Within the last two centuries, technology has emerged as a key driver of global economic growth. It has redesigned international competition in all major industrial sectors by enabling speed, efficiency and capacity in business processes and operations. It has become the most important enabler of national wealth creation and productivity. As the world moves towards knowledge-based economic structures and data-driven societies, made up of networks of citizens, organizations and countries, mutually and interdependently linked globally, the impacts of technology will remain central in commerce, industry and culture. Both in the short and long terms, this global technological progress—improvements in the techniques by which goods and services are produced, marketed, and brought to market—will remain at the heart of human progress and development. And the pace of technological innovation will continue to accelerate, disrupting markets and industries, along the way.

Increasingly, the world is experiencing major new dimensions in knowledge acquisition, creation, and dissemination. The trend has become a virtuous circle where new ideas facilitate new processes and tools which in turn drive new concepts. This progress has advanced to the point where researchers are able to work at the levels of atoms and molecule, evolving a new field, called nanotechnology. Nanotechnology is the science of minuscule molecule or a wide range of technologies that measure, manipulate, or incorporate materials or features with at least one dimension between approximately 1 and 100 nanometers (a nanometer is one billionth of a meter; the width of an average human hair is about 100,000 nm). At this scale, the laws of quantum physics supersedes those of traditional and classical Newtonian physics, and materials change yielding to unique characteristics in chemical reactions, electrical, and magnetic properties. Nanotechnology offers the closest means to manipulate matter and life whose building blocks are at nanoscale.

Nanotechnology is a transformative technology and has the ability to bring about changes that can rival the Industrial Revolution of the late 18th and early 19th centuries where mechanization of industry, changes in transportation and introduction of steam engine had a profound effect on the socioeconomic and cultural conditions in the world. Heralded to underpin a new global turning point in human society, nanotechnology “has the potential to fundamentally alter the way people live”. But it is not completely (scientifically) proven, still growing with only few nanostructures at commercial productions. In most cases, precision is lacking and controls are difficult with many of the concepts not economically viable with the present body of knowledge. It poses environmental and health challenges, though it can also be used in combating pollution and other environmental hazards by enabling advanced water purification and clean energy technologies. Its impact will be profound in medicine where it is leading many innovations; for instance, in situ nano engineered robots (as small as pills) offer the prospects for better medical diagnosis. The technology is broad with convoluted ethical and safety issues.
Nanotechnology is estimated to grow in excess of $1 trillion global market by 2015 with energy, textiles, and life sciences the leading sectors transitioning from labs to markets. This technology will drive a new global economy, nanomics or nanotechnology-driven economy and usher in a revolution that will advance genetics, information technology, biotechnology and robotics through low cost, high utility and high demand of its products.

While nanotechnology is an evolving technology, microelectronics has relatively matured. Microelectronics is a group of technologies that integrate multiple devices into a small physical area. The dimension is about 1000 larger than nanotechnology dimension; micrometer vs. nanometer. Usually, microelectronics devices are made from semiconductors such as silicon and germanium using lithography, a process that involves the transfer of design patterns unto a wafer. Products are called ICs, chips, microchips or integrated circuits. They are found in computers, mobile phones, medical devices, toys and automobiles. Contemporary, the world lives in the era of microelectronics as everything is enabled by microchips. Its impacts, arguably, are unrivalled in the human history. As engineers make the transistor sizes smaller to improve performance and reduce cost, microelectronics begins to converge with nanotechnology. This advancement comes at a huge price as power dissipation and noise in chips increase- potential limiting factors that could stall further progress in the industry unless novel architectures, materials and processes are developed. Possibly, nanotechnology could address many of these challenges as microelectronics transmutes into nanotechnology. Indeed, the ETC Group notes that “with applications spanning all industry sectors, technological convergence at the nanoscale is poised to become the strategic platform for global control of manufacturing, food, agriculture and health in the immediate years ahead.”

Together, nanotechnology and microelectronics are the engines of modern commerce, and are directly or indirectly enabling many revolutionary global changes. Whenever there is advancement in their performances, a dawn emerges in global economy bringing improvements in all areas of human endeavors. Yet, despite these pervasive impacts of these innovations on daily lives and businesses, the technologies have not diffused globally. Patents, academic journals and other metrics for ascertaining technology creation and innovation indicate that advanced nations dominate the creative sectors of these technologies and the global diffusion trajectory will flow from them to other parts of the world. This implies that the prospects of transferring these technologies around the world will involve an adoption and diffusion strategy from developing nations which lack inventive capability to create technology. Records show that in many previous efforts, these nations have failed to absorb new technologies effectively. However, owing to the expected impacts of nanotechnology, the abilities of developing nations to adopt and drive penetration in their economies will affect their economic viabilities in the long-run.

This book is written to assess the state of nanotechnology and microelectronics, and emerging technology in general. While some aspects focus on nanotechnology and microelectronics, others discuss technology transfer and diffusion within the generic technology context with no specific distinction. It examines many issues, climate change, trade, innovation, diffusion, etc, with a theme focused on facilitating the structures for the adoption and penetration of the technologies into developing nations. The problems which continue to undermine technology progress in developing nations along with suggestions that can accelerate progress are examined. The strategic importance of moving from dependence on minerals, commodities and hydrocarbons to nations that thrive on knowledge anchored on technology is emphasized. It is almost certain that nanotechnology will exacerbate the economic divide between the advanced and poor nations unless the latter develop new pragmatic technology policies. This book shares some insights from various experts on what these policies could be for a reliable, sustainable and profitable nanotechnology era.
The technologies are capital intensive and the returns are not immediate. In short, there exists a level of uncertainty in nanotechnology as many of the discoveries cannot be economically commercialized, at least with present technology. This calls for tripod partnerships among governments, firms and academic communities in structuring policies and mapping the technology roadmaps. Around the world, even in developed nations, governments have played and continue to play major roles in accelerating innovations in nanotechnology and microelectronics. The developing nations must not be on the illusion that market forces alone can drive development in these areas. They lag well behind in both the technology creation and dissemination and spirited efforts must be made to facilitate adoption and improvements in the business environments.

Consequently, government interventions on infrastructure, education and business climate for these ultra knowledge-driven technologies must be paramount in national developmental plans. Critics argue that developing nations should focus on spending their limited resources on mundane activities like food production and water supply instead of investments in these emerging technologies. The problem with that argument is that food production, water supply and others are driven directly or indirectly by these technologies. Microchips continue to improve crop yields by enabling better sensors while water purification has a future anchored on nanotechnology. In this century, it makes no sense to separate activities from technology because technology leads the world and only those that invest and develop it will prosper. Investments in technology will bring progress and presence of technology clusters will continue to influence global technology diffusion trajectory. It is a continuum, where the presence of one technology enables another. Nanotechnology investment today could lead to breakthroughs in energy and food security tomorrow.

Nonetheless, nanotechnology must not be viewed as a fix to all the technology problems in the developing world; in other words, it must not be adopted without examining alternatives or immediate needs which may be more appropriate to the particular nation. Cautious and systematic approach is needed as these nations develop plans for the adoption of any aspect of nanotechnology or microelectronics. Without this strategy, the technologies may not be sustainable as previous technology adoption efforts have shown. For many developing countries, provision of power supply to their industries will be the beginning of wisdom as inadequate electricity remains a major reason for de-industrialization, especially in sub-Sahara Africa. By focusing on the basics and improving industrialization climate, conditions for high-tech economy will be nurtured.

This book explains how technology and technological progress are central to economic and social well-being, and why the creation and diffusion of goods and services are critical drivers of economic growth, rising incomes, social progress, and medical progress. It notes that political climate, corruption, stifling business environment, poor infrastructures, lack of innovation culture, poor economy regime, along with low technology literacy are major challenges which must be overcome. While the world discussed digital-divide in the information technology era, the future will potentially will be nano-divide. The reasoning is that nano will continue to enable economic concentration in developed nations (holders of core patents with economic rights) and developing ones will find it increasingly difficult to transition from their present states. It is up to developing nations to observe that global powers and respects are not won by gun powers anymore, rather by economic prosperity driven by technology creation.

Besides, with lack of innovation in developing nations, the disruption of global economic systems by nanotechnology can harm the developing nations since they lack the resilience and fluidity to react to market and industrial changes. The prospect of nano-weapons could be a concern in the hands of these unstable developing countries as they can self-destruct or destroy neighbors. Terrorism could escalate
to a level not imagined, not just in the developed world, but globally as nanotechnology will make it
easy to terrorize with devastating global impacts. The world could be visited with arms race and nuclear
anti-proliferation could be relegated to the background with anti-nano (weapon)-proliferation upfront. If
nanotechnology products could affect trade patterns with replacements of raw materials, the developing
world would be the most affected as poverty could increase. Displacing their exports will increase global
unemployment and that can pose global insecurity. The world within the last few centuries have depended
on the raw materials of developing nations to sustain civilization, if nanotechnology can replace the
needs of those materials, monumental upheavals could result in these countries with (soon) worthless
cotton, copper, and rubber. Simply, the prospects of nanomaterials pose a huge security implication in
the developing world.

Across the globe, many nations have developed initiatives towards transitioning discoveries to markets.
Just like in the Industrial Revolution, which took half a century to come to fruition, nanotechnology is
expected to advance overcoming many of the technical challenges that presently stall commercialization
of many of the discoveries. As its standardization and safety improve along with ethical regulations, the
global ‘innovation economy’ with be revamped. The new economy will witness new breakthroughs in
computing where performance can be increased exponentially even at decreasing cost. Early detection
of tumors, efficient and cheap solar cells delivering vast amounts of energy, effective HIV/AIDS preven-
tion control, and hosts of other applications will be made possible. These impacts will be ubiquitous and
most likely will be gradual and evolutionary, rather than very sudden. A look into the future of nano-
technology and microelectronics shows that any nation that fails to develop programs aimed at tapping
their enormous benefits will compete internationally at disadvantaged positions. It will be catastrophic
to misunderstand that Technology leads the world and mastering the process of creating, enabling and
commercializing technology is one of the most important duties of any modern parliament or congress.

One major goal of this book is to highlight multifaceted issues surrounding nanotechnology and
microelectronics and technology in general on the basis of economics, innovation, policy, transfer, and
global penetration through comprehensive research, case studies, academic and theoretical papers. More
than forty five experts spread in about twenty countries with its respective understanding, perspectives
and resources provide a very broad audience to accomplish that. This book will be a useful reference for
academics, students, policy-makers and professionals in the field of technology economics.

This book is organized into six matrixed sections. Section 1 is focused on the foundations and the
science of nanotechnology and microelectronics. The first chapter discusses the science, trends and global
diffusion of nanotechnology and microelectronics, highlighting some of the historical advancements in
the technologies. The manufacturing process, molecular manufacturing, which is structured for building
nanosystems, is explained in Chapter 2.

Section 2 focuses on technology transfer, diffusion and innovation in the contexts of both nations and
organizations. Chapter 3 explains the latest trends in nanotechnology knowledge creation and dissemina-
tion, and Chapter 4 shares insights on collaborations in the age of open innovation. Chapter 5 discusses
Kondratieff cycle of nano revolution with Chapter 6 explaining how economic agility of nations could
affect capacity building for technology resilience and diffusion. Then Chapter 7 points out that fatigue
could occur in diffusion of innovations especially in adopter nations.

Section 3 examines the industry, policy and experiences from nations and institutions. Chapter 8
highlights the case of a university in Sydney on firm innovation and university-industry networks. Chap-
ter 9 discusses licensing and R&D, and Chapter 10 outlines nanotechnology industry entry barriers in
Turkey. In Chapter 11, micro and nanotechnology maturity and performance assessment are discussed.
Section 4 considers the ethics, regulation, environment, and climate control challenges. It begins with Chapter 13 which examines the diffusion of the clean development mechanism. Then Chapter 14 looks at the intellectual property rights challenges under information and communication technologies, nanotechnologies and microelectronics. Chapter 15 discusses how the global south could benefit from climate finance, technology transfer and effective climate policies. It is followed by Chapter 16 that highlights emission distributions in post-Kyoto international negotiations, and Chapter 17 that outlines the ethical concerns in nanotechnology.

Section 5 examines some lessons within agriculture and agricultural technology which could be helpful for many developing nations adopting technology. Agriculture being their mainstay, it is natural they can relate to this industry. Chapter 18 discusses how the industry has moved from biotechnology to gene revolution and asks if nano revolution is the next for agriculture. Chapter 19 sees the patterns within the industry and connects them with adoption and development. In Chapter 20, the author gives lessons on technology development and transfer drawing from agriculture, and finally Chapter 21 discusses technology transfer and diffusion in developing economies from the perspectives of agricultural technology.

In the final Section 6, regional developments are highlighted. Its first chapter, Chapter 22 shares very comprehensive insights about nanoscience and nanotechnology on Latin America, covering Chile, Argentina, Mexico, and Brazil. Subsequent chapters are devoted to Africa. They are technological innovation and the continent’s development in the 21st century (Chapter 23), and emerging technology transfer and policy (Chapter 24) which has four sub-chapters: thoughts on nanotechnology transfer, sustainability and management challenges, factors affecting nanotechnology and microelectronics transfer, and recent polices on science and technology. Others are trade policies and technology development (Chapter 25) and finally in Chapter 26, a technology penetration national case study.

In conclusion, it is important to note that penetration of nanotechnology and microelectronics into developing nations will not just benefit them alone; it will help to accelerate market growth for advanced nations that drive the industries. Technologies will remain major catalysts for wealth creation to nations that create and commercialize them. For developing nations that merely consume, lacking inventive capability and depending on minerals, commodities and hydrocarbons, it is very imperative they change strategies because if nanotechnology era goes as heralded, economically, these nations could be imperiled. Just as R. Wright noted, “Society becomes increasingly non-zero-sum as it becomes more complex, specialized, and interdependent,” the whole concept of globalization is not win-win by default because knowledge and technology disparities exist. It is still early for any nation to get into the nanotechnology business by building its capacity- one that will be used to access national competitiveness in the near future.

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