1

Technological Change and Economic Transformation

Musa Jega Ibrahim
Economic Research and Policy Department,
Islamic Development Bank, Jeddah
Kingdom of Saudi Arabia

1. Introduction

Technological change is a term used to describe incremental change in the quality and quantity of knowledge and ideas that are applied in the stream of activities to enhance the social and economic well being of the society. Due to the positive nature of the implied change, it is also referred to as technological progress. Technological change occurs through the process of invention, innovation and diffusion that leads to the transformation of ideas and knowledge into tangible products that have high utility value to human needs. The effect of technological change propels economic transformation; a change in the structure of an economy over time from a lower, rudimentary and subsistence level to a higher and more sophisticated level of economic activities. Thus, economic transformation is the attainment of significant high level of economic growth above previous levels with capacity to sustain it through self-perpetuating economic activities that are associated with industrial and post-industrial production activities[1].

Economic transformation stems from high sustainable economic growth that feeds from, and into technological change. While the acquisition and application of technology is a key factor in achieving economic transformation, economic activities are in turn, veritable source of technological progress. Hence, economic growth, economic transformation and technological change are intervolving activities that reinforce each other. This three-dimensional relationship reflects in the definition of economic growth as a long term rise in capacity to supply increasingly diverse economic goods to the population based on advancing technology and the institutional and ideological adjustments that it demands (Kuznets, 1971).

Real productive activities engender economic growth by ensuring a continuous improvement in the methods of production, discovery of new resources and thus creating the necessary conditions for efficient utilisation of resources. Resources, in their natural form, have limited direct economic use in satisfying human needs but transforming them into goods and services enhances their economic value to the society. The process of transforming resources involve substantial mix of ideas (technology) with other factors of

[1] Some have ascribed ideological connotation into the term thus referring to economic transformation as transition from centrally planned economies towards open market economies.

production such as land and labour, in addition to other resources from different activity sectors of the economy. A multiple sector positive performance is essential for the growth of the overall economy, but a sector of the economy that attracts large spectrum of economic activities can stimulate the productive fibre of other sectors towards real production and provide the requisite impetus for sustainable growth of the economy. This requires the catalyst of technological application and thus underlining the essence of technological change as a critical determinant of economic growth and by extension, economic transformation.

In general, sources of technological change are innovation, direct acquisition from purchase, learning-by-doing, Research and Development (R&D) and transfer through interactions of economic activities between two countries (technology transfer). Experiences of economic development of countries indicate that, acquisition and application of technology depends largely on economic circumstances and natural endowments of countries, nevertheless it is imperative for all economies to adapt to technological change to inspire economic transformation that springs into high sustainable growth and prosperity.

In the remainder of this chapter, section 2 highlights the perspectives of economic growth theories on the relationship between technological change and economic growth. Section 3 analyzes the dimensions of technological change and economic transformation and section 4 articulate measures for fostering technological change and economic transformation.

2. Perspectives of economic growth theories

2.1 Overview

Economic growth occurs through the transformation of resources into different forms of use involving the interactions of variables such as demand, supply, wages and prices. Basically, economic growth is driven by a process that is generated and sustained by the efficient utilisation of economic resources to meet effective demand and social needs. Increase in the outputs of major sectors of an economy, especially manufacturing, due to increase in the use of inputs or improvement in technology, leads to economic growth. Progressive increase in the outputs of major sectors of an economy that stems mainly from efficient utilization of economic resources and through the effective use of technology leads to high and sustainable economic growth, a *sine qua non* for economic transformation.

From the theoretical literature, economic growth process is based on intricate interaction of variables relating to the basic components of the economic system. The basic ideas of modern growth theories are based on competitive behaviour and equilibrium dynamics, diminishing returns and its relation to the accumulation of physical and human capital, the interplay between per capita income and the growth rate of population, the effects of technological progress as increased specialization of labour and discoveries of new goods and methods of production and the role of market structure (monopoly and/or competition) as an incentive to technological advancement.

Economic growth theory has evolved over the years leading to different cluster of economic growth theories based on ascription to common principles in their strands of analysis of economic growth. Even though there are several of these cluster of economic growth theories, modern economic growth analysis are dominated by the neoclassical and endogenous, which are regarded as the two broad classifications of economic growth theory (McCallum, 1996). Each of these broad categories of theory has variants of economic analysis and they all converge on the critical role of technological change as the driving force of high and sustainable economic growth.

2.2 Neoclassical growth theory

This cluster of economic growth analysis was inspired by the earlier works of classical economists but the Solow and Ramsey-Cass-Koopmans (RCK) models have emerged as the most recognized neoclassical economic growth theories. They underlined the effects of technological change on increased specialization of labour and discovery of new goods and methods of production in a self-perpetuating process of economic growth. They are built on the basis of the idea that a given level of natural resource requires the use of labour, capital and the "effectiveness of labour" (technology) to spring-up a production process. At any given time the economy has some amounts of capital, labour and knowledge that are combined to produce a given level of output, implying that changes in input over time leads to changes in output correspondingly. Regardless of the levels of any factor of production, technological change is the only factor that can change per capita long-run growth rate of an economy. Hence, the "effectiveness of labour" (knowledge or technology) is the fundamental determinant of high level of sustainable economic growth.

There are four variables of production; output *(Y)* and three inputs; capital *(K)*, labour *(L)* and "knowledge" or the "effectiveness of labour" *(A)* that enters a production function of constant returns to scale in the form:

$$Y_{(t)} = F(K_{(t)}, A_{(t)}L_{(t)}) \tag{1}$$

At any point in time *(t)* the economy has some amounts of capital, labour and knowledge that are combined to produce a given level of output. Change in input over time leads to corresponding change in output. Based on the multiplicative effect of technology *(A)* and constant returns to scale, it is possible to denote k as capital per unit of effective labour and y as output per unit of effective labour leading to intensive form of the production function as follows:

$$y_{(t)} = f(k_{(t)}) \tag{2}$$

The growth rate of labour is represented by n, that of knowledge (technological change) by g while δ represents the rate of depreciation of capital. Moreover, output is partly consumed and partly saved at any given point in time, which give rise to the formation of change in capital stock as:

$$\dot{K}_{(t)} = sY_{(t)} - \delta K_{(t)} \tag{3}$$

In intensive form and using the definitions of n, g and δ, change in capital stock per unit of effective labour can be expressed as:

$$\dot{k}_{(t)} = sf\left(k_{(t)}\right) - \left(n + g + \delta\right)k_{(t)} \tag{4}$$

$\dot{k}_{(t)}$ is the rate of change of the capital stock per unit of effective labour
$sf(k_{(t)})$ is the actual investment per unit of effective labour, and
$(n+g+\delta)k$ is break-even investment

According to (4), the rate of change of the capital stock per unit of effective labour at any time is the difference between actual investment per unit of effective labour and the break-even investment. The break-even investment is necessary for two important reasons; to replete the depreciation of existing capital and to respond to growing quantity of labour to sustain or enhance its effectiveness. For the break-even investment to be adequate to match this requirement, it must be equal to the sum of depreciation rate and the rate of growth of the quantity of effective labour $(n+g+\delta)$.The capital stock per unit of effective labour will be rising whenever actual investment per unit of effective labour, $sf(k)$ exceeds the break-even investment, $(n+g+\delta)$ and vice versa, and when the two are equal, capital stock is constant.

The economy, regardless of its starting point, eventually converges to a balanced growth path, where all the variables grow at a constant rate and at this stage, the growth rate of output per worker, a key measure of economic growth, is determined only by the rate of technological change. Changes in all other variables, apart from technological change, will only lead to a shift in the level of the balanced growth path.

The key conclusions of the neoclassical growth analysis implies that, differences in capital per worker (K/L) and differences in the effectiveness of labour are the two main sources of variations in economic growth over time and across countries. However, only the changes in effectiveness of labour, which occurs through technological change, can generate permanent growth. Significant changes in saving have only moderate effects on the level of output per unit of effective labour on the balanced growth path, but not on the growth rate of the economy. Capital per worker influences output per worker, so a country that saves more of its output has more capital per worker and hence more output per worker but requiring the strong effect of technological change to stimulate high sustainable growth of the economy.

2.3 Endogenous growth theory

The main motivation for endogenous growth theory is to identify how technological change can occur from economic activities, rather than exogenous factors adduced by the neoclassical economic growth theory. Technological change evolves from the interplay of economic forces in a two-way interaction between technology and economic life. Technology is a by product of innovation, which is nurtured by rational economic behaviour; but technology also transforms economic life in turn. Ideas are the root of technology, which can be obtained from the production process as factors of production, especially labour, tend to learn and know more through engagement in production activities and seek to improve over time. This facilitates technological change through learning-by-doing. Incentives for high share of markets motivate firms to invest in Research and Development (R&D) to build on learning-by-doing advantages to bolster the momentum of technological change that leads to improvements in quality of products and emergence of new products.

Endogenous technological change emanates from three main sources; accumulation of physical and human capital, learning-by-doing and R&D. A firm that increases its physical capital learns simultaneously how to produce efficiently due to technical knowledge embodied in new capital goods. Each time a capital good is produced, the experience of producing it generates new insights to both the particular production sector and to the economy in general. It implies that investment and production makes use of ideas and also obtains additional ideas through the positive effect of production experience, thereby eliminating the tendency for diminishing returns of factors of production, making it possible for technological change to occur as intended or unintended by-product of investment. Hence, technological change is endogenous because it evolves from the operations of the economy.

Absence of diminishing returns to capital makes it possible for per capita growth to occur in the long-run driven by technological change that emerges from economic activities. There is one-to-one relationship between output and inputs due to constant returns to scale. One unit of either physical or human capital input leads to one unit of (additional) output. The non-diminishing marginal product of capital give rise to production function of the form:

$$Y_t = A_t K_t \tag{5}$$

A is a positive constant reflecting the level of technology. In intensive (output per worker) form:

$$y_t = Ak_t \tag{6}$$

K is conceived broadly to encompass physical and human capital, knowledge and public infrastructure. The growth rate of investment per unit of effective labour is in the form:

$$\frac{\dot{k}_t}{k_t} = \frac{sf(k_t)}{k_t} - (n + g + \delta) \tag{7}$$

Due to learning-by-doing and other associated positive externalities, this prevents the marginal product of capital from diminishing, hence the production function of the form:

$$Y = F(K_i, A_i L_i) \tag{8}$$

Several firms engage in investment based on this production function. An increase in a firm's capital stock leads to a parallel increase in its stock of knowledge through learning-by-doing. Each firm's knowledge is assumed to be a public good, so other firms can gain access to it at zero cost. This implies that knowledge spills over onto the entire economy so each firm's discovery of new knowledge (technological change) is a reflection of the level of technology of the overall economy and is therefore proportional to the change in the aggregate capital stock. Learning-by-doing and knowledge spillovers make it possible to replace A_i with *K* and for the production function to be written in the form:

$$Y = F(K_i, K.L_i) \tag{9}$$

Each firm expands its capital stock, $K_,$ in the process of production, so *K* rises accordingly and provides a spillover benefit that raises the productivity of all the firms, thereby generating endogenous growth. Each firm's increase in its capital stock adds to aggregate capital stock, and hence contributes to the productivity of all other firms in the economy.

Activities of government through its functions of public expenditure for the provision of infrastructure services, the protection of property rights as well as taxation policies have implications for technological change. Assuming there is no population growth and based on the activities of government, the aggregate production function will be in the form:

$$Y_t = AL_t^{1-\alpha}K_t^{\alpha}G_t^{1-\alpha} \tag{10}$$

This exhibits constant returns to scale in the private inputs, *L* and *K*. If G (government expenditure) is fixed, there will be diminishing returns to capital accumulation, *K*, except if *G* rises along with *K*. This implies that public services are complementary with the private inputs in the sense that an increase in G raises the marginal products of labour and capital while the exponent of G (1-α) determines the extent to which G impacts on technological change to drive economic growth. For instance, if the exponent of G is less than (1-α), there will be diminishing returns to K and G and this will stultify technological change and by extension, endogenous growth.

Technological change is further enhanced when firms, driven by profitability, invest their resources in R&D leading to either quality improvement or variety expansion. Technology is regarded as a private product, so investors enjoy some level of preservation either because of the possibility of secrecy or acquisition of patent rights. Innovation leads to new products either in quality or variety, so innovators exploit some form of monopoly power. It is assumed that there are no bounds to new ideas, so there is no diminishing return in the creation of technology.

The final output and the R&D sectors as well as the labour market are assumed to be competitive, but the intermediate goods sector that provides inputs to the final goods sector is based on blueprints from R&D (knowledge). As R&D success leads to a new "state-of–the-art" version of the products through innovation, an existing product is replaced by an improved version of it or completely different version rendering it obsolete. Since the newly invented product will be available in the market, other researchers can examine its characteristics and learn knowledge embodied in it and use it for further research that could lead to further innovation of an improved version of it. This is a case of knowledge spill-over, which brings to the fore, the non-rivalry and non-excludability attribute of knowledge. This process is described as "Quality-Ladder" phenomenon or "Creative Destruction" (Schumpeter, 1975).

2.4 Inferences and deductions

The analytical building blocks of the two main economic growth theories (neoclassical and endogenous) implies that, a baseline technology is a key input that provide an initial condition for appropriate mix of factors of production. This lends credence to the fact that, it is the value-adding capabilities of the factors of production as a result of their effective use in production process that generates economic growth. Even though they both underline the essence of technological change as the driving force of economic growth, they differ on the sources and mechanisms through which technological change occur to impact on economic growth. The neoclassical theories subscribe to an exogenous (external) technological change effect while the endogenous proponents emphasize the emergence of technological change from active involvement in economic activities.

It is possible for technology transfer (exogenous technological change) to catapult economies with low level of technology to achieve high levels of sustainable growth (Bernard and Jones 1996; Dowrick and Rogers 2002). However, this will require adaptation of transferred technology into the stream of economic activities to provide a basis for "learning-by-doing" that diffuses into various sectors of the national economy to propel technological change. Some other economies can grow through the transfer of existing ideas as well as positive externalities of production processes. This reflects the proper application of ideas as a contingent part of the growth process, incorporated as a factor of production with a balanced need for using existing ideas and producing new ideas (Romer, 1992).

The significance of labour input in the production function means that there could be a positive relationship between the size of the population and economic growth. This has given rise to the idea of "scale effects" in economic growth analysis but mere size of population without developing and appropriately utilizing capabilities in production process does not provide significant advantage for technological change and economic transformation. This implies that, a foremost condition for optimal utilization of technological knowledge is development of robust human capital to be complemented by opportunities to unleash human capital in pushing the frontiers of technological change.

Thus, knowledge-in-use, not knowledge per se is critical for engendering technological change and the nature and dimension of knowledge spillover effects determine the robustness of economic growth. Therefore, effective number of researchers, rather than the population, is the critical determinant of production of ideas. In essence, high sustainable economic growth, which is the fountain of economic transformation, hinges on significant increase in productivity, which, in turn, depends on technological change that emanates from new ideas (designs) through R&D that springs from the labour force, which is a function of human capital that is drawn from population.

The productivity of competitive firms depends on their ability to innovate to adapt to technological change in order to gain from markets. Technological change festers on absorptive capacity (ability of capital investment or resource to yield appreciable level of return) of the overall economy. The absorptive capacity of the economy drives endogenous demand through the use of goods and services of a sector by other sectors of the economy. The essential relationship between effectiveness of labour and technological change requires intensive and efficient utilization of outputs of different sectors by other sectors of the economy. Thus, the intensity of sectoral interdependence generates high level of learning-by-doing and prompts the need for innovation that leads to R&D activities, which springs into technological change and economic transformation.

Apart from the neoclassical and endogenous growth theories, other perspectives of economic growth analysis converge on the critical relationship between technological change and economic transformation. For instance, the evolutionary growth theory asserts that economic activities evolves and springs into economic transformation through natural interdependence between changes in aggregate demand and technological change (Foley and Michl, 2011). Moreover, the process of transformation growth hinges on structural changes of the evolution of an economy that is driven by growth in effective demand that in turn, stimulates investments through adaptation to technological change to respond to market needs (Gualerzi, 2011). Inferences from Classical-Marxian evolutionary model points to the fact that technological change results from a random neutral innovation process that follows competitive market behaviours and motivation for profitability with labour productivity and wages evolving in concert (Levy and Dumeril, 2011). Heterodox Growth Theories (HGT) has illuminated certain dimensions, the key among which is the distinction between natural and actual economic growth rates implying that growth is exhaustible in the long-run, if all potential factors of growth are fully and efficiently utilized (Setterfield, 2009).

The impact of technological change on economic transformation requires a commensurate change in key factors of production, especially capital and labour, to enhance Total Factor Productivity (TFP) of the economy. It implies that transitional growth rates will differ among economies based on differences in the ratios of capital to effective labour. Economies with lower ratios of capital to effective labour relative to the steady state values will grow faster. If different economies have the same parameters for taste, technology and population growth rate, variation in growth rates will occur due to variations in distances from steady state and the rate of decrease of returns to capital, which in turn depends on technological change.

3. Dimensions of technological change and economic transformation

3.1 Invention-innovation-diffusion mechanism

Technological change occurs through a three chain relationships-- invention, innovation and diffusion. Invention is the creation of an item based on original ideas and knowledge more often described as “breakthrough” technology. Innovation is additional creativity that improves the features and usefulness of invented products. Diffusion refers to the spread of technological knowledge into various streams of economic activities that expands the space for further creativity to amplify the chain mechanism of invention, innovation and diffusion. Each aspect of this chain involves the appropriation of ideas through direct acquisition, “learning-by-doing” and R&D. Innovation is the pivot of this chain relationship in that innovation inspires invention and motivates diffusion, implying that both invention and diffusion posses some attributes of innovation.

An economy without the requisite technological wherewithal needs to evolve a system of innovation to engender technological change, which is synonymous with knowledge. System of innovation entails a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies (Freeman, 1987). As the pivot of the chain relationship of technological change (invention-innovation-diffusion), innovation constitutes the bedrock of system of innovation.

The essence of system of innovation is that even though natural endowments confer strategic advantages for certain activities that relates to specific aspects of technological knowledge, it is possible to create the requisite conditions for activities to flourish and propel technological change. For instance, geographical agglomeration (concentration of people and activities) is essential for stimulating effective diffusion and accumulation among local firms through which the process of technological change can be skewed to reflect the functional performance of firms, sectors, countries and regions based on the efficiency of the institutions that embody the innovation system (Patrucco, 2005). This underlines the crucial role of institutions in achieving technological change in firms, sectors, countries and regions. A functional system of innovation amplifies technological change due to penetration of knowledge into various economic activities.

Innovation is therefore the most critical factor in transforming sectors into dynamic systems through adaptation and interaction of factors of production based on coordinated national system of innovation. All agents within the innovation system are active partakers in the process of learning as economic activities continue over time. Learning takes place heuristically over a long period of time and possesses an incremental character. Technological change emerges as a by-product of active participation in the process of production, complemented by R&D activities. The system of innovation could target a key sector and after success spill-over to other sectors of the economy. To achieve this, the institutional processes, functions and policies need to play crucial roles of recognizing the essence of evolving cognitive technological capability to enhance the value-adding performance of factors of production.

Knowledge and by extension, technology, posses some degree of two significant attributes of public good; non-rivalry and non-excludability. A purely rival good is that for which its use by one agent precludes its use by another. In the same vein, a purely excludable good is that for which the possessor is capable of preventing others from using it either through legal means (property rights) or secrecy of inbuilt knowledge. Complete rivalry and excludability is not applicable to knowledge and technological change given that in the three chain processes (invention, innovation and diffusion), sharing with, and learning from other sources is imperative. Ideas that originate from thinking and reflections on the need to create something for specific use in real life is invention, which forms the foundation upon which other aspects of technological processes are built. Continuous use of invented technological product leads to innovation based on improvements in the form, use and adaptation of the initial product. The diffusion mechanism takes cognizance of knowledge or technology that is useful to the activities and sectors within the economy.

That is, knowledge spill-over effect is made possible by the degree of non-rivalry and non-excludability of knowledge that is imbued in technology. Any newly invented product will be available in the market, researchers can examine its characteristics and learn knowledge embodied in it so as to replicate or produce improved version of it through R&D. The non-rivalry character of knowledge and the possibility of spillover benefits to rival firms implies that the gains of R&D (profitability) is not limited to one firm alone making it possible for the social benefits to outweigh the private ones. Empirical study of innovating German manufacturing reveals that incoming spillovers have a positive effect on profitability on top of a firm's own R&D investment (Czarnitzki and Kraft, 2012). Improvements in quality of innovation leads to continuous replacement of existing products with a new version and the old ones become obsolete continuously over an infinite horizon. A key sector with innovation-driven technological change interacts with other sectors of the economy to expand opportunities for innovation and technological change through adaptation that is anchored on interconnectedness of sectors of the economy.

Technological inter-connections among various sectors of the economy evolve from structural and spatial interdependence of the production processes of the sectors. Through rational response to inducements and incentives, capabilities of factors of production are enhanced and transmitted into technological relationships. The cumulative effect is that as the sector from which technological "breakthrough" occurs increase production to take advantage of the efficiency of new technology, it increases the production of other sectors through demand for raw materials. In response to the demand from the resurgent sector, other sectors will seek to improve on their delivery efficiency and in the process adapt to existing technology or improved version of it. Economic activities will expand across sectors of the economy through this self-reinforcing process of inter-sectoral linkages. This provide opportunities for economies of scale that leads to lower per unit cost of production, thereby translating into market advantages that propel industrialization as manufacturing activities expand to take advantage of global markets.

3.2 Industrialization, manufacturing and globalization

Economic development experiences of both advanced and emerging countries illuminate the fact that technological change is the most critical factor in the transformation of low-level economies into high-level economic activities to drive sustainable high economic growth path. Technological change enhances human capabilities that lead to quality improvements and efficiency in terms of producing more without additional resources. Corollary, increasing specialization of labour leads to discovery of new goods and methods of production. This enhances Total Factor Productivity (TFP), which propels the "effectiveness of labour" that brings about high sustainable economic growth path. It has been established that differences in developmental levels of countries are largely due to differences in the efficiency of production as measured by relative levels of TFP, which is a reflection of technology gap (Hulten and Isaksson, 2007).

The need for technological change to drive economic transformation has become even more intensified by an increasingly interdependent global economic dispensation that tends to undermine and marginalise indolent economies. Economic growth disparities among countries of the world are largely attributable to degree of technological change that has, through improvements in the effectiveness and efficiency of harnessing economic resources, impacted on economic activities. This has given rise to a "four-speed world" categorisation of the global economic landscape relative to economic growth transformation achievements into four group of countries (Wolfensohn, 2007) as follows:

Affluent: those that have maintained global economic dominance for 50 years, constituting about 20 percent of world's population yet accounting for about 70-80 percent of global income. The United Sates of America, Canada, Japan and Germany are some of the countries in this group.

Converging: those that are poor and middle income economies but achieve high and sustainable economic growth (economic transformation) to emerge as key global economic players. China and India are prominent in this group.

Struggling: those with unsteady pattern of economic performance (irregular growth achievements at times strong and at times low), which implies a lack of coherent economic structure that drives economic performance. Their influence on global economic system is relatively weak.

Poor: those countries where income is stagnating or falling, mostly in Sub-Saharan Africa and where most of the "Bottom Billion" (Collier, 2007) lives. In the context of global economic schemes, they are very weak and significantly vulnerable to the adverse effects of globalisation.

The most significant underpinning factor for the differences in economic performances in the context of the four-speed world is the capacity to generate and absorb new technologies, which reflects in TFP of countries. The growth of TFPs of different group of countries in the four speed categorization over the period 2000-2007 (Table 1) indicates that the converging group of countries has the highest TFP growth of 2.8 percent, the affluent with 1.1 percent while the struggling and poor groups achieved 0.5 and 0.6 percents respectively (OECD, 2010). This indicates a growing technological divide that underpins the transformation of global industrial and economic landscape that is springing new global economic power houses. This is even more obvious from the TFP growth rates of China and India, the most remarkable success of economic transformation in recent years, at 4.4 and 2.1 percents respectively. As Table 1 further illustrates, there is a strong relationship between TFP growth and output growth as well as strong correlation between TFP growth and other key factors of economic growth; physical capital growth and human capital growth.

	Output growth	**TFP growth**	**Physical capital growth**	**Human capital growth**
Affluent	3.5	1.1	3.6	1.0
Converging	6.5	2.8	4.5	2.0
Struggling	3.0	0.5	2.7	2.6
Poor	3.0	0.6	2.8	2.7
Brazil	3.4	1.4	1.6	2.4
China	9.3	4.4	9.6	0.9
India	7.0	2.1	8.1	2.2
South Africa	4.2	1.8	3.6	1.4
OECD Average	2.5	0.9	1.0	1.2

Source: OECD (2010), "*The Growing Technological Divide in a Four-Speed World*" in Perspectives on Global Development 2010: Shifting Wealth"

Table 1. Average Annual Growth of Key Economic Growth Factors, 2000-2007 (%)

Global development experiences have shown that, the most effective route to economic transformation is industrialization, the core of which is robust manufacturing activities. Historical evidence indicates that it is rare for any country to achieve high-sustained growth without industrializing as virtually all advanced economies experienced industrial revolution in their march towards development as stressed by the United Nation Industrial Development Organization (UNIDO) thus:

> "Although the essence of industrialization is not new, recent changes in the global economy have substantially altered the opportunities for industrialization and recent academic research has, in turn, substantially changed our understanding of the process of industrialization and illuminates the significance of manufacturing. The past several decades have witnessed a major restructuring of the global economy, one in which more and more industrial output and employment is now located in emerging developing countries, while the developed countries have become ever more service oriented economies. Globalization, through increased trade and investment flows is driving this restructuring, along with technological and associated organizational change" (UNIDO, Industrial Development Report, 2009).

Manufacturing value-added (MVA) plays multiple roles in industrialization and economic transformation. It enhances productivity, increases absorptive capacity and provides the basis for “learning-by-doing” that springs into technological change. Cross-country economic growth empirics points to the fact that, structural change that leads to shift in capital and labour from low productivity to high productivity sectors by propelling the TFP, is the driving force of economic transformation[2]. Evidence of strong positive relationship between MVA and economic transformation abound. The IDR 2009 illustrates the crucial role of MVA in the stupendous economic transformation of emerging industrial countries that has transformed the global industrial and economic landscape. Based on long-term growth performance[3] and initial level of income in the base year between 1975 and 2005, the report classified countries into five different groups:

- High-income countries, mostly OECD member countries
- Fast-growing middle-income countries
- Slow-growing middle-income countries
- Fast-growing low-income countries
- Slow-growing low-income countries

Comparing the rate of MVA growth per worker in 1975-2000, MVA per capita in 1997 and 2005, and growth rates of countries, it revealed that MVA growth rates was about twice higher while MVA per capita was three times higher in fast-growing countries than in slow-growing ones. Thus, productivity gains in manufacturing accounts for the large differences between fast-growing and slow-growing countries. As further evidence of the significance of manufacturing, the emergence of East Asian industrial countries into high-growth economies has been due to large contributions of their manufacturing relative to other sectors.

The changing share of manufacturing in GDP of regions indicate that, there is strong causality between MVA and high growth performances of the Asian tigers that are driving global economic growth pattern in recent years. In East Asia, the relative share of manufacturing to GDP increased from 25 percent in 1965 to about 35 percent in the 1980s and remained at above 30 percent throughout the 1990s. Conversely, the manufacturing share of GDP in Latin America, which was at the same level with East Asia in 1965, remained stagnant. Furthermore, as a reflection of the critical role of MVA in the changing global economic landscape, emerging global economic powers achieved significant growth in MVA while that of developed countries has slowed. Due to the significant rise of emerging economies, average growth rate of MVA of developing countries have increased significantly above that of developed countries in recent years. For instance, average annual growth rate of MVA of developing countries between 2001 and 2005 was 6.2 percent against world average of 2.7 percent and developed countries average of 1.4 for the same period. Developing countries improved to 7.1 percent between 2006 and 2010 while developed

[2] While an economy’s aggregate TFP is a weighted sum of each sector TFP levels, TFP growth of the entire economy reflects also, the changes in the structural composition of the economy. Lipsey and Carlaw (2004) used simple mathematical calculations to show that aggregate TFP changes as movement of labour between formal sectors occur.

[3] Growth performance is measured by “growth experience”, which is defined in terms of GDP per capita growth above the median sample. Countries with “growth experience” more than half of their annual observations are classified as “fast growers”.

countries deteriorated to 0.2 percent for the same period with the world average at 2.4 percent. China and India, the foremost in current global economic transformation, achieved average MVA growth rate of 4.8 and 8.6 percent for the period 2001-2005 and 4.9 percent and 6.2 percent for the period 2006-2010, respectively.

In a nutshell, the existence of industrial production on one hand, and demand for the products of the industries on the other hand, creates opportunities for market expansion, competition and specialization. Through a favourable "forward linkage" effects, an endogenous self-perpetuating process of growth emerges and feeds on it almost automatically. Through internal and external economies of scale, the process of industrial production evolves into higher and more sophisticated levels of production, giving rise to further specialization, new products and quality improvements, leading to technological change that spurs economic transformation. Adaptation to a growing market, widened by international trade, stimulates industrial production and provides additional impetus for technological change and economic transformation. Globalization facilitates both technological change and economic transformation as it creates opportunities for market expansion, competition and specialization, which are essential for industrialization. Extension of markets in integrating economies across national borders has contributed significantly in global technological change and economic transformation, especially through the catalytic effect of information and communications technology (Atkinson, 2009). The process of structural transformation increases the relative contribution of manufacturing activities with strong interdependence among domestic sectors and regional economies. This provides the basis for expansionary effect of inter-industry linkages and creates opportunities that enhance prosperity and standard of living.

3.3 Prosperity and standard of living effect

High sustainable economic growth is the *sine qua non* for economic transformation but prosperity relates to the share of the proceeds of economic growth benefits that reaches most of the people. Since benefits come in form of rewards for work, effective participation of most, if not all, of the people, in the productive activities of various sectors of the economy in the process of economic transformation is essential. Therefore, economic growth needs to be inclusive by providing equal opportunities to all members of the society to participate and contribute to the growth process regardless of their circumstances (Ali and Zhuang, 2007) to inspire the process of technological change and economic transformation. This will require that all productive sectors of the economy are active enough to absorb factors of production to optimal level through multi-sectoral input-output interdependence of productive activities.

The effect of technological change has been very tremendous not only on living standards but also in life characteristics. For instance, output per worker in the United States increased 10 times more than 100 years ago (Maddison, 1982). There has been a 7-fold increase in market TFP in the USA between 1800 and 1990 along with increase in real wages by a factor of 9 over the period 1890 to 1990, which led to a decline in fertility from 7 kids per woman in 1800 to 2 in 1990 (Greenwood and Seshadri, 2004). China's GDP has almost doubled between 1997 and 2004 with the annual change in GDP approaching 8.3 percent per year leading to increase in per capita income by 83 percent in urban areas and 41 percent in rural areas (Bromley and Yao, 2006). This fundamental changes in life patterns has been largely due to the fact that technological change has significantly improved the skills of workers, propelled industrialization and driven economic transformation.

In any modern society, the people are involved in four basic activities that are intertwined with their livelihood. These are:

- *Production* of goods and services by industry and commodity sectors at different stages of activity chain (primary, manufacturing and service activities).
- *Consumption* (purchases) of goods and services by industries, individuals and various government agencies which provide markets for the goods and services produced to create room for more and continuous production.
- *Trade* which involves selling goods and services produced by the society and buying of goods and services produced from elsewhere.
- *Accumulation* (generating surpluses) through savings and capital transactions such as fixed investment expenditure and stock change made possible by the surpluses generated after the production and selling of goods and services.

The intensity of involvement of the people and the level of technology applied in the process of production determine the level of value-added and by extension the level of income to be earned from the proceeds of trade. The higher the value-added content the higher the returns on investment and the lower the value-added content the lower the returns on investment. Higher level of returns could lead to surpluses (extra income after purchases of needed goods and services) which could be ploughed back into the investment stream (accumulation). This leads to a regeneration process that is self-perpetuating and thus a path towards self-reliant and sustainable economic prosperity that spills over to other aspects of life. As the process of production becomes more sophisticated and global markets lead to expansion of economic activities, the nature of labour participation in production changes due to the effects of technological change. For instance, empirical evidence suggests a link between declining share of labour in value added manufacturing and increasing productivity that is driven by expansion in international trade (Böckerman and Maliranta, 2012). This leads to higher productivity with declining labour involvement with much higher earnings relative to input-output ratio thereby enhancing prosperity.

Thus, economic prosperity is attainable through industrial production activities that cater for the essential needs of the people and provide opportunities for the people to work and earn income. The higher the value-added content through the application and adaptation to technological change, the higher the returns on investment and the lower the value-added content the lower the returns on investment. The higher the levels and intensity of the involvement of the people of a society, the more they are able to provide for their needs, trade favourably and generate surpluses and hence the more economic prosperity and higher standard of living the society can attain.

4. Fostering technological change and economic transformation

4.1 Essential conditions

Previous sections have established that technological change and economic transformation are mutually reinforcing aspects of development process that enhances standard of living. Effective utilisation of resources is fundamental to the attainment of technological change and economic transformation. It requires strategies that create incentives for investments that use natural resources as intermediate goods and transform them into finished goods by a manufacturing production process that enhances the value-adding capabilities of factors of production. Institutional efficiency and effective macroeconomic management are essential in creating solid infrastructures that forms the basis for fostering technological change and economic transformation.

Technology is related to production of all aspects of goods and services and has four components. The first component is human capital involving the training of people to equip them with skills. The second component is technical requiring the provision of necessary equipment and new materials. The third is institutional, which is about regulatory and policy framework and the tools of implementation. The fourth component is the informational aspect, which is about accessing available developments and progresses in global technological application. Each of these components is crucial for ensuring continuous improvement in the methods of production, discovery of new resources and thus creating the necessary conditions for efficient utilization of resources to foster technological change and economic transformation.

A system of innovation strategy is essential for ensuring effective domestic participation in value-adding activities to generate synergy for technological change and economic transformation. The role of the public sector is crucial in providing the requisite platform for generating ideas (knowledge or technology) through learning-by-doing and R&D activities, as well as co-ordinated linkages among sectors of the economy. This creates incentives for effective private sector investments that expand economic activities and opening-up opportunities for knowledge spillovers, learning-by-doing and R&D to engender technological change and economic transformation.

Technological change and economic transformation depends largely on the creation of ideas that are derived from human capital, which draws from population of a country. However, ideas do not automatically emanate from population as certain conditions are required for knowledge creation to occur. Hence, there is no direct correlation between population growth and technological change. In real world, there are examples of countries with both large and low population that recorded significant success of achieving technological change and economic transformation. The effective number of researchers, rather than the population, along with thriving competitive enterprise are the crucial driving forces of technological change and economic transformation. Population growth could be useful in providing a pool of human resources that can be effectively transformed through training and productive engagement to create ideas and steer the process of technological change.

Even though, the fundamentals of fostering technological change and economic transformation are familiar to a large extent, many developing countries, especially Least Developed Countries (LDCs) have not demonstrated significant achievement in fostering technological change and economic transformation. This is largely due to entrenched public sector inefficiency in management, coupled with weak production structures, which combine to constitute stumbling block for technological change and economic transformation. Various agents play essential roles in fostering technological change and economic transformation but the two most critical agents are the public and private sectors.

4.2 The role of the public sector

Efficient functioning of government in discharging its responsibilities to create enabling condition for investments and thriving industrial production create opportunities for expansion of economic activities, which enhances the efficiency and effectiveness with which economic resources are utilized. Availability of efficient public services provides incentives for industrial production that leads to expansion of economic activities through interconnectedness of economic activities of various sectors of the economy. Large involvements of people in chain economic activities create opportunities for enhancing their capabilities to motivate innovation instincts to drive technological change.

This conforms to the fundamental development principle that the economic and social progress of any country depend largely on government's ability to generate sufficient revenues to finance an expanding programme of essential, non-revenue yielding public services (Todaro, 1994). Human capital formation, which is the bedrock of economic transformation and technological change, needs to be provided or strongly supported by governments through non-profit making principles. Production activities by all sectors of the economy is possible only if basic infrastructures and the rule of law that guarantees property rights (patents and copy right laws) are in existence. Economic transformation occurs in the course of development as public sector activities evolve through a system of revenues that accrue to the government and expenditures based on the varying and changing needs of the economy.

Although essential services (infrastructure, rule of law and human capital formation) are needed by all levels (household, firms and government), their non-excludability character means that firms with competitive profit maximizing objectives would not like to finance their provisions. Furthermore, there is the need for effective coordination to strengthen the significant relationship between consumption and production that is anchored on input-output mechanism that accentuates industrial production. The functions of providing essential services (public goods), which includes critical coordination of economic and social activities to align with aspiration of the society are functions that can only be undertaken by government based on its non profit and welfare provision disposition.

Thus, effectiveness of government's coordination and essential services provisions is a crucial component of the building blocks of economic transformation and technological change. For instance, sound educational and health service delivery will lead to the emergence of skilled and healthy workforce, a prerequisite for "effectiveness of labour", which in turn, is a key requirement for industrial production that leads to economic transformation and technological change. Beside, natural resource sectors which are the basic seeds from which economic activities germinate requires legal and institutional framework of operations and this can only be provided by government institutions.

There is complementarily between public services and private sector activities in the process of economic transformation and technological change. A robust and efficient system of government expenditures leads to high marginal products of labour and capital to individual firms. This is because of the quality of capital formation that occurs due to good educational and health provision functions of government. Government purchases a portion of private sector outputs with which it uses to provide free public services that is non rival and non excludable. Firms benefit from this as effective source of demand for their goods and services to be able to meet the wage requirements of the highly skilled labour and as well enhance their profit levels. This reflects in the high quality and large quantity of the aggregate output of the economy. In this context, government is a key factor in facilitating economic transformation and technological change in addition to enhancing the prosperity of the people through social optimal growth of the economy.

Adequate provision of basic needs of the society through the public sector machinery motivates private investments and enhances the productivity of factors of production to stimulate high sustainable economic growth. Thus, effective functioning of government creates the foundation upon which robust private sector activities spring to build upon existing ideas associated with economic activities through “learning-by-doing” and R&D activities. This provides opportunities for the emergence and effective contribution of the private sector.

4.3 Private sector

Robust private sector activities are essential for technological change and economic transformation. It is widely perceived that private sector investments are more effective due to their higher efficiency in utilizing resources. Private sector investments tend to use ideas much more and gain additional ideas through the positive effect of production experience. Knowledge creation is an unintended by-product of investment as such as firms increase the combination of their physical and human capital; they automatically improve their efficiency in production beyond the equivalent levels of the increase in capital. Private sector firms therefore tends to apply technical knowledge in their activities more and therefore are more likely to gain insights from capital goods that enhances production activities in their particular sectors as well as the overall economy through spill over effects.

In their drive to gain large control of markets, firms invest in R&D to improve quality and expand variety of their products. New discoveries of technology by firms through the combination of learning-by-doing and R&D are initially regarded as a private product and they enjoy some degree of preservation that gives them a measure of monopoly power over the discovery with the support of patent rights, in addition to secrecy of methods and codes of the technology. However, over time, competitive firms gain access to the new products from the market and analyse the new knowledge in them and make efforts to replicate or apply the ideas to create their own products with equivalent or even higher level of sophistication.

Increase in a firm’s capital stock leads to a parallel increase in its stock of knowledge through learning-by-doing. Each firm’s knowledge is assumed to be a public good, so other firms can gain access to it at zero cost. This implies that knowledge spills over onto the entire economy so each firm’s discovery of new knowledge (change in technology) impacts on the overall economy. Therefore, a firm’s level of technology and by extension, the changes in its technology, is proportional to that of the overall economy.

There are two dimensions of spillover effects of technological change on private firms. The first is sustaining technologies, those that help organizations to make marginal improvements in what they do and requires only gradual change to modify existing systems and products. The second is termed disruptive technologies, those that involve fundamental and at times unexpected technological breakthrough that requires corporations to radically rethink their very existence. There is the tendency for large companies to be comfortable with sustaining technologies due to their preoccupation with maintaining markets under their control and aversion to risks of uncertainties associated with disruptive technologies. Apart from the challenge of successful application of the newly "unknown" disruptive technologies, getting consumers to accept the transformed product could threaten market control (Christensen, 1997 and 2003).

Firms that pioneer disruptive technologies do not usually achieve straightforward success in transforming their products and getting the most market attractions and therefore could experience deteriorating performances. However, nurturing the process of applications leads to improvements that make it possible for disruptive technologies to bring substantial benefits to firms in terms of market shares based on positive sentiments of new designs and the perception that it is associated with quality improvements. Products that emerge from disruptive technologies are therefore of limited interests because they don't provide "quick wins" for firms but for those that endure the gradual process of mutation of the technologies into new products, they eventually completely overtake existing products and markets thereby bringing substantial benefits to endured firms.

The comfort of short-term gains from sustaining technologies and averting the risks of uncertainties associated with disruptive technologies on one hand, and the potential substantial gains of the success of nurturing the applications of disruptive technologies on the other, presents a dilemma to firms. To resolve this dilemma, firms will need to acquire separate "spin-off organizations" that are separate from their mainstream operations to nurture the applications of disruptive technologies to eventually reap associated benefits. This strategy provides a basis for accommodating failures from applications of disruptive technologies. (Christensen, 1997 and 2003)

4.4 Key conclusions and insights

Fostering technological change and economic transformation could address a pertinent intergenerational economic management dilemma; a trade-off between present and future consumption and by extension, welfare. The declining effect of the use of economic resources especially exhaustible natural resources, over time implies that output and consumption will also decline over time. Sustaining a level of output and consumption over a long period to establish intergenerational equity therefore becomes a challenge.

The combined effect of technological change and economic transformation ensures that through inventions, innovations and diffusions, quality of available goods and services are enhanced and new goods and services are created through more efficient production processes. In the context of sustainability for intergenerational prosperity, technological change could ensure non-declining consumption (utility); maintaining (constant) production opportunities over time; non declining natural capital stock; maintaining a steady yield of resource services; stability and resilience of the ecosystem through time and the development of capacity for consensus building.

A key strategy in fostering technological change and economic transformation is significant investments in human capital development through various aspects of education, training for skills acquisition and provision of social support services. This needs to be in tandem with facilitation of large-scale investments that create expansionary effects on the economy complimentarily with a robust household sector that provides effective market and supply labour services. Effective functioning of the public sector in providing essential needs propels the private sector to engage in profitable investments that in turn, motivates the drive for technological change through direct acquisition, learning-by-doing and R&D activities.

Efficacy of regulatory framework, the structure and operations of critical sectors of the economy along with sound macroeconomic management of the economy is essential. Appropriate measures for acquiring technological capabilities should be anchored on domestic value-adding activities based on formidable linkages between a strategic sector with other sectors of the economy driven by innovative transformation of sectors into dynamic systems through adaptation and interaction of factors of production based on co-ordinated national system of innovation.

5. Acknowledgments

The author is grateful to the comments and suggestions of the anonymous reviewer, which has helped improved the contents of the chapter. The contents of the chapter are the responsibility of the author and not his affiliated organization, the Islamic Development Bank.

6. References

Aghion, P. and Howitt, P. (1998) Endogenous Growth Theory. MIT Press, London, England.

Ali, I. and Zhuang, J. (2007): *"Inclusive Growth Toward A Prosperous Asia: Policy Implications"* Asian Development Bank, ERD Working Paper No. 97

Atkinson, R (2009): "Globalisation, New Technology and Economic Transformation" in Cramme, O. and Diamond, P (eds), Social Justice in the Global Age, Polity Press, Cmbridge CB2 1UR, UK

Barro, R. and Sala-i-Martin, X. (1995), Economic Growth, McGraw Hill, New York.

Bernard, A.B. and Jones, C.I. (1996); "*Productivity across industries and countries: Time series theory and evidence*". Review of Economics and Statistics, vol. 78, pp. 135-146.Bernard, A. and Jones

Böckerman, P. and Maliranta, M. (2012): Globalization, creative destruction, and labour share change: evidence on the determinants and mechanisms from longitudinal plant-level data , Oxford Economic Papers 64(2): 259-280

Bosworth, B. et al (1972) The Recent Productivity Slowdown: Comments and Discussions, *Brookings Papers on Economic Activity*, 3, 537-545.

Bower, J. and Christensen, C. (1995), "Disruptive Technologies: Catching the Wave", *Harvard Business Review*, January–February 1995

Bromley, D. W and Yang Yao, Y. I. (2006) "Understanding China's Economic Transformation: *Are there lessons here for the developing world*?", World Economics, Vol. 7, No. 2, April–June 2006

Chenery, H. B., Shishido, S. and Watanabe, T. (1962) The Pattern of Japanese Growth, 1914-1954 *Econometrica*, Vol. 30, No 1, January 1962, pp98-139.

Chenery, H. B., Robinson, S. and Syrquin, M. (1986) "Industrialization and Growth: A Comparative Study" The World Bank, Oxford University Press

Christensen, C. (1997), The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, *Harvard Business School Press,*

Christensen, C. and Raynor, M. (2003), "The Innovator's Solution", Harvard Business School Press,

Collier, P. (2007), "The Bottom Billion: Why the Poorest Countries are Failing and What Can Be Done About It", Oxford University Press

Currie, L. (1974) The 'Leading Sector' Model of Growth in Developing Countries, *Journal of Economic Studies,* Vol.1, No. 1, May, 1997.

Czarnitzki, D. and Kraft, K. (2012) Spillovers of innovation activities and their profitability, Oxford Economic Papers 64(2): 302-322

Dasgupta, P. and Stiglitz (1981), Resource Depletion under Technological Uncertainty. *Econometrica*, 49(1), 85-104.

Dowrick, S. and Rogers M. (2002), Classical and Technological Convergence: Beyond the Solow-Swan Growth Model. *Oxford Economic Papers*, 54, 369-385.

Dumenil, G. and Levy, D. (2011), "The Classical-Marxian Evolutionary Model of Technical Change: Application to Historical Tendencies" In: Setterfield, M. (ed) Handbook of Alternative Theories of Economic Growth, *Edward Elgar Publishers*

Foley, D. K. and Michl, T. (2011), "The Classical Theory of Growth and Distribution" In: Setterfield, M (ed) Handbook of Alternative Theories of Economic Growth, *Edward Elgar Publishers*

Frankel, M. (1962), The Production Function in Allocation and Growth: A Synthesis, *American Economic Review* 52 (December), 955-1022.

Freeman, C. (1987) "Technology Policy and Economic Performance: Lessons from Japan, Frances Printer, London

Greenwood, J. and Seshadri, A. (2004) Technological Progress and Economic Transformation, Working Paper 107665, National Bureau of Economic Research

Gualerzi, D. (2011), "The Paths of Transformational Growth" In: Setterfield, M. (ed) Handbook of Alternative Theories of Economic Growth, *Edward Elgar Publishers*

Harrington, D. R., Khanna, M. and Zilberman, D. (2005) Conservation Capital and Sustainable Economic Growth, *Oxford Economic Papers*, 57, 2, 336-359.

Hulten, C. and Isaksson (2007): "Why Development Levels Differ: The sources of Differential Economic Growth in a Panel of High and Low Income Countries", NBER Working Paper, No. 13469

Ishikawa, J., Sugita, Y. and Zhao, L. (2005), "Corporate Control, Foreign Ownership Regulation and Technology Transfer". Presented at FAI seminar, Department of Economics, University of Strathclyde, Glasgow, United Kingdom.

Jones, C. I. (1995), R&D-Based Models of Economic Growth, *Journal of Political Economy*, 103, 759-84

Jones, C. I. (1999) Growth With or Without Scale Effects? *American Economic Review Papers and Proceedings*, 139-144.

Jones C.I (2002), Introduction to Economic Growth, W. W. Norton, USA.

Koopmans, T. C. (1973) Some Observations on 'Optimal' Economic Growth and Exhaustible Resources In: Box, H. C., Linnemann, H. and Wolff, de P., *Economic Structure and Development*, Elsevier, New York, U. S. A., 239-255.

Koopmans, T. C. (1974) A Proof for the Case Where Discounting Advances the Doomsday, Review *of Economic studies, 41, Issue on the symposium of Exhaustible Resources.*

Koopmans, T. C. (1978) The Transition from Exhaustible to Renewable and Inexhaustible Resources, *Cowles Foundation Discussion Paper*, No. 486, Yale University.

Kubo, Y. and Robinson, S. (1984) Sources of Industrial Growth and Structural Change: A comparative Analysis of Eight Economies, *Proceedings of the Seventh international Conference on Input-Output Techniques,* United Nations, New York, 1984.

Kuznets, S. (1971) Modern Economic Growth: Findings and Reflections, *Nobel Prize Lecture*, December 11, 1971

Li, C. W (2001) Growth and Scale Effects: The Role of Knowledge Spillovers, *Economic Letters*.

Lucas, R. Jr (1990) Why Doesn't Capital Flow from Rich to Poor Countries? *American Economic Review*, 80, 92-96.

Maddison, A. (1982): Phases of Capitalist Development, Oxford University Press, Oxford

McCallum, B.T. (1996), "Neoclassical vs Endogenous Growth Analysis: An Overview", *Federal Reserve Bank of Richmond Economic Quarterly, Fall 1996. Also NBER working paper no. 5844.*

Organization for Economic Co-operation and Development (OECD, 2010); "The Growing Technological Divide in a Four-Speed World" in *Perspectives on Global Development 2010: Shifting Wealth*, OECD Report.

Patrucco, P. P. (2005) The Emergence of Technology Systems: Knowledge Production and distribution in the case of the Emilian Plastics District, *Cambridge Journal of Economics*, 29, 1, 37-56

Ramsey, F. P (1928) "A Mathematical Theory of Saving", Economic Journal, 38, 543-549.

Romer, M. P. (1992) "Two Strategies for Economic Development: Using Ideas and Producing Ideas" Proceedings of the Annual World Bank Conference on Development Economics.

Romer, D (1996) Advanced Macroeconomics, McGraw Hill.

Romer, M. P. (2007). Endogenous Technological Change, The Journal of Political Economy , Vol. 98, No.5 (March 200) pp. 71-102

Sala-i-Martin, X, Doppelhofer, G. and Miller, R.I (2004) Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) approach. *American Economic Review*, Vol. 94, No 4, September, 2004.

Sandilands, R. J. (2000). Perspectives on Allyn Young in Theories of Endogenous Growth. *Journal of History of Economic Thought*, Vol.22, No.3.

Schumpeter, A. J. (1975): "Capitalism, Socialism and Democracy", Harper and Row

Setterfield, M (2009) "Neoclassical Growth Theory and Heterodox Growth Theory: Opportunities For and Obstacles To Greater Engagement", Working Paper 09-01, Department of Economics, Trinity College, Hartford Connecticut, USA

Sinha, D. (1999) The Relevance of the New Growth Theory to Developing Countries In: Dahiya, S. B. (ed) *The Current State of Economic Science*, Vol.5, pp 2457-2466.

Solow, R. M. (1956), A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics,* 70 (1), 65-94.

Solow, R. M (1994), Perspectives on Growth Theory, *The Journal of Economic Perspectives*, 8(1), 45-54.

Swam, T. W. (1956). Economic Growth and Capital Accumulation. *Economic Record*, 32, 334-361.

Todaro, P. M. (1994) Economic Development. Longman, New York

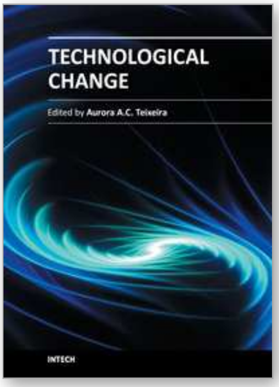
United Nations Industrial Development Organization (UNIDO, 2009), "Breaking In and Moving Up: New Industrial Challenges for the Bottom Billion and Middle Income Countries": *Industrial Development Report 2009*

United Nations Industrial Development Organization (UNIDO, 2011), "Industrial Energy Efficiency for Sustainable Wealth Creation: Capturing Environmental, Economic and Social Dividends": *Industrial Development Report 2011.*

Wolfensohn, J. (2007), "The Four Circles of a Changing World", International Herald Tribune, June, quoted in OECD (2010) "Shifting Wealth and the New Geography of Growth" in Perspectives on Global Development 2010: Shifting Wealth, OECD Report.

Wyckoff, A., Sakurai, N. and Leedman, C. (1992). Structural Change and Industrial Performance: A seven country Growth decomposition Study. OECD, Paris Cedex 16, France

Young, A. (1991). Learning by Doing and the Dynamic Effects of International Trade. *Quarterly Journal of Economics,* 106 (2), 369-406.



Technological Change
Edited by Dr. Aurora Teixeira

ISBN 978-953-51-0509-1
Hard cover, 238 pages
Publisher InTech
Published online 11, April, 2012
Published in print edition April, 2012

Technological change is today central to the theory of economic growth. It is recognised as an important driver of productivity growth and the emergence of new products from which consumers derive welfare. It depends not only on the work of scientists and engineers, but also on a wider range of economic and societal factors, including institutions such as intellectual property rights and corporate governance, the operation of markets, a range of governmental policies (science and technology policy, innovation policy, macroeconomic policy,competition policy, etc.), historical specificities, etc. Given that technology is explicitly taken up in the strategies and policies of governments and firms, and new actors both in the national and international arenas become involved, understanding the nature and dynamics of technology is on demand. I anticipate that this book will decisively contribute in this regard.

How to reference
In order to correctly reference this scholarly work, feel free to copy and paste the following:

Musa Jega Ibrahim (2012). Technological Change and Economic Transformation, Technological Change, Dr. Aurora Teixeira (Ed.), ISBN: 978-953-51-0509-1, InTech, Available from: http://www.intechopen.com/books/technological-change/technological-change-and-economic-transformation

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821