Udvari B. (ed) 2020: Proceedings of the 4th Central European PhD Workshop on Technological Change and Development. University of Szeged, Doctoral School in Economics, Szeged, pp 190–209.

4th Industrial Revolution: The middle income trap, technological advancement and socio-economic development nexus

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The Middle-Income-Trap (MIT) concept has received considerable attention among development practitioners and economists in recent times due to its associated lower socioeconomic development and negative welfare consequences such as increasing poverty and inequality in affected economies. Of the many factors proposed for breaking out of the MIT, technology has been singled out as absolutely essential, based on the hypothesis that MIT countries have lower technological development and lower socio-economic development compared to high income countries. Although the relationship between technology and socioeconomic development has been established, existing studies have not utilized the latest Global Innovation Index (GII) to examine this relationship. In the current era, the "4th Industrial Revolution" offers a higher potential for human development through rapid technological development. The Sustainable Development Goals (SDGs) also recognize innovation and technology as critical for ending all forms of poverty and inequality. As a result, there is the need to examine the MIT hypothesis by answering the question: do countries with higher levels of technological development also have higher socio-economic development? A cross-sectional research design was utilized. Quantitative analyses GII scores and selected socioeconomic indicators for 126 countries corroborate the MIT hypothesis that countries with higher innovation and technological development also have higher income levels.

Keywords: 4th Industrial Revolution, Technological Progress, Middle Income Trap, Global Innovation Index, Human Capital, Sustainable Development Goals

1. Introduction

As the world enters the 4th Industrial Revolution (or Industry 4.0), the important role of technological progress in the socioeconomic development status of countries has taken center stage in economics and development discourse (See UNCTAD 2017, United Nations 2017, World Bank 2019). The importance of technological advancement to economic growth and development have featured in economics literature at least since the 1950s with the introduction of Solow's growth model (Mankiw–Taylor 2014), and currently it is argued that technological change is an extremely important factor if not the main factor, in economic growth (Bajmócy–Gébert 2014). The recognition of the importance of technological advancement to economic growth and development has resulted in policy makers across globe adopting various innovation policies over the years making the term 'innovation policy' very popular in the last two decades (Edler–Fagerberg 2017). It is also widely accepted that innovation can help address global challenges and affect various socioeconomic situations (Edquist 2014). Thus, the 2016 edition of '*The Global Information Technology Report*' posits that a key feature of the Fourth Industrial

Revolution is that, “the future holds an even higher potential for human development as the full effects of new technologies such as the Internet of Things, artificial intelligence, 3-D Printing, energy storage, and quantum computing unfold” (Samans–Hanouz 2016).

In spite of its potential for improved socioeconomic development, the most recent World Development Report 2019 has cautioned that, some countries are likely to benefit more from technological development than other countries. For instance Samans–Hanouz (2016) points out that Information and Communication Technologies (ICTs) are the backbone of this Fourth Industrial Revolution, and that countries and businesses that embrace these developments as well as anticipate challenges, and deal with them in a strategic way, are more likely to prosper, while those that do not are more likely fall behind (Samans–Hanouz 2016). Similarly, *Information Economy Report 2017* notes that “the world is on the cusp of a new digital era…This has major implications for the implementation of the 2030 Agenda for Sustainable Development, presenting significant opportunities, but also challenges, for developing countries” (UNCTAD 2017).

As part of global efforts to ensure that all countries and their citizens benefit from the 4th Industrial Revolution and the opportunities technological progress and innovation offer, the Sustainable Development Goals (SDGs), which was adopted by world leaders at the 2015 United Nations General Assembly, has set – among other aims – specific targets for governments to increase investments in science, technology, and innovation, and also to ensure that everyone has access to ICTs (UN 2015, UN 2017). In spite of these efforts, Nikoloski (2016) posits that, there is a very refined technological gap that currently exists between developed countries on the one hand and developing countries on the other, with the gap widening to the detriment of developing countries. According to Nikoloski, the “developed countries have a monopoly on the sources of technological development and export of modern equipment and technology while developing countries are technologically dependent on developed countries (2016, p. 48). Empirical evidence from studies on the Middle Income Trap (MIT) – a phenomena whereby when countries enter the middle income bracket, they are unable to progress to high income status – suggests, that technological advancement is a critical factor in escaping the trap (Glawe–Wagner 2016). Out of 101 middle-income countries in 1960, only 13 were able to escape the MIT by the year 2008, and Glawe–Wagner (2016) have cited several empirical studies which indicate that the few countries that were able to escape the MIT were those that have moved up the technological development ladder from being only consumers of technology to also becoming producers and exporters of technology. Meanwhile the MIT is of concern to development practitioners and economists because empirical evidence suggests that countries that get stuck in the middle income bracket have higher levels of poverty, inequality, and lower scores on other socio-economic indicators (Glawe–Wagner 2016).

In spite of the MIT hypothesis that higher income countries have higher levels of technological and socioeconomic development, empirical studies are yet to examine this relationship using the most recent data. This justifies the need to examine the relationship between national levels of technological progress and socio-economic development indicators using the most recent data. This paper seeks to provide new insights into the technology and socioeconomic development nexus by answering the following questions: What is the relationship between the level of socio-economic development of countries as measured by GDP, per capita income, and the Human Development Index (HDI) and their level of technological progress, as measured by the most recent Global Innovation Index (GII) 2018; also, is there a significant difference between the GII stores of high income and middle income countries; is there equal participation by countries in different income groups in the 4th Industrial Revolution. In this study, participation in the 4th industrial revolution is as measured by trade in ICT goods, and the proportion of people using the internet by the respective income levels of these countries? The results of these analyses provides new insights into the existing literature on the countries that are likely to benefit from the 4th Industrial Revolution, as well as the nexus between technological progress, socioeconomic development, and the MIT. The next section provides an overview of the relevant theoretical and conceptual issues including the theoretical foundations of technology in economic growth, the MIT hypothesis concerning the role of technology in socioeconomic development, as well as the nexus between the 4th industrial revolution, technological development, and the socioeconomic development status of countries. This is followed by discussions on the methodology and key findings.

2. Theoretical and Conceptual Issues

2.1. Theoretical Foundations of Technology and Innovation in Economic Growth and MIT Hypothesis

The theoretical foundations linking technological progress to the economic growth of nations can be traced to classical economists such as Adam Smith, David Ricardo, Thomas Malthus, and much later Frank Ramsey, Frank Knight, and Joseph Schumpeter, among others (Barro–Sala-i-Martin 2004). However, contemporary theorising on the importance of technology to the economic growth and productivity of nations can be traced to the seminal work of Solow in the 1950s (Bajmócy–Gébert 2014, Mankiw–Taylor 2014). According to Gill and Kharas, economists started to "unpack the technological black box of the Solow growth model" after the pioneering work by Romer in the year 1986, Lucas in the year 1988, and a decade later by Aghion and Howitt in 1996 (Gill–Kharas 2015). For instance, building on Solow's growth model, the endogenous growth theory proposed by Robert Lucas and Paul Romer in the late 1980s (Mankiw–Taylor 2014) posited that investment in a nation's human capital will be a key driver in economic growth rather than trade, because human capital is likely to lead to increases in technology, which in turn would help promote efficiency and increases in productivity (Mankiw–Taylor 2014). This assumption is captured by Mankiw–Taylor in the model below:

Determinants of Economic Growth Model

$$Y=\beta f(K,L,H,N)$$

Where;

Y – the output (GDP) of a country is dependent on the following:
β(beta) – the rate of technological progress;
K – the quantity of physical capital;
L – the quantity of labour;
H – the quantity of human capital; and
N – the quantity of natural resources.

Based on the model above, developed countries have high levels of physical and human capital and in a production function analysis, this would explain their high levels of output per person whereas the opposite is true for low income developing countries (Mankiw–Taylor 2014, Todaro–Smith 2015). Whereas Solow's growth model and the endogenous growth theories seemed to better explain the phenomenon of "club convergence" and also pointed to the importance of technological progress in disparities between the economic development status of different countries, Gill–Kharas (2015) posit that these models were only successful in addressing growth problems in high income and low income countries; however, neither of those two frameworks were satisfactory in understanding and addressing the nature of economic growth challenges in middle-income countries. This gave rise to the notion of MIT which Glawe–Wagner (2016) observed is a relatively new phenomenon, conceptually. Thus, according to Gill and Kharas who introduce the term middle income trap' in a 2007 World Bank Report *titled 'An East Asian Renaissance, Ideas for Economic Growth',* the MIT concept emerged due to the inability of the existing economic growth theories to satisfactorily inform development policy in middle income countries (Gill–Kharas 2015).

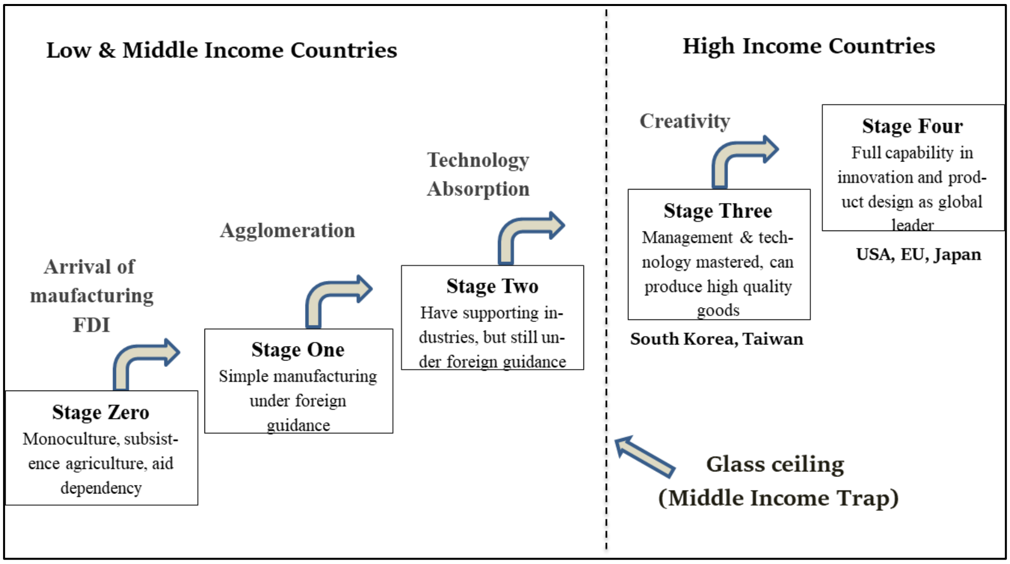
Insights from various economic growth theories have been used to explain the poverty trap in developing countries and also to justify the need for increased investments in human capital. For instance, Mankiw–Taylor (2014) posit that 'education – investment in human capital – is at least as important as investment in physical capital for a country's long-run economic success' (p. 487). Todaro–Smith (2015) also posit that health and education are inputs into the national production function in their role as components of human capital, meaning productive investments embodied in persons; however, improvements in health and education are also important development goals in their own right. To underscore this point, UNDP (2016) states that 'human capital is an asset, and differences in educational attainment prevent poor people from becoming part of the high-productivity growth process' (p. 12). Similarly, World Bank (2019) points out that 'delivered well, education – and the human capital it creates – has many benefits for economies and for societies as a whole. For individuals, education promotes employment, earnings, and health. It raises pride and opens new horizons. For societies, it drives long-term economic growth, reduces poverty, spurs innovation, strengthens institutions, and fosters social cohesion' (p. 11).

The collective impact of human capital and technological advancement on economic growth is based on studies which analyse mechanisms known as the 'productivity channel' (Li–Wang 2018). The core argument of this approach is that higher levels of human capital increase a country's ability to innovate and/or to adapt to existing technologies. Brue–Grant (2013) have observed that human capital in the form of the entrepreneur is central to a key process in economic change and the introduction of innovations – which can be defined as changes in the methods of supplying commodities, such as introducing new goods or new methods of production. Innovation can also be distinguished from invention in that, an invention becomes an innovation only when it is applied to industrial processes and this transformational process requires people with exceptional abilities who seize opportunities that others are oblivious to or who create opportunities through their own daring and imagination (Brue–Grant 2013). According to Edler–Fagerberg (2017) it was the founding father of innovation theory, Josef Schumpeter, who introduced the distinction between invention (a novel idea for how to do things) and innovation (carrying it out into practice). The justification for this distinction was based on the realization that, what matters economically and societally is not the idea itself but its adoption and subsequent exploitation in the economic and social system (Edler–Fagerberg 2017). Meanwhile the processes of invention, innovation, the adoption, and exploitation of technology are dependent on the human capital base of a nation. Therefore, the "productivity channel," approach, argues that differences in growth rates across countries largely arise from differences in levels of human capital in those countries (Li–Wang 2018).

2.2. Technology, human capital, and Middle-Income-Trap Hypothesis

Li–Wang (2018) as well as Wang et al. (2018) have recently investigated the nexus between human capital and the MIT. According to Li–Wang (2018) there is a more recent work by Vandenbussche et al. in 2006 which measures the role of human capital and technology in economic growth, in which the contribution of human capital to growth has both a level effect as well as a composition effect through the "productivity channel". Based on this model, the productivity-enhancing impact of human capital depends on not only its level but also, controlling for its level, the composition of skilled human capital and the country's position relative to the technological; therefore, skilled human capital is more important for countries that are closer to the technological frontier (Li–Wang 2018). It is in this regard, that empirical studies on the MIT such as Eichengreen et al. (2013) have concluded that the MIT is 'less likely in countries where the population has a relatively high level of secondary and tertiary education and where high-technology products account for a relatively large share of exports (Glawe–Wagner 2016). Therefore, in order for countries to break out of or avoid the MIT, they must move up the technological ladder as depicted in the stages of the catching up process in Ohno's MIT Model (Figure 1).

Figure 1 Middle Income Trap Hypothesis – Stages of the catching up in Ohno's Model



Source: Author's construct adapted from Ohno (2009)

Ohno's MIT model indicates that, the countries that have escaped the MIT are those that have mastered technology, which Nikoloski (2016) defines as the sum of knowledge about procedures and processes not only in manufacturing but also in other spheres of social life, and have full capability in innovation and product design. Based on this model, the process of escaping or breaking out of the MIT is described as a catch-up process in which development is viewed as a linear process in which countries must move from one stage to another in order to develop; however, empirical evidence suggests that transitioning from one stage to another is not as smooth as many countries have remained in the poverty trap and middle income bracket for several years (Glawe–Wagner 2016). Similar to Ohno's model, Todaro and Smith had earlier observed that, "technology transfer is critical to more rapid growth, competing internationally, and beginning to catch up with advanced countries" (2015)

2.3. Technology, the 4th Industrial Revolution, and the SDGs

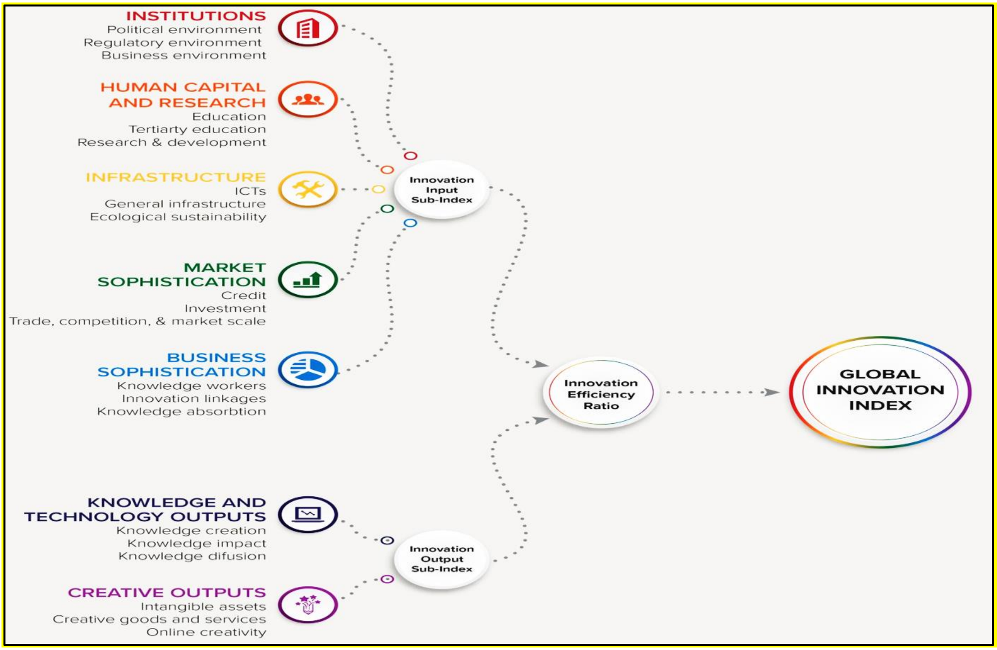
The academic literature related to the developments of the so-called 'Fourth Industrial Revolution" is still relatively new (Glawe–Wagner 2018) thus there are different conceptions as to the scope of this revolution. A distinguishing feature between the 4th and previous industrial revolutions is the recognition of the need for more skilled and knowledgeable workers (World Bank 2019). Nikoloski (2016) summarises the key features of the previous industrial revolutions as follows: the 1st industrial revolution which was accompanied by the steam engine resulted in replacement of some of the physical effort with machines; the 2nd industrial revolution or simply automation changed man and human development not only in the execution of physical operations, but also in the performance of certain mental operations; the third industrial or technological revolution referred to as the electronic revolution brought about a transistor whose application enabled the development of computers or computers and microprocessors. The emergence of the 4^{th} Industrial Revolution and the growing importance of technology in life and business means that all types of jobs (including low-skill ones) require more advanced cognitive skills; therefore, a basic level of human capital, such as literacy and numeracy, is needed for economic survival (World Bank 2019). According to Samans–Hanouz (2016) ICTs are the backbone of this 4^{th} Industrial Revolution, and the countries and businesses that embrace these developments, anticipate challenges, and deal with them in a strategic way are more likely to prosper, while those that do not will more likely fall behind. In this regard, the World Bank (2019), points out that developing countries need to increase investments in human capital and technological capabilities.

As part of global efforts to ensure everybody benefits from the opportunities that the 4th Industrial Revolution offers, the SDGs have several targets and indicators for countries to achieve. Specifically target 17.6 of SDG 17 requires nations to "Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism" (UN 2015, UN 2017). Additionally, SDG target 17.8 also has the aim to "Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology" (UN 2015, UN 2017). The global indicator for measuring progress on SDG 17.8 for instance, is the 'Proportion of individuals using the Internet' in various countries (UN 2017). Similarly, the SDG 9.c has the aim to "Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020" (UN 2017).

In addition to ensuring that everyone has access to the available ICTs, the SDGs further emphasize the importance of technology to poverty reduction, and economic growth. For instance the SDG on No Poverty has target 1.4 which seeks to "ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology" by the year 2030 (UN 2017). According to the UN (2017) SDG 8.2 also aims to "Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors". Furthermore, SDG 9 also has the following targets and indicators: 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending. An indicator for this target is research and development expenditure as a proportion of GDP (UN 2017). The targets and indicators highlighted above, give an indication of the pledge that world leaders have made to ensure that as many people as possible benefit from the 4th Industrial Revolution through the SDGs.

According to UNCTAD (2017) information technology has provided opportunities for businesses and countries to improve productivity across all sectors and to build new sectors. In spite of this potential of ICTs provided by the 4th Industrial Revelotion, Nikoloski posits that developed countries have a monopoly on the sources of technological development and export of modern equipment and technology while developing countries are technologically dependent on developed countries (Nikoloski 2016). If such a trend persists, then it has the potential to inhibit the ability of developing countries to benefit from the 4th Industrial Revolution and also achieving the SDGs. Furthermore, this trend would also inhibit countries from breaking out of or avoiding the MIT as indicated earlier. It is in view of of the potential welfare consequences of the development challenge discussed above that this study focuses on examing the implications of the technological development status of countries using the Global Innovation Index.

Figure 2 Framework of the Global Innovation Index 2018



Source: Cornell University, INSEAD & WIPO (2018); Dutta et al. (2018, 16)

The Global Innovation Index (GII) is a composite measure of seven (7) indicators, also referred to as pillars, that are used to measure the technological progress and level of innovation of countries (See Figure 2). Five (5) of the 7 pillars constitute the Innovation Input Sub-Index, comprised of the following elements of the national economy that enable innovative activities: (*1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication,* and *(5) Business sophistication.* The other two pillars constitute the Innovation Output Sub-Index, which provides information about outputs that are the results of innovative activities within the economy: *(6) Knowledge and technology outputs* and *(7) Creative outputs.* Each pillar is divided into sub-pillars and each sub-pillar is composed of individual indicators (80 in total in 2018). Sub-pillar scores are then calculated as the weighted average of individual indicators; pillar scores are calculated as the weighted average of sub-pillar scores and the overall GII Score is computed by taking a the simple average of the Input and Output Sub-Index scores (Dutta et al. 2018). According to Cornell University et al. (2018), GII gathers data from more than 30 sources, covering a large spectrum of innovation drivers and results, and the framework is revised every year to improve the way innovation is measured. Although the relationship between technology and economic growth has been established, existing studies have not utilised the latest GII to explore this relation. The relationship between GII and HDI is also yet to be analysed in literature.

3. Methodology

The study utilized a cross-sectional research design. Cross-sectional studies entail the collection of data on more than one case (usually many more than one), at a single point in time, with the objective of providing a snapshot of a given phenomenon (Babbie 2008, Walliman 2006). Walliman (2006) points out that the advantage of using cross-sectional design is that it allows for patterns of association between variables to be examined in order to detect associations; in addition, causal influences can also be inferred. As indicated earlier, the objective of the paper was to investigate the relationship between the level of socio-economic development of countries as measured by GDP, per capita income, and the Human Development Index (HDI), and their level of technological progress as measured by the most recent Global Innovation Index (GII) 2018. The socioeconomic development indicators adopted for this study were selected because they are the most widely used and accepted. A total of 126 countries were selected based on the availability of data sets used to compute the GII.

The study relied on secondary data sources and all indicators analyzed were based on official 2017 figures. The data sources included the World Development Indicators database (World Bank 2019), Human Development Index database (UNDP 2018) the Global Innovation Index 2018 database (Cornell University et al. 2018), the World Economic Outlook database (IMF 2018; 2019), and UNCTADStats. Various statistical analyses including descriptives, t-tests, and Pearson's product moment correlation were conducted to answer the research questions. Descriptive statistics were used to describe the distribution of the study countries by their income levels for the various variables studied. The t-tests were used to examine whether there is a significant difference between the mean GII scores of high income and middle-income countries. The correlation analysis was also conducted to examine whether there is significant relationship between the level of technological development of countries and their respective socio-economic development indicators. In order to determine if the participation of various countries with different income in the 4th Industrial Revolution is equal, their trade in ICT goods and persons using the internet were cross tabulated. The focus of this paper on analyzing the income level of countries is based on the MIT hypothesis and empirical literature that suggest there is a gap in the level of technological and socioeconomic development of the high-income countries, on one hand, and the middle and low income countries on the other hand. These assumptions formed the basis of the various analysis used to answer the research questions. The key findings of the various analyses are discussed next.

4. Findings and discussions

4.1. The sample countries

A descriptive analysis of the 126 countries analysed in this study indicates that most of the countries were from the Europe and Central Asia region (37%) followed by Sub-Saharan Africa (19%) and then the Latin America and Caribbean region (14%); North America (2%) and South Asia (4%) had the fewest countries respectively (Table 1). As indicated earlier, these countries were selected due to the availability of complete data sets. Although the GII data does not cover all countries, the number of countries in this study represents about 65% of the countries in the world. The countries analysed also represent close to 90% of the world's population and 97% of global GDP (Cornell University et al. 2018, IMF 2019).

Table 1 Distribution of countries analyzed by regions and percent of world GDP 2017

Regions	**Frequency**	**Countries analysed (%)**	**2017 GDP share in Purchasing power parity (%)**
East Asia & Pacific	15	11.9	30.5
Europe & Central Asia	46	36.5	21.2
Latin America & Caribbean	18	14.3	6.0
Middle East & North Africa	16	12.7	5.4
North America	2	1.6	16.6
South Asia	5	4.0	9.3
Sub-Saharan Africa	24	19.0	7.5
Total	126	100.0	96.6

Source: Author's construct based World Bank Classifications and GII (2018), and IMF (2019).

A crosstabulation of the GNI per capita of the income levels of various countries against the World Bank income group classifications indicates that, most of the countries analyzed were in the middle-income group (59 representing 47%) whereas 39% and 13% of the countries were in the high income and low income groups, respectively. The World Bank's classification distinguishes between four income categories based on the real per capita gross national income (GNI) calculated on the basis of the Atlas method and is the most widely used indicator. Since analysis of the MIT requires the comparison of middle income against high income countries, the sample size of each of the groups which are above 30 satisfies the required assumptions to make statistical comparisons among the GII scores of the two income groups using correlation analysis and t-tests.

Table 2 Distribution of countries analyzed by income groups

Income Group	World Bank Threshold ($)	Frequency	Percent
High Income	> 12,055	50	39.68
Upper Middle Income	3,896 – 12,055	34	26.98
Lower Middle Income	996 – 3,895	25	19.84
Low Income	< 995	17	13.49
Total Countries Analyzed		126	100.00

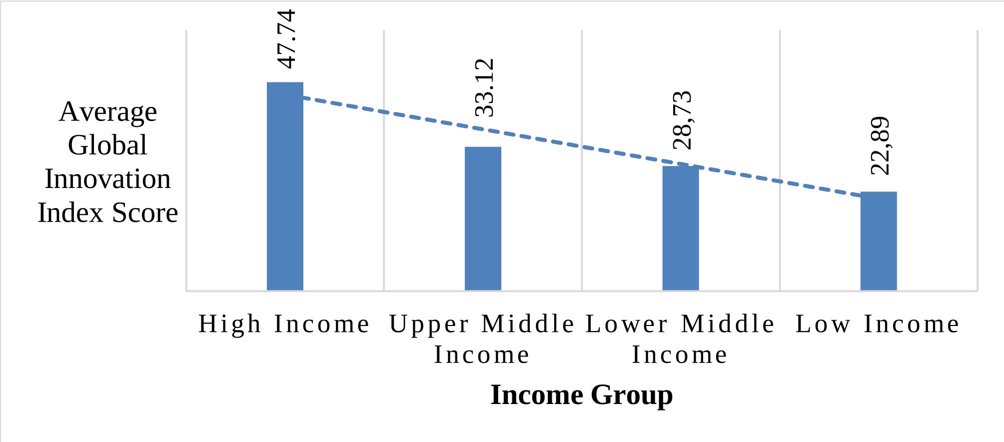
Source: Author's construct based on World Bank classifications and GII 2018 data

4.2. Findings on the relationship between Global Innovation Index scores and income of countries

In order to investigate the existing literature on the nexus between the level of technological progress and output of countries as theorised by literature on the MIT, a correlation analysis was conducted on the GII scores of the countries against both their output as measured by GDP and the GNI per capita used by the World Bank to categorise countries into different income brackets. The study finds a significant relationship between the technological progress and output of countries. The GII scores positively correlated with both the GNI per capita ($r= .836$) and GDP per capita in both current prices ($r = .780$) and purchasing power parity ($r = .696$). The correlation between the GII and GDP was also statistically significant and positive ($r = .347$); however, it was weaker than the correlation between the GII and various measures of income per capita. It should be noted that the GNI per capita is the indicator that is used to classify countries by income groups. The implications of this finding is that countries in the higher income also have higher GII scores and vice versa, which is consistent with the MIT hypothesis that high income countries are higher up the technology ladder.

An independent-samples t-test was also conducted to compare GII Scores for the high and middle income countries. There was a significant difference beween the GII scores for the high countries ($M = 47.74$, $SD = 10.10$) and middle income countries (M = 31.26, SD = 6.04); t (77) = 10.11, p = .00, two-tailed). The magnitude of the differences in the means (mean difference = 16.49, 95% CI: 13.24 to 19.73) was very large (eta squared = . 488). The eta square value means that about 50% of the variance in the GII scores of the the high income and middle income countries can be explained by the income levels of the respective countries.

Figure 3 Distribution of Global Innovation Index scores by income groups



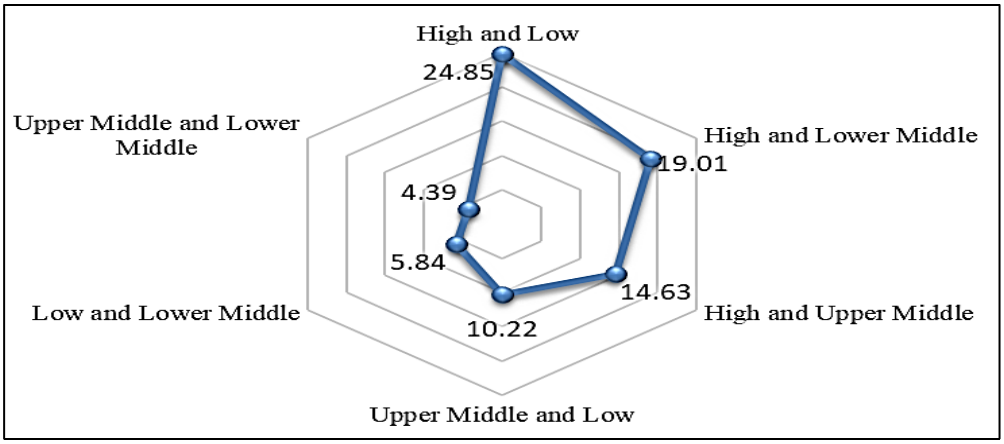
Source: Author's construct based on GII 2018 data and World Bank classification.

Another independent samples t-test was also conducted to determine if there was a significant difference between the GII scores of the high income countries and the lower middle income countries, and also between the high income countries and the uppper middle income countries. In both cases the study finds a significant difference between the GII scores of the high income countries and middle income countries. However, the gap was wider between high income countries (mean difference = 19.01, 95% CI: 15.37 to 22.65, t(72)=10.42, p = .00, two-tailed) and the lower middle income countries as compare with the gap between the high income countries and the upper middle income countries (mean difference = 14.63, 95% CI: 11.19 to 18.06, t (79) = 8.46, p = .00, two-tailed). In the case of the difference between the GII scores of the high income and lower middle income countries the eta square was .593, indicating that about 60% of the difference in the gap of GII could be explained by the income levels of the countries. For the difference between the high income and upper middle income countries the eta square was .476 slightly, lower that the eta square when all the middle income countries are combined. The highest gap in GII scores is between the high income and low income countries (See Figure 4)

These findings corroborate the earlier correlation analysis which indicates that the higher the income level of a country the higher their technological development. The findings are also consistent with the assertion of Nikoloski (2016) that there is a very refined technological gap that currently exists between developed countries on the one hand and developing countries on the other. Although Nikoloski

(2016) indicates that the technolgical gap is widening to the detriment of developing countries, the focus of this study was just to provide a snapshot of the current situation with respect to the relationship between the technological development of countries and their income levels. Consistent with the Global Innovation Index 2018 Report, the analysis of the GII scores against the income levels of countries indicate that the middle income countries performed worse than the high income countries on the GII with the exception of China. The Report notes that with the single exception of China, which is an upper-middle income economy, there has been a stable group of high-income economies that composes the top 25 of the GII suggesting a form club convergence as theorised Nikoloski (2016) and other MIT literature (Glawe–Wagner 2016).

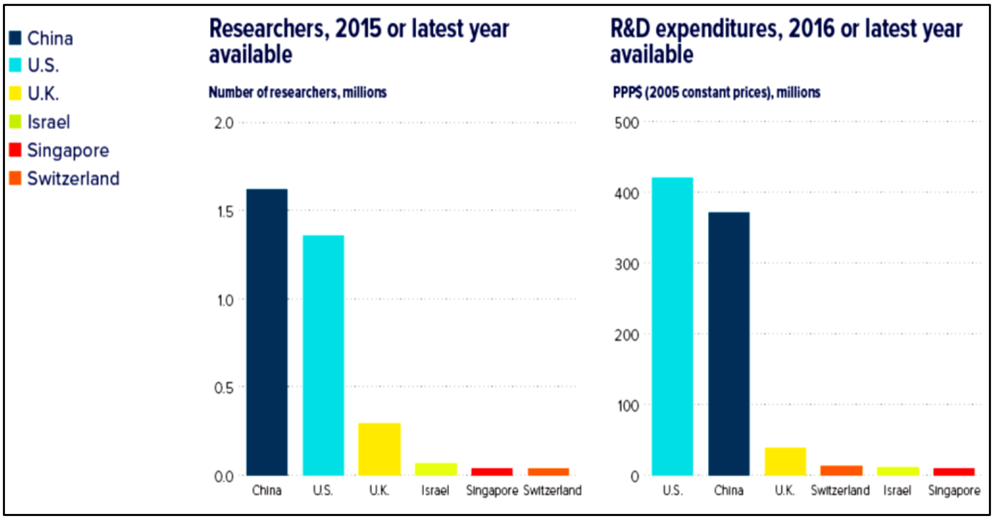
Figure 4 Gaps in Global Innovation Index scores by income groups



Source: Authour’s calculations

An analysis of the GII rankings indicates that China was ranked 17th overall, performing better than more than almost 70% of the high income countries. A trend analysis of the GII rankings indicates that China entered the top 25 group in 2016 and has consistently moved up in the rankings to reach 17th place in 2018. According to the GII 2018 Report, China has been able to make this rise as a result of improvements in global R&D companies, high-tech imports, the quality of its scientific publications, and tertiary enrolment. Furthermore, the Report indicates that, China’s score in knowledge and technology outputs continues to be above that of the top 10 group average. According to the GII Report, China’s rapid rise in the GII rankings indicates how other middle-income can possibly bridge the technology gap. China currently has the highest number of researchers per 1 million people and was second only to the United States in terms of research and development expenditure (See Figure 5). As indicated earlier, these 2 indicators have be identfied in the SDGs. Specifically, the aim of target 9.5 of the SDGs is for countries to enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending and an indicator for measuring the progress of this target is the research and development expenditure as a proportion of GDP (UN 2017).

Figure 5 Comparison of China's GII/SDG indicators against selected high income countries



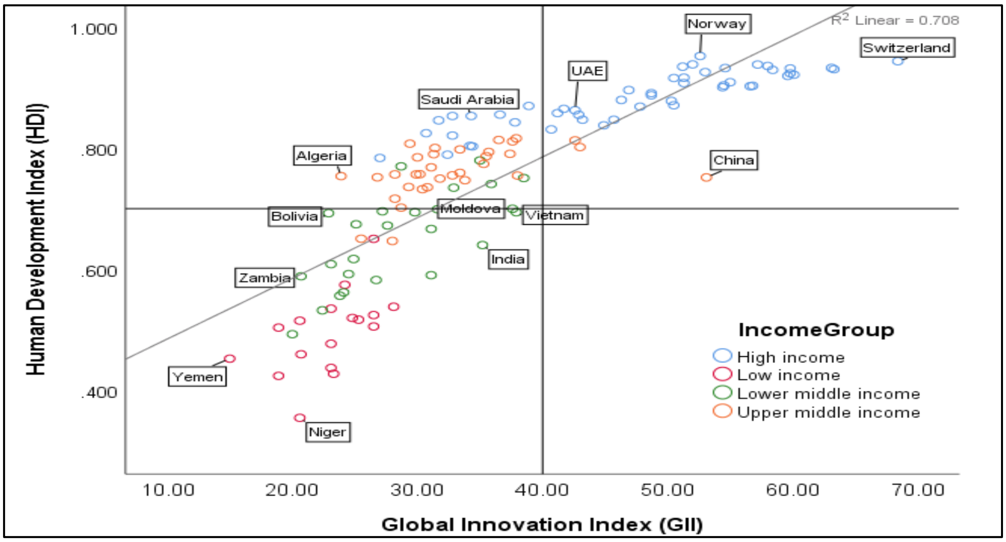
Source: Global Innovation Index Report (2018) and Dutta et al. (2018)

The findings on China's performance on the GII gives an indication of how the achievement of some of the SDG targets may improve the technological progress of countries and particular help low and middle income countries to avoid the MIT. This finding also gives credence to the earlier observations including that of the World Bank (2019) that developing countries may miss out on the benefits of the 4th Industrial Revolution, and also miss out on various SDG targets, if they do not make the necessary investments in human capital, science, innovation, research and development. Thus, the World Bank (2019) points out that, innovation will continue to accelerate, but developing countries will need to take rapid action to ensure they can compete in the economy of the future. Although China is still a middle income country, empirical studies indicate that investments in human capital and technological progress played a a key role in the the 5 East Asian countries (Japan, Taiwan, Singapore, South Korea, Hong Kong) that were able to break out of the MIT (Kanchoochat 2015).

4.3. Findings on the nexus between technological progress and Human Development Index

In order to investigate existing MIT literature claiming that countries with higher levels of technological development also have higher socio-economic development levels, a correlation analysis was conducted on the GII and HDI scores of the 126 countries The result of Spearman's correlation test of .842 indicates a strong significant positive relationship between the HDI and GII scores of countries. The implication of this result is that, countries with higher levels of technological advancement also tend to have higher HDIs. Furthermore, the coefficient of determination indicates that the GII scores helps to explain about 71% (.842 x .842 x 100) of the variance in HDI of different countries. As already discuss in section 4.3 there is also a strong positive correlation between the GNI per capita of countries and GII scores. This finding justifies the need for countries to invest in technological development not only for avoiding the MIT but also for improving the well-being of their citizens.

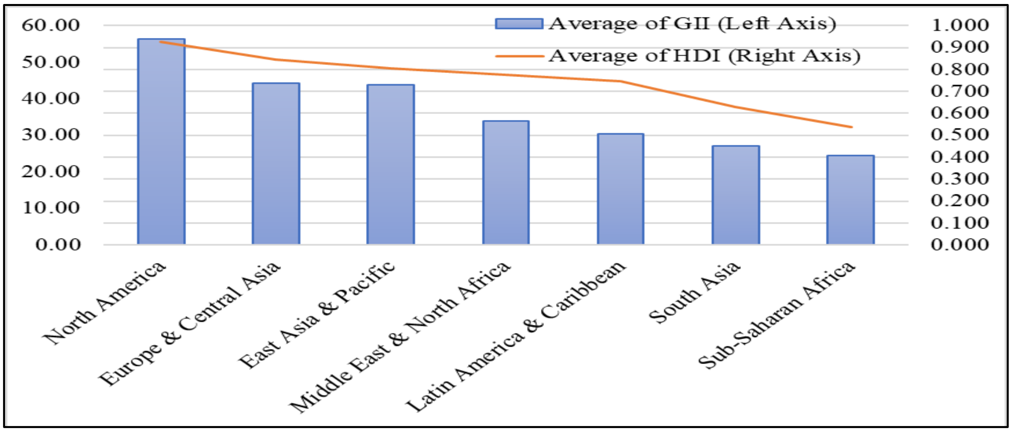
Figure 6 The relationship between the GII, HDI, and income groups of 126 Countries



Source: Authors construct based on data from World Bank (2018) and UNDP (2018) and GII.

In terms of geographical regions, the study finds that North America had the highest average GII scores as well as the highest average HDI scores followed by Europe and Central Asia (See Figure 7). The Sub-Saharan Africa region had the lowest average GII scores as well as the lowest HDI scores. The regions with higher GII scores also had higher HDI scores. These findings give an indication of the geographical location of countries with the lowest technological development as well as lower human development indicators. The findings also give an indication of the location of countries that are likely to miss out on the benefits of the 4th Industrial Revolution.

Figure 7 The relationship between the GII, HDI, by geographical regions

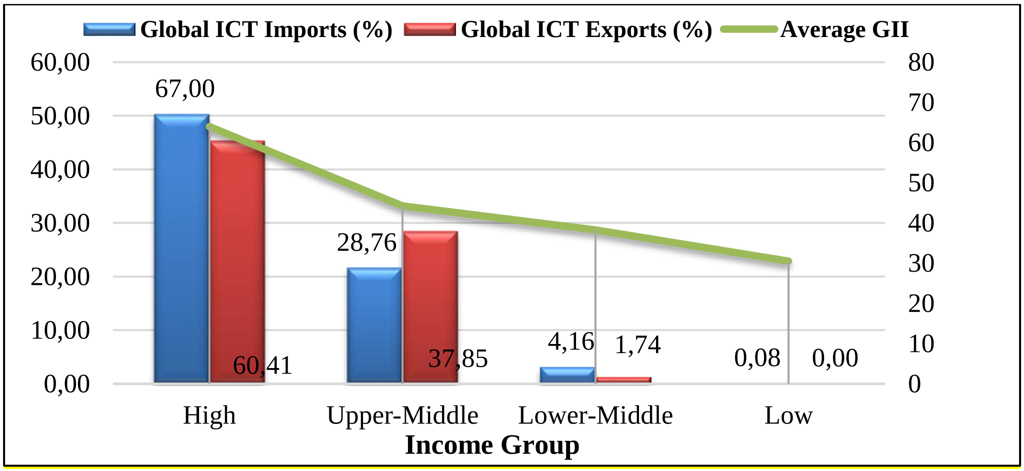


Source: Author's construction

4.4. Findings on the level of participation in the 4th Industrial Revolution by income groups

As indicated earlier, information and communication technologies (ICTs) are the backbone of the Fourth Industrial Revolution, and countries and businesses that embrace these developments, anticipate challenges, and deal with them in a strategic way are more likely to prosper, while those that do not will more likely fall behind (Samans–Hanouz 2016). In this regard, the study analsed data on global ICT Goods trade of countries by their income to access the extent to which countries are positioned to benefit from the 4th Industrial Revolution. The study finds great disparities between the high income and lower income countries (see Figure 8).

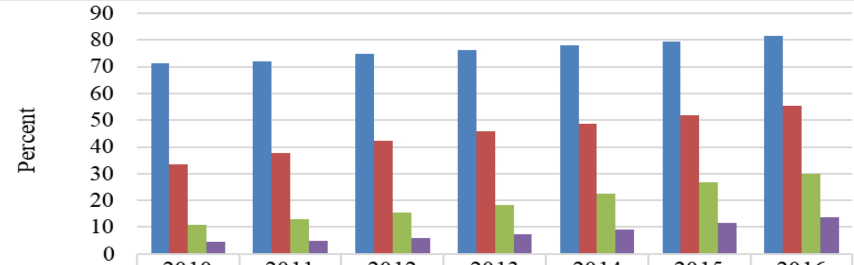
Figure 8 Correlation between GII, global ICT trade and income level of countries



Source: Author's Construction based on data from UNCTADStats and GII 2018 data.

An analysis of the most recent data on bilateral trade goods flows of countries by income level indicates that high income countries account for the majority of both global ICT imports (67%) and exports (60%) whereas middle income countries accounted for about 40%. Low income countries accounted for less than 1% of both global ICT imports and exports. There was also a positive correlation between the bilateral trade in ICT goods the and the GII scores (See Figure 8). These findings support the observation of Nikoloski (2016), who posits that developed countries have a monopoly on the sources of technological development and export of modern equipment and technology while developing countries are technologically dependent on developed countries.

Figure 9 Trend of individuals using the internet 2010–2016 (% of population) by income group



	2010	2011	2012	2013	2014	2015	2016
High income	71	72	75	76	78	79	82
Upper middle income	33	38	42	46	49	52	55
Lower middle income	11	13	16	18	23	27	30
Low income	4	5	6	7	9	12	14

Source: Author's construct based on World Bank (2018)

A trend analysis of the proportion of people using the internet in various countries from 2010 to 2016 also indicates that lower income countries lag behind the high-income countries (See Figure 9). This trend gives an indication of the extent of participation by countries in the 4th Industrial Revolution according to their income levels, and is consistent with the observation of UNCTAD (2017) that there is a "digital divide" between the rich and the poor, as developed countries massively buy goods or services from the Internet, while less than 5 per cent do so in most developing countries. As indicated earlier, the SDGs have several targets aimed at bridging the digital divide. SDG 9.c has the aim to "Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020" (UN 2017). SDG target 17.8 also has the aim to "Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology" (UN 2015, UN 2017). The global indicator for measuring progress on SDG 17.8 is for instance, the 'Proportion of individuals using the Internet' in various countries (UN 2017). The findings of this study clearly indicate that the lower income countries are far behind on this indicator and this has implications for the middle income trap.

5. Conclusion and Recommendations

The study finds a significant difference between the level of technological progress among countries in different income brackets. Higher levels of technological advancement were finds to be a strong determinant of the socioeconomic development status of countries. Countries with higher GII scores were finds to have higher output, higher income per capita, and higher human development. There was a strong positive correlation between the GII scores of countries and their HDI (.842), GNI per capita ($r = .836$), as well their GDP per capita in both current prices ($r = .780$) and purchasing power parity ($r = .696$). The findings of this study are consistent with the MIT hypothesis that countries with higher levels of technological development also have higher incomes and higher socio-economic development. The findings of this study also corroborate suggestions that countries with higher technological progress are likely to benefit from the 4th Industrial Revolution. For instance, higher income countries appear to be benefitting more as evidenced by their trade in ICT goods and the percentage of people with access to the internet. The findings of this study also underscore the need for policy makers to pay attention to the observation of UNCTAD (2017) that a major global concern is the prevalence of various "digital divides" between the rich and the poor and that, as the old ones remain, new ones are emerging.

China's stand-out performance on the GII among middle income countries and rise in GII rankings, which has been attributed to investments in human capital, science, technology, and innovation, gives an indication of how developing countries could possibly avoid or break out of the so-called middle income trap (MIT), since the hypothesis is that countries that get stuck in the MIT are those that are lower down the technological ladder. The findings also give credence to the global calls on policy makers and governments as captured in the SDGs and the World Development Report for increased investments in research and innovation as well as health and education, which are the building blocks of human capital – the drivers of innovation – particularly for developing countries, if they are to harness the benefits of technology and mitigate its adverse disruptions which are an inevitable by-product of the 4th Industrial Revolution. Although the GII does not cover all countries, this paper has used the most recent data to confirm the technological advancement, socioeconomic development, and MIT nexus and emphasizes the need for governments to invest in human capital and technological development. The weakness of a cross-sectional study is that it does not allow for explanations and understanding causal processes that occur over time; it only provides a snapshot of the prevailing phenomena. The focus of this study was just to use current data to understand the relationship between technological development and socioeconomic development, but not to infer causality. Therefore, more in-depth time series analyses is needed to understand the mechanics of the potential role of innovation and technology in helping countries to avoid and break out of the MIT. Regression models could also be used in future studies to investigate causality and the impact of technology on socioeconomic development. The author together with Udvari Beata (PhD) and Associate Professor of Economics (name missing) at the University of Szeged in Hungary are currently undertaking in-depth studies on the determinants of the MIT and key drivers for escaping the MIT. Nevertheless, this paper contributes to the existing MIT literature by providing an empirical situation analysis of the relationship between the level of innovation of countries and their socioeconomic development status using the most recent data. Whiles the GII is the index currently available that captures the multi-dimensional facets of innovation and provides the tools that can assist in tailoring policies to promote long-term output growth, improved productivity, and job growth, the methodology and scope of the GII also needs further examination. Again, further studies could build on this study by investigating the implications of the SDGs on the MIT and participation in the 4th Industrial Revolution.

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