What’s Next for Key and Core Tech?

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The Universe is a complicated network that evolved out of the Big Bang to the human-dominated world we see today. Technology is a collection of natural or scientific phenomena that have been discovered and used by human beings. The combination and evolution of technology is forming a complex, self-organizing, and evolving scale-free network. Originating from a technological system, key and core technology is the cornerstone to boosting economic and social progress. To develop a more sustainably focused planet, key and core technologies will play an increasingly vital role.

It is a brief story of The Universe, the Earth, and ourselves.

The Universe is a scale-free network that is complex, self-organizing and evolving.1 It began with the Big Bang some 13.8 billion years ago. Galaxies, stars, and planets were created during a very long evolutionary process, and then by chance, life emerged on this big blue marble we call Earth. It was only a mere ~200,000 years ago that modern humans debuted.

In order to survive, humans learned to use fire, tools, and developed new skills to collect food and dominate the world around them. The brain also began to evolve. However, the constraints were obvious, that available resources could not keep up with the increasing demands for food and materials. When hunting and gathering could not meet existing demands, humans were forced to domesticate crops and animals, which set off the Agricultural Era. During this era of population expansion, plague, famine, war, and death were constant companions. Humans repeatedly faced a Malthusian Trap. With an accumulation of experience, mankind mastered a set of tools to study the laws of nature. In the Age of Exploration, international trade and The Enlightenment gave birth to the Industrial Revolution. Scientific and technological inventions, represented by textile machines and steam engines, ushered the globe into an era of unprecedented growth.

Accompanied by the development of research paradigms and academic communications, new branches of science and technology started to emerge. After continuous progress and self-organization, a complex and enormous knowledge system (KS) was gradually established, including a vast number of disciple-based societies, associations, and consortia.2 Subsequently, the economy was fueled by great technological innovations.3 Coupled with a rapid evolution in knowledge, products became more diverse and the division of labor increasingly specialized, thereby forming a complicated economic system (ES). On the basis of family, clan,
and cluster, villages and cities emerged, leading to organizations and class structures, which eventually resulted in a more complex social system (SS). Over the past 200 years, science and technology have re-shaped the ES and SS at breakneck speeds. On the other side, the advance of ES and SS has also contributed to the advancement of KS. The three systems, KS, ES, and SS, enjoy some overlap. Actually, they are interdependent, and KS is the central power on which all economic and social systems hinge.

Technology is constantly evolving. All new technologies are combined and integrated from earlier ones. The continuous combination and evolution of technology is forging a complex, self-organizing, and continuously evolving scale-free network. Complex networks without scales all conform to the Power Law. That is to say, few innovations have produced value, far exceeding other technologies. The role of these core technologies is unrivaled and critical. All key technologies in previous industrial revolutions showed a wide array of features, such as the steam engine in the first Industrial Revolution, electrification and the internal combustion engine in the second, and integrated circuitry and atomic power in the third. The key technologies have made their way into every aspect of our lives. Furthermore, several key technologies were developed based on this core innovation. The upgrade of technology led to dramatic increase in productivity that facilitated rapid social and economic advances.

How should we define such rare key technologies? After in-depth research and analysis, I put forth the concept of Key and Core Tech (KCT) in 2010. KCT refers to the key node and cornerstone of the technical system according to the Power Laws. KCT is based on scientific discovery and technological invention, forged through long-term scientific accumulation. KCT has higher technical thresholds and clear application scenarios, representing the most advanced level. The majority of technologies are descendants of earlier iterations of KCT, which will eventually lead to another industrial revolution.

KCT is distinct from other technologies. A technology that meets one or more of the following features is considered KCT. (1) The first is that it is revolutionary. KCT is generally a radically original technology accompanied by scientific accumulation. It is an out-of-the-box innovation that has the power to change the way we live. (2) The second is that it is essential. KCT has a strong industry-driving capability to drive economic development. (3)
The third is leadership. KCT was born to spearhead science and technology trends as well as generate a series of industrial clusters. In short, KCT is the cornerstone of the industrial chain. By combining it with other technologies, it can lead to tremendous breakthroughs.

KCT is a concept of dynamics and nonstop transformation. Each era had its own KCT that led to both an economic and social revolution. Under the current global model, KCTs are originating from optoelectronic chips, artificial intelligence, aerospace, biotechnology, information technology, new materials, new energy, quantum mechanics, as well as intelligent manufacturing. As the benefits of the third Industrial Revolution are fading, a new industrial revolution is on the horizon. Now more than ever, KCTs are a significant element to drive the current economy. It is my opinion that governments should pay more attention to scientific research and encourage integrative research on a raft of important issues. Furthermore, I do believe that the world should intensify its collaborative efforts to develop new KCTs.

In this connected world, no man is an island unto himself. With that in mind, what is next for humanity? Deeply integrating KS, ES, and SS is the destiny for KCTs. “Natural phenomena lie at the heart of all technologies.” Learning from nature, and then changing the world via KCTs is what our focus should be (Figure 1).

Declaration of interests
The authors declare no competing interests.

References
1. Spier, F. (2011). Big History and the Future of Humanity (Wiley-Blackwell Press).
2. Fortunato, S., Bergstrom, C.T., Börner, K., Evans, J.A., Helbing, D., Milojević, S., Petersen, A.M., Radicchi, F., Sinatra, R., Uzioni, B., et al. (2018). Science of science. Science 359, eaao0185.
3. Arthur, W.B., "Complexity and the economy." Science, 5411, 107-109.
4. Barabasi, A.L., and Albert, R. "Emergence of scaling in random networks." Science, 286, 509-512.
5. Barabási, A.L., Ravasz, E., Vicsek, T., "Deterministic scale-free networks." Phys. Stat. Mech. Appl., 299, 6.