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Alimah Rehan

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Article

Analyzing Predictions about The Future of Manufacturing and Technology and Their Extension to India: A Social Shaping of Technology Approach

Alimah Rehan

Abstract

The twenty first century is an era of exponential change. It witnessed the boom of the IT sector, the development of digital technology and the rise of intelligent knowledge based machinery. Keen observers of the trends have predicted the coming of a Fourth Industrial Revolution that they say will disrupt society and production like no other revolution before. Smart factories will use smart workers to produce smart products. Early signs of this exponential change are visible in the new forms of work emerging from innovations such as Artificial Intelligence, 3D printing, biotechnology and robots. Work and society as we know is changing. The developed economies are already investing heavily in the deployment and use of this technology. They are the ones who are predicted to succeed. For others, it is argued, consistent and sustained growth lies in giving up their limited competitive advantage found in traditional technology and following the first movers. The new technology will determine the fate of society.

This paper challenges this assertion and puts forward an argument based on the Social Shaping of Technology Approach. Technology is not neutral. It is determined by the social, economic and political contexts in which it is embedded. Since most economies experience a unique mix of the socio-political, their experiments with industry and technology ought to be distinct. The article illustrates this through an examination of the Indian trajectory with industrialisation. It analyses the feasibility of the extension of western developed concepts about the future to nations which are still in the developing phase. Overall, the paper does not underestimate the developments in technology but underlines that their application is subjective to contexts.

Alimah graduated from Jesus and Mary College, University of Delhi in 2017 with a degree in Political Science. In 2018, she took up postgraduate studies at Alliance Manchester Business School at the University of Manchester in the sciences of Management.

The traditional classification of manufacturing is rooted in the production of industrial and/or consumable things. Both, the products and processes of manufacturing have been vast, spanning consumer categories, techniques and taxonomies.[1] Manufacturing serves as an umbrella sector for a gamut of industries ranging from energy and resource intensive commodities, chemicals and industrial equipment, semiconductors and electronics to consumer goods like textiles, apparel and furniture.[2] Likewise, process taxonomies vary from agile techniques, just in time production, lean production to additive manufacturing.[3] Therefore, manufacturing is not simple. Over the past decade, the relevance of industrialisation to the development index of nations became questionable as the world economy hit a speed bump caused by the 2008-09 recession, leading to a decline in the demand for factory output. Yet, the manufacturing sector remained crucial to economic growth of both the developed and the developing countries, as it conventionally nurtures massive Research and Development, generates innovation, fuels export and supports national market competitiveness.[4]

Today, the future of manufacturing is predicted along the successful adoption of new technology. It is asserted that industry is susceptible to exponential change due to the integration of digitisation and automation in business operations.[5] The onset of Fourth Industrial Revolution (4IR), a by-product of the 21st century, has introduced newer innovations at work. These include the block-chain, 3D printing, Artificial Intelligence, machine learning, biotechnology, bio-manufacturing, cybersecurity, high performance computing etc. Unlike the revolutions that preceded it, the 4IR is deemed to be the most disruptive one. It enables the convergence of physical, digital and biological technology, which can transform the production and use of products.[6] These will generate more digitally produced output in the future than before.[7] Additionally, to match the advancement in technology, workers today are being assessed for their intellectual and physical capital than their labour. This is where the revolution stands at the knife's edge - it has dramatically increased concerns about the mass displacement of labour. As machines will take over human jobs, it is articulated, millions of people will be left without work.[8]

However, most predictions about the future of work and technology fit the industrial models of the developed economies of the West and a few countries of East Asia. Innovations introduced with the onset of the Fourth Industrial Revolution adopted in these countries, it is presumed, will enhance their competitive advantage in the global market. Others are presumed to struggle in sustaining their traditional business models.[9] This is where the paper is positioned. It does not advocate or renounce technology

adoption as such, but questions the presumption around its neutrality. A systematic application of what worked in the West to what will work in the East has resulted in the theoretical rejection of industrial progress in the developing world.[10] This paper questions the casual assumption about the neutral nature of technology by analysing the placement of western pressure of technology adoption on a leading economy of the developing world-India. Firstly, it begins by understanding western academic, corporate and research based predictions about the future of manufacturing and technology in general and its extension to India in specific. It then assesses and highlights problems of extending this developed approach to the unique context of the developing world. The Social Shaping of Technology approach is next introduced to assert that technology is often socially determined. In the last segment, the approach is used to critique the predictions as only speculative, and to underline and magnify the sui generis socio-economic environment in which the Indian industrial sector is embedded.

This brings to the fore the core foundation of industry in the Fourth Industrial Revolution era -- machine consciousness.

Predictions About The Future of Manufacturing

India is not just expected to become the fifth largest manufacturer globally by 2020, it is also home to the second largest population in the world, a massive labour pool. The country's extremely strong demographic dividend adds to India's advantage in the industrial sector. India's Manufacturing Value Added was at US $420 billion in 2016, accounting for a 16-20% contribution to the country's GDP. The manufacturing sector in India has blossomed by 7% annually over the past three decades.[11] To add to this, with the Government of India's recent policy initiatives and the announcement of *Make in India*, optimism about the future of investment in domestic manufacturing has risen.[12] However, international predictions challenged this perspective with its own. A World Economic Forum Report (2018) terms India as a 'Legacy Country', with a strong production base but low levels of readiness for the future of production. It marked the economy as one which benefitted from the onset of globalisation as the country catered to the demands of cheap outsourced production by the developed world. India focussed on scaling production than amassing and inculcating complex techniques of the industry, an area where "leading" neighbours like China, Japan and the Republic of Korea first moved. The Report critiques India for failing to develop its 'drivers of production', including sustainable resources. This now positions the developing economy in

disadvantage as it risks losing traditional manufacturing to alternative *Nascent* countries, like Indonesia and Brazil, which offer cheaper labour to foreign investors.[13]

Other predictions come from the foreign developed corporate world. A member of the Big 4 companies, *PricewaterhouseCoopers* or PwC, asserts that India needs to adopt technology driven growth to stay afloat at its 7%+ rate of growth. Major challenges to technology in the nation are low compelling business reason to adopt innovation, infrastructural inadequacy and the lack of skilled workforce. A report by the firm highlights that while the contribution of Indian industry to India's GDP is at an average of 17% and celebrated, most strong manufacturing economies contribute consistently over 30%. Newer tech innovations like the Internet of Things (IoT), predictive maintenance practices, additive manufacturing and advancements in simulation may bring along breakthrough improvements in production efficiencies.[14] This is close to the general predictions about future of global manufacturing. An envisioned Industry 4.0 will feature smart integrative factories with equipment capable of exchanging information that will make the factory, in itself, a conscious entity, able to predict and control machines. Embedded with sensors and components which will be used to convey functional instructions to the customers and carry back real time feedback, the smart factories will produce smart products. This brings to the fore the core foundation of industry in the *Fourth Industrial Revolution* era -- machine consciousness. Intelligent machinery will discover knowledge, make independent decisions and deliver desired product.[15]

In the developing and underdeveloped countries on the other hand, most technical change is exogenous.

Even as it's enabling design principles and technologies are already being used in practice, Industry 4.0 is speculated to be the norm in the near future. It is seen as a potential phenomenon that will hit its mark, much like the internet revolution. Research, therefore, today reads more like warning papers, signalling manufacturers to prepare themselves to not just to take the hit, but to up their pace of action. A turbulent and hypercompetitive market is foreseen, where first movers into technology advancement are better positioned than those who follow.[16] Exponential technologies are deemed more essential for manufacturing today than ever before. They will enable change at an accelerating pace, disrupting processes and industries and creating opportunities for their users. It is believed that the introduction of such

technology will force competition on existing industries from non-traditional sources blurring industry lines and dissolving barriers to entry. The advantage lies beyond the product – there will emerge customer knowledge and proximity, access to crucial data in depth, et al. It is also pressed that agile players, even if they are small, by leveraging multiple exponential technologies will be able to scale up and outperform larger industrial competitors.[17] Among the technologies which will transform manufacturing are 3D printing or additive manufacturing, advanced analytics, advanced materials, robotics, artificial intelligence, Internet of Things, biotechnology, block-chain, etc. However, this exponential change is not only in productivity, output and outreach. When change is predicted in manufacturing led by the brilliant technologies of the fourth industrial revolution, it forces us to re-imagine the *what* (technology and automation), *who* (talent acquired) and *where* (physical location) of industry.[18] This paper looks at the*who* aspect of future work. It is assumed that as work and industry becomes more and more automated, smart technologies will take over most human jobs. Newer talent will be sought and acquired, altering the demand for skills sets and intellectual capabilities.[19] We explore the predictions about the human side of emerging future in greater detail in the sections which follow.

Problems with the Predictions

Even as these predictions about the potential exponential change in manufacturing led by advanced technology incite enthusiasm and optimism within industry, governments and the economy, they do not come without problems. In fact, the faults in these predictions are so embedded that one often finds her/himself blindly believing all that is presented as inherently obvious. The biggest challenge with these forecasts about the future of technology in/and manufacturing is their acceptance as being 'neutral'. In developed countries, technical change is often endogenous, meaning it comes up organically. New techniques and technologies are designed to match a system which is already in place and therefore tend to be appropriate for them. In the developing and underdeveloped countries on the other hand, most technical change is exogenous. It is created outside the system to match the need of a foreign socio-economic context. Technologies are heavily influenced by the social and economic institutions and technical environments for which they are developed. Their viability is best in those environments.[20] The gap in these predictions and their practicability lies here. A model established in the developed economies is extended as applicable to the developing economies. Even as their competencies, industrial capabilities and cultures differ

fundamentally, paradoxically any change brought about by technology is deemed neutral across them.[21] The application of regular tech-procedure from a developed country is assumed possible and plausible at a unit of a less developed country. Predictions are based on limited investigations which rarely study domestic technical knowledge generation in these nations.[22] Additionally, in the predictions stated above, we are able to trace most sources to consultancies and lobbying bodies. These reports by consultancies are often aimed at providing answers sought by their clients. It must be highlighted that their suitability to theory and pan-national practices is dubious. Sturdy (2018) points out that even in policy decisions, consultants play a strong role in the promotion of supply-pushed solutions than driving demand led results. This means, they tend to create the need for what they have to offer, politically.[23] To add to this, most consultancies are headquartered in economically developed countries today. For example, *PwC*, a company that emerged in New York, U.S.A., is today globally managed from London, United Kingdom. In reading reports from such organisations, one must be cautious about the physical and politico-economic environments where they emerged.

In analysing the research on the advent of the Fourth Industrial Revolution and the tech that brings it in, two major camps exist..[24] These are either the apparent pessimists, like Brynjolfsson and McAfee, who believe that with the automation and digitisation of work, current jobs will disappear. As machines take over human jobs millions of people will be left without work.[25] They fear mass human redundancy, which may nullify income, shrink consumption and accentuate economic inequality.[26] The other camp of the optimists looks at the positive side of the changes at work. It recognises the upheaval caused by automation, but argues that this brings the opportunity to liberate from some of the burden of work.[27] This camp argues that technology may in fact augment jobs since machines will facilitate human labour.[28] Overall, in the argument between the two camps on the effects of automating work and industry, one assumption is widely shared -- that technology will disrupt work and society as we know it. This extreme importance given to technology as being able to govern social life and work is termed as the 'technological determinism of society'. It is the tacit awareness amongst people that allows technology to be looked at as a crucial agent of change. For example, with the advent of computers, people, either voluntarily or involuntarily, incorporated the systems in their day to day routines - at home, work, supermarkets,

> **....more than technology determining life, it is often the societies that people live in which determine technology.**

banks, post offices, etc. They looked at technology as being capable of driving history, changing routine and causing important things to happen.[29] There is, however, a problem with the technological determinism of society-- it only contains partial truth.[30]

The Social Shaping of Technology Approach

Between the 1920s and the 1970s, two hundred overpasses and bridges were built in Long Island, New York. Unlike other overpasses in America, the height of these bridges was kept extremely low, with only 9 feet of clearance around the curbs. Langdon Winner (1977, 1980) argues that these two hundred overpasses were deliberately designed to reach a desired social effect by their master builder, Robert Moses. The low height of the bridges discouraged the passage of buses from under them. It marked a huge page in the American political history, as buses were mostly used by the poor and the African Americans then. Most of the higher classes and the white population chose personal automobiles over public transit. This careful designing of technology was aimed to achieve a purpose.[31] It reflected the expression of social bias and prejudice by its engineer, covered nobly in the name of connectivity, ease and development. This is where the Social Shaping of Technology (SST) is introduced. In their adoption, what matters often is not the technologies themselves, but the social or economic systems in which they are embedded. The social determination of technology contains the necessary wisdom which assesses the social circumstances of their development, deployment and use.[32]

As per a NASSCOM Report (2017), India has the world's third largest tech start-up base.

We cannot undermine the necessity and importance of technology in our everyday life. It matters to our biological and physical environments as much as to the way people live together socially. Yet, more than technology determining life, it is often the societies that people live in which determine technology.[33] This is not to say that in using the Social Shaping of Technology approach we decipher negative motivations. SST only underlines that some technologies cater to requirements of particular social circumstances, where they are more compatible with the needs of certain segments of society than others. The adoption of new technology is not only restricted to a change or advancement in science. Assuming that would be passive. Far more, in adopting new technology, organisations opt for its economic, political, cultural and technical value.[34] Technology is a social product. Recourse to SST is to bring to the fore an element which

lies at the core of this approach – choice. They may not necessarily be conscious choices. These choices, both in the design and the trajectory of technology or an artefact, lead to differing implications for societies and their social groups. More often technology is negotiable. However, it is revered as emancipating, a privilege which is inevitable and stands above the social order. This has led to crude forms of technological determinism which (a) sees the nature of technology and the direction of change as unproblematic, and (b) believes in the necessary impact of technology on work, economic life and society as a whole.[35] The apprehended displacement of labour fits in here. Applying the SST approach to the argument and accepting that technology is not neutral helps us in classifying the prediction about the future as a myth. Automation may replace jobs, it cannot kill work. As long as people decide its application, technology, robots and digitisation cannot fully substitute for humans. Yet, it is capable of breeding on existing inequalities.[36]

Having laid down the predictions about the future of manufacturing and technology, I introduce the SST approach to lay the ground for an analysis of the viability of the extension of these predictions to the Indian industries. India is known for its rich heritage, culture and diverse societies. The politics and social structuring of the nation are deeply rooted in its history and have guided the economic trajectory. Even today, they continue to play a pivotal role in the country's everyday functioning. It is only fair that we trace evolution of Indian industry through its socio-political unfolding over the years and analyse its future under the social shaping of technology lens.

The Feasibility of the Extension of the Predictions to India

The quest to become an Artificial Intelligence powerhouse is visible in India's recent politico-economic initiatives. The country is responding to the global call for technological shift and upgradation. The National Institute for Transforming India has launched a Centre for the Fourth Industrial Revolution in collaboration with the World Economic Forum, the pioneer organisation championing the cause of the revolution. India is looking at reforming its technology strategy and policy and creating an enabling environment for its beneficiaries.[37] As per a NASSCOM Report (2017), India has the world's third largest tech start-up base. The emerging Indian start-ups in IoT, Augmented Reality, Virtual Reality, block-chain, e-health and analytics are serving a huge international customer base. This consumer category includes sectors ranging from banking, e-commerce, e-health to global manufacturing.[38] In terms of technology consumption patterns in the Indian industries though, there emerges a full spectrum. As

per the United Nations Industrial Development Organisation, there are only a few production firms which stand close to the international frontier in terms of their process technologies and product designing capabilities. Manufacturing is a vast sector and covers a range of industries. Within India, we find almost all. Due to this diversity while

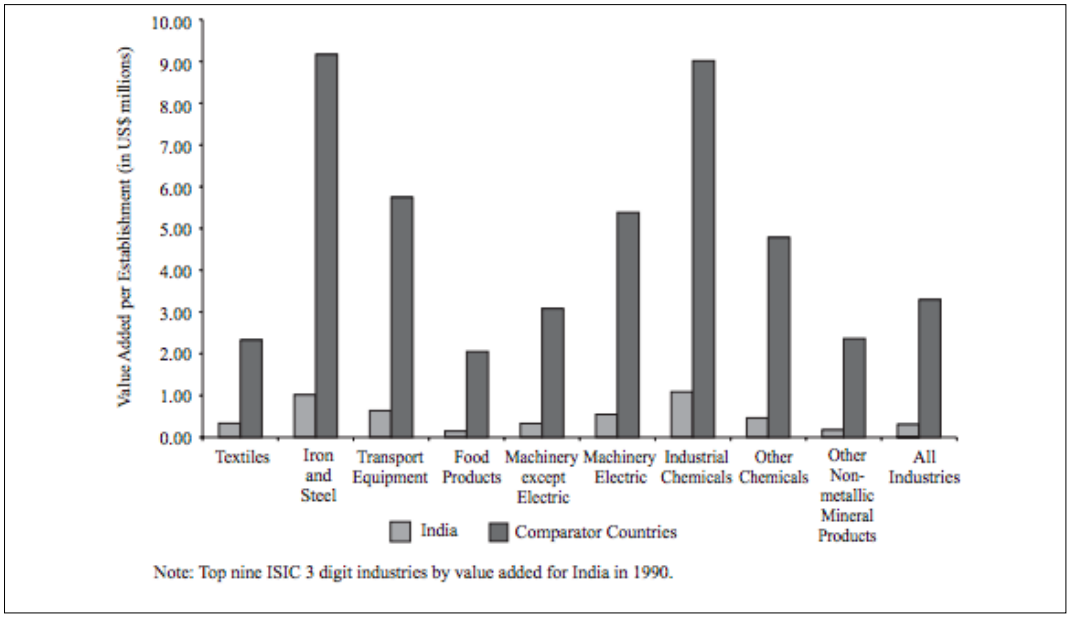

Figure 1: Average Firm Size in India and Comparator Countries, Rajan, 2009.

there maybe a few industries which are actively adopting new technology a large number of industrial units find themselves at the basic or intermediate levels of technological capabilities. These enterprises are perceived as hosting obsolete technology and infrastructure of inferior quality and face limitations in tech-growth posed by the heavy costs of new technology. Industries classified as having basic technological capabilities in the country include food processing, metal forming and forging, chemicals, electrical and electronics, and machines tools. Steel, pharmaceuticals, automotive and petrochemicals were classified under the intermediate capabilities category. It was only IT based and the telecommunications industries which are at an advanced level.[39] This enables us to deduce that while India may be a leading producer of technology, in terms of its own industries it may not be the biggest consumer of its own tech products.

If we trace Indian manufacturing to its inception we find ourselves treading deep into the modern history of India. India witnessed the beginnings of first class manufacturing way early in time, with automobiles and sleek sport cars produced by Tata, for example. However, India's experience with modern industrialisation is best

understood through its industry, technology and economic policies adopted since the 1950s.[41] Between the 1950s and the 1970s, the economy saw strong policy interventions in the form of import substitution and a great emphasis on the public sector. The attitude towards the private sector was not of complete neglect, but was significantly ambivalent. Investment in the private sector was restricted through a strict regime of licensing.[42] In terms of technology, in the protective environment of import substitution, Indian industry had to be built. This created the need for foreign technology to build industrial capacity. However, as competition from foreign producers was annulled, the incentive to upgrade or improve equipment or learn technical skills was scant. By the end of the 1960s, policy focussed narrowed to pursue self-reliance, which enhanced regulation and government control over trade and production, completely cocooning the secondary sector from global innovation.[43] Further, India did not have any incentive for developing technologies which could produce for international markets and, therefore, lost out on export competitiveness.[44] As a result of the mesh of protections, laws and licensing, the country's manufacturing sector became massively diversified in comparison to other developing countries. However, the establishments in India were far smaller than their counterparts abroad. So even as India had a vast range of industries, they were much smaller in size individually[45] (see figure 1). In continuation, today, India hosts a remarkable presence of 30 million Micro, Small and Medium Sized Enterprises (MSMEs), which contribute about 45% to India's total industrial output.[46]

Further, under the Scientific Policy Resolution of 1958, India established major institutions of technology and management. This produced a huge cadre of scientists and engineers. India became focussed on skill development and the promotion of its large scale public industries. However, it withdrew focus from its small scaled industries which absorbed a chunk of its labour force. The needs of the labour intensive small industries were distinct from those of the larger skill based units. As engineers and scientists participated in the bigger public bodies through their involvement in minimal research and development or moved abroad due to the limited absorbing capacity of Indian industry, small scale industries were found to be attracting labour pools which were largely technically unskilled. It is imperative for a labour-surplus economy to upgrade technical skills of its labour and invest in techno-management. The social shaping of technology unfolded as new and efficient technologies were discouraged and the limited technical manpower deteriorated.[47] India was ranked the fourth highest country in the availability of engineers and scientists. Yet, it was also ranked extremely low in its

ability to retain its qualified manpower, reflecting brain drain.[48] The nation stands as an unfortunate example of a society with adequate infrastructure to produce trained manpower and generate new knowledge, but with a liable dependence on imported foreign technology, especially after the 1990s.[49] Therefore, technological dynamism couldn't establish firm roots in India.[50]

A brief history of India's quest into industrialisation was stated above to analyse how applicable the predictions about the future of manufacturing and technology are to India. The social shaping of technology allows us to acknowledge that most societies will experience technology differently. India's industrial trajectory highlights that there exists a historical gap between the technology generation of countries which are developed and countries which are developing.[51] Even amongst economies which ventured into industrialisation together, stark differences appear due to the policy action and economic structuring they adopt. For example, India and Korea commenced their industrialisation processes as independent states within the same time frame. However, their chosen patterns of growth yielded distinct results for each. While India focussed on self-reliance and import substitution, Korea complimented import substitution with an export oriented strategy. It based its industries on innovation and initiated a liberal policy on technology licensing. Secondly, while Indian technical education was imparted largely through the higher public institutions, the comparator country invested heavily in universal primary education. Theorists iterate that universal primary education in Korea created the domestic absorptive capacity of technology. Finally, in terms of Research and Development, India curtailed innovation based development. In the formative years of its development, when R&D was still being adapted, India imposed heavy restrictions on technology imports. In Korea, on the other hand, technology imports were liberalised in the second phase of development, which facilitated rigorous R&D. Indian mentality before the 1990s considered this technology acquisition as substituting and discouraging domestic research and development.[52] India's considerable socio-economic and political stake in industrialisation is justified in its own merit and was intended to protect its small indigenous production units. The move cannot be undermined given the great presence of small and medium sized manufacturing units in India today. However, even after the economy was liberalised in the 1990s, the initial political action had already shaped the way technology would integrate within the Indian system. An empirical study conducted by Pradhan (2010) on the R&D investments by SMEs in the period1990-2008 suggests that R&D activities were never expanded markedly in the 2000s. In comparison to larger firms, the SMEs are not able to sustain financing for innovation and technology

upgradation as they are faced with competition from their larger counterparts. As compared to domestically owned SMEs, those manufacturing SMEs which are facilitated by foreign investments have higher intensity of research and development and therefore higher technology adoptive capacity.[53] This explains the inability of domestic factories in general to absorb new technology..

The Social Shaping of Technology in India is evident in the socio-politico context in which technology was introduced. India's experience with technology is visibly distinct from its competitors and from the first movers into industrialisation. Therefore, I contest the extension of the predictions about the fourth industrial revolution to India. It is a leading economy, however its competitive advantage lies in its demographic dividend and its possession of a huge labour pool.[54] It did not experience the other three industrial revolutions simultaneously with the world. A report by the Prime Minister's Task Force on MSMEs (2010) suggests that to facilitate scaled production with technological upgradation, India must apply lean manufacturing, Quality Management Standards and Incubators, et al., through its small and medium sized domestic production units.[55] These are industrial schemes from 20th century Europe and Americas, some introduced as early as the 1910s! Further, the success of the technologies that announce the coming of the 4IR, is only speculative. These are predictions which are *deemed* to work. In fact, there are debates going on about the future of technology - be it the block-chain, artificial intelligence, additive manufacturing or robots – within the developed western society. These are the places for which the exponentially abled technologies are created. . That this technology can be introduced, used and expected to yield the same outcomes in a developing country like India, is therefore only ideational at present..

Conclusion

The world holds onto the speculations about the success of technology and its implications for society as a prophecy which is meant to come true sooner than it is ready for it. There is nothing wrong in the development of technology, its application at work and accepting its necessity in everyday life. The problem is in accepting its reverberation as being neutral across social, economic and political contexts. In the context of manufacturing, a sector which has dominated its position in economic structures over the past few centuries, it is deemed as natural for industry to absorb and use ground-breaking results of contemporary research and development. In fact, the ability to promote innovation and welcome exponential technology is seen as the hallmark of future industrial growth, especially in the era of the coming Fourth Industrial Revolution.

The first drawback of this perspective is that it is founded in speculations. The truth is that the argument that a Fourth Industrial Revolution will alter work, nullify jobs and establish a machine led production system is, but, a conjecture. Secondly, the fault in this proposition, augmented in the developed world, is that it is presumed to be neutral across socio-political and economic contexts.

As history has demonstrated, technology and its application is not neutral. More than technology determining the future of society, it is in fact technology which is sui generis to the environment in which it is introduced. The Social Shaping of Technology approach brings out that technologies cater to those social circumstances and structures where they are more compatible. The application of this approach to the trajectory of Indian industrialisation highlights the unique experience of the country with technology, given its distinct set of policies after Independence. India's strict licensing and tax regime of the 1950s to the early 1980s to protect its indigenous industries carved the way technology would be adopted and used in its factories even after the liberalisation of its economy. A comparison with Korea establishes that two countries within the same time frame can adhere to innovation and technological development in distinctly unique ways. Therefore, the paper contests the extension of the predictions on the future of manufacturing and technology and the consequent exponential changes in the developing world. Change is the product of conscious decisions by people. As long as people govern inconsistent societies, the future of technology and manufacturing will be inconsistent across the world.

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