**Disruptive innovation**

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The world is witnessing a huge change because of the onslaught of disruptive innovations that are completely uprooting conventional industries and establishing fresh industrial landscapes in the developed world.

A new world order is being set up based on technology-driven knowledge and economic transformations. Let us consider how carefully planned investments in science can extricate us from the present increasingly depressive scenario.

Artificial Intelligence (AI) and machine learning are revolutionizing numerous industries by automating tasks, enhancing decision-making processes, and creating new opportunities for innovation. AI encompasses a range of technologies that enable machines to mimic human intelligence, including learning, problem-solving, and adaptation. AI is predicted to have a huge economic impact of $15,900 billion within five years according to a McKinsey Global report.

By automating routine tasks, AI is already increasing productivity and efficiency across various sectors. In manufacturing, AI-driven robotics is streamlining production lines, reducing costs and improving quality. In finance, AI algorithms are being employed to analyze market trends and execute trades at unprecedented speeds, optimizing investment strategies.

Healthcare benefits from AI in diagnostics, personalized medicine, and administrative tasks, are reducing operational costs and improving patient outcomes. Advanced robots are increasingly used in manufacturing, healthcare, and service industries. In manufacturing, robots perform repetitive and hazardous tasks, reducing labour costs and improving workplace safety. In healthcare, robots assist in surgeries, patient care, and logistics, improving service delivery and patient outcomes.

An important emerging disruptive innovation is that of quantum computing. Combined with AI, it promises to change the entire civilization by solving complex problems in seconds that would take classical computers millennia. The advent of quantum computing will revolutionize industries reliant on complex simulations and data analysis. In pharmaceuticals, quantum computing accelerates drug discovery by simulating molecular interactions at unprecedented speeds, potentially reducing the time and cost of bringing new drugs to market. In finance, quantum computing enhances risk analysis and portfolio optimization, enabling more sophisticated investment strategies.

The deployment of 5G networks has begun to revolutionize numerous industries. Enhanced connectivity is enabling the Internet of Things (IoT) to reach its full potential, facilitating the development of smart cities, autonomous vehicles, and advanced healthcare solutions. In the manufacturing sector, 5G is supporting real-time data analytics and remote monitoring, thereby enhancing efficiency and productivity. The technology also drives innovation in entertainment, with augmented reality (AR) and virtual reality (VR) applications becoming more immersive and widespread.

Another fast-developing field that is disrupting many industries is that of advanced biotechnology. It encompasses innovations in genetic engineering, synthetic biology, and bioinformatics. These technologies manipulate biological systems to develop new products and processes, from genetically modified crops to personalized medicine. In agriculture, genetically modified crops are increasing yields, resistance to pests and harsh conditions, enhancing food security and reducing the need for chemical inputs.

In healthcare, biotechnology is enabling the development of targeted therapies and personalized medicine, improving treatment outcomes and reducing healthcare costs. Innovations like CRISPR gene editing have the potential to cure genetic diseases, further reducing the long-term economic burden of chronic illnesses. In agriculture, CRISPR can create crops that are more resistant to pests, diseases, and environmental stresses, leading to higher yields and reduced dependency on chemical pesticides.

The field of advanced materials is also progressing at a fast pace. These include nanomaterials, metamaterials, and bioplastics. They possess unique properties that enable new applications and performance enhancements in various fields. Advanced materials are driving innovation in industries from electronics to construction. Nanomaterials, for example, enhance the performance of electronic devices, leading to faster and more efficient gadgets. Metamaterials, engineered to have properties not found in nature, have enabled the development of advanced optics and telecommunications technologies.

In construction, advanced materials are contributing to improved building durability and energy efficiency. Smart materials can respond to external stimuli, such as temperature, pressure, or electrical fields, and change their properties accordingly. Smart materials have applications across numerous industries. In construction, self-healing concrete can reduce maintenance costs and extend the lifespan of infrastructure.

In the energy sector, hydrogen fuel cells promise to transform the energy and transportation sectors. They can generate electricity through a chemical reaction between hydrogen and oxygen, producing only water and heat as byproducts. They provide a sustainable alternative to fossil fuels, reducing greenhouse gas emissions and dependence on oil. In transportation, hydrogen fuel cell vehicles offer longer ranges and faster refueling times compared to battery electric vehicles, making them suitable for heavy-duty and long-distance applications.

The shift to electric vehicles (EVs) is transforming the automotive industry. EVs reduce the oil demand, which can stabilize global oil prices and reduce geopolitical tensions related to energy resources.

One worrying development that our armed forces need to be aware of is that of contaminated chips. Electronic chips can be a double-edged sword. If contaminated or compromised, they can be exploited to render equipment dysfunctional through remote signaling, posing significant risks to both civilian and military applications. In military applications, hardware Trojans embedded in electronic chips can be used to compromise defence systems.

One of the most well-known examples of remote manipulation through contaminated electronic chips is the Stuxnet worm, which targeted Iran's nuclear programme. Stuxnet exploited vulnerabilities in industrial control systems (ICS) to sabotage uranium enrichment centrifuges. Contaminated electronic chips and software vulnerabilities pose significant threats to critical infrastructure and security. Stuxnet, BlackEnergy, Triton, NotPetya, Havex, Industroyer, Shamoon, and Operation Aurora illustrate the diverse and evolving nature of cyber-physical attacks.

China's ‘Made in China 2025’ initiative aims to achieve self-sufficiency in high-tech industries, including semiconductors. By fostering domestic semiconductor production, China reduced its dependence on foreign chips, which may be more susceptible to contamination or tampering.

Despite the rapidly changing economic scenario which is now largely dependent on science, technology and innovation, Pakistan is on the opposite path aimed at destroying its higher education sector. This is illustrated by the fact that, while the operational budget of our public-sector universities has been frozen at Rs66 billion for the last five years, bringing them to their knees, the present government has decided to slash the budget to Rs25 billion. Sanity must prevail.

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minister. He can be reached at: ibne\_sina@hotmail.com