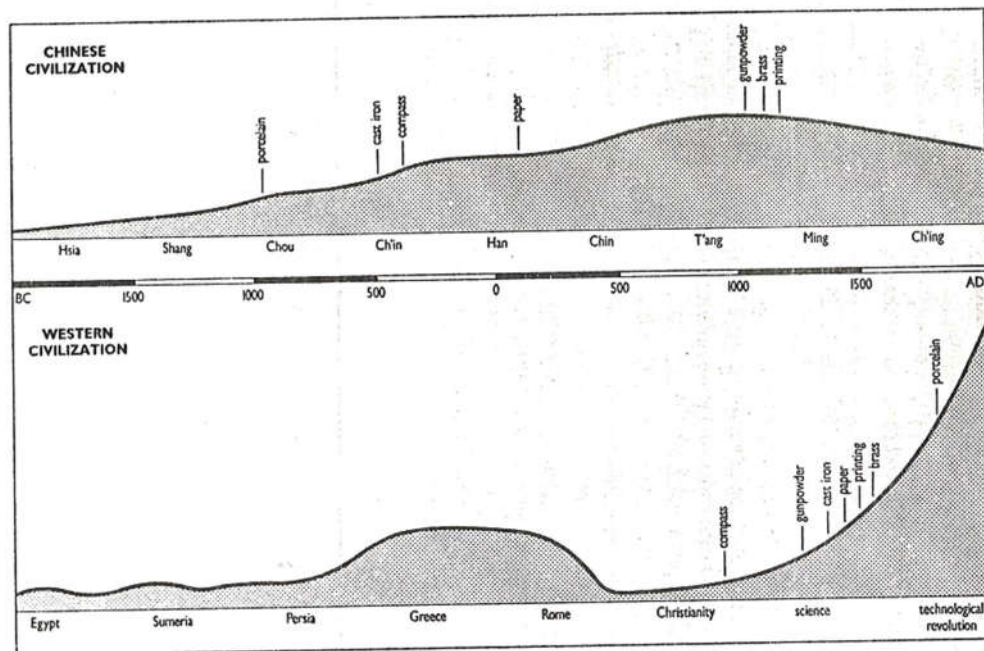
52. **The Lee hypothesis** (Lee Kuan Yew, 1923-2015; president of Singapore, 1959-1990): **nondemocratic systems are better at bringing about economic development.**
53. **Joining the rank of developed countries appears to be extremely difficult.** Up to 2012, only 11 developing countries have risen to the rank of developed countries: Hong Kong (1997), Israel (1997), Singapore (1997), South Korea (1997), Taiwan (1997), Cyprus (2001), Slovenia (2007), Malta (2008), Czech Republic (2009), Slovakia (2009), and Estonia (2011).



Columbus's Santa Maria (20 m) vs Admiral Zheng He's (1371-1433, the 'Chinese Columbus') flagship (138.4 m by 56 m or 447 by 183 feet, though it is claimed that rather than 447 it was probably closer to 200-250 feet). Eight expeditions of a rather diplomatic nature were undertaken (1405-1433) to the 'Western Oceans': to impress and build allies, consolidate peace and preserve power at home. The first voyage comprised 312 ships and 27,800 men.

54. Siddhartha Mukherjee, 2015, *The laws of Medicine*: "Normals' teach us rules; 'outliers' teach us laws." (Law 2)
55. The extra factor. Hidalgo (2015) adds to the conventional factors with which economics textbooks describe an economy (capital, labour) and to those in natural science textbooks (energy, matter, information) another factor that links physical quantities with social processes: **economic complexity**. Economic complexity refers to the knowhow and knowledge accumulated at the aggregate level and which is expressed in the diversity and sophistication of economic activities. The chart above on the right illustrates the positive correlation between economic complexity and GDP per capita (standard of living).
56. **Globalization as an egg-chicken problem** (Lindsey, 2001). View 1 (popular view): globalization occurred first and that forced governments to adopt pro-market policies and reforms. View 2: globalization has been a deliberately chosen response to failures of centralization. The reaction to

the problems caused by those failures was the removal of controls over the economy (economic liberalization). In this view, governments were not forced to accept market-friendly policies; rather, it was the exploitation of the pro-market alternative that has made globalization possible. Causality then runs backwards: pro-market policies and reforms came first and globalization was the consequence.



57. The catch-up illusion. Kim and Kim (2014) argue that the high growth rates of latecomers in the process of economic development depend on the developed countries. This implies that developing countries can at most aspire to keek pace with advanced countries, not to overtake them. The leaders (countries that industrialized first) will probably remain leaders forever and the followers (the latecomers) will also remain so.
58. Global markets create global tensions. Global markets are engines of creative destruction, generating progress through cycles of expansion and contraction of economic activity (economic crises) and financial speculation (financial crises). In this global markets resemble national markets. The difference is one of scale: there is no isolated place where to seek protection from the activity of global markets. Global capitalism delivers prosperity by destroying occupations, industries, sectors, countries and ways of life. One of the victims of globalization is the career: middle-class worker can no longer occupy their working lives with a single vocation. Globalization is also a threat to the peace between states: lacking institutions of global governance, states struggle for the control of natural resources.
59. Globalization does not imply homogeneity, uniformity or cultural convergence. Globalization is not an end-state towards which all economies are converging or will converge. The increasing global interconnection of economic activity accentuates the unevenness of international development: developing (peripheral) economies become more dependent on investment from developed (core) economies. Hierarchical relations between states are not disappearing: they are transformed. There are also dimensions of society that resist the impact of global markets: local realities and cultures are modified by contact with the rest of the world, but not necessarily uniformized or homogeinized. The local has the opportunity to have a global reach rather than the global dissolves the local. Instead of stimulating cultural convergence, globalization makes cultural differences more evident and contributes to reinforce/deepen the differences. The lack of a common global language encourages communications media to focus on specific cultural and linguistic groups, contributing to create barriers between them. Cultures (and religions) are still segmented. New forms of capitalism are created by putting in contact global markets with local business cultures.
60. Who is right in their perception of globalization, the hyperglobalizers (utopians) or the globalization Sceptics? Are the latter correct in not considering that globalization has made the world economy radically different from any international economy that has existed. Are

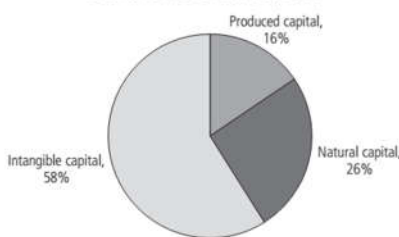
utopians just presenting fantasies and illusions as realities? Is the current globalized/international market rather orderly or disorderly?

61. Today's global economy is the result of (i) an unceasing stream of new technologies, (ii) unfettered market competition and (iii) weak or fractured social institutions. Since no one is in charge of the process, what ensures that it will not get out of control?

62. For low-income countries, the figures on the right show: (i) that having natural capital a larger share of total wealth than produced capital, managing natural resources appears to be a key strategy of a development policy; and (ii) that intangible capital (human capital and institutional quality) is the preponderant form of wealth.

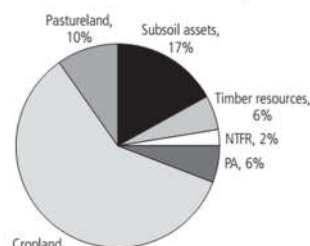
63. Why does religion (and superstitions) appear immune to the spread of material values and the exposition to scientific information? That this phenomenon points to an inherently insoluble social tension, with the potential of breaking the stability of a hypothetical global society? Are the Western values and ideas (rationalism, self-criticism, disinterested search for truth, separation of church and state, rule of law, equality before the law, freedom of conscience and expression, human rights, liberal democracy) morally superior to other values? [In *Drunk with blood: God's killings in the Bible*, 2010, Steve Wells counts the number of persons killed by God in the Bible. Using numbers provided in the Bible, the number is 2,476,636 (Satan, 10). His estimated total is that God killed 24,634,205 persons (Satan only 60).]

Figure 1 Shares of Total Wealth in Low-Income Countries, 2000



Source: Authors.
Note: Oil states excluded.

Figure 2 Shares of Natural Wealth in Low-Income Countries, 2000



Source: Authors.
Note: Oil states excluded.
NTFR: Nontimber forest resources. PA: Protected areas.

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