

Impacts of technological innovation: a systematic review for smart Bangladesh

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Abstract. Economic stability is the lifeline of a nation as it is the vital condition for the standard of living of the citizens. Economic growth and stability are prerequisites for an emerging country to upgrade to the status of a middle-income country. The potential dimensions of the digital economy in Bangladesh are intrinsically linked with the fostering of economic development and prosperity by the year 2041. Technological innovation is one of the major forces of economic growth and digital Bangladesh. It is expected to impact directly and indirectly the economic development since the Industrial Revolution. Accordingly, this research seeks to provide an overview of the present impacts of technological innovation, focusing on evolving trends that have direct and indirect impacts on the economy. The methodology of the study engages a qualitative approach using a systematic review of the research objectives, applying secondary data. The findings of the study reflect on the potential of technological innovation on individual, organizational, and environmental impacts on Bangladesh. Considering the nascent impacts of technological innovation the study suggests that policymakers should take prompt action to ensure an efficient labor force through research and development and this may follow organizational excellence and environmental sustainability. The study suggests that these three dimensions will cascade in the economic improvement of Bangladesh shortly.

Keywords: technological innovation, economic impact, systematic review, qualitative approach, smart Bangladesh.

1. Introduction

Despite all the growth models argue technological development as the key to economic growth, endogenous models explain how technological development promotes economic growth. Specifically, Solow (1956), and Swan (1956), assume technology as an external element in the purview of the Neo-classical model whereas the Endogenous Growth Models by Arrow (1962), Romer (1986, 1990), Lucas (1988), Grossman and Helpman (1991a, 1991b) and Aghion and Howit (1992) assume it as an endogenous element [1].

Technological innovation (TI) plays a crucial role in determining a country's growth and development. It is a measurement technique that enhances welfare and living standards. Technology is a source of knowledge used to improve production efficiency, marketing, and new product production. With its dynamic construction, technology is used in defining the classification of countries, their industrialization, and economic policies. It is commonly acknowledged that a substantial positive relationship between the countries' high technology production and economic growth prevails in the world.

Advanced technology production implies the production of not only high-value-added but also high-yielding products simultaneously. The developed countries in the world are the forerunners in terms of high-tech product exports. Economists contend that high-tech industry exports can spur rapid economic growth across all economic sectors by promoting knowledge spillover, boosting firms' competitiveness in overseas markets, boosting the productivity of production factors and relying on skilled labor, lowering risk and stabilizing export revenues, and other means [2].

The advantages associated with owning high-technology, facilitate an economy with many competencies. Among many, the most important is economic growth. Infrastructure development investments have been the foundation of technical advancements and have become one of the most significant drivers of economic growth, particularly in developed nations. Innovations and technological advancements immediately raise productivity and output capacity. Technological advancements have made it possible to employ factors of production more effectively by boosting production efficiency. This, in turn, has accelerated economic growth and development and raised people's standards of living. Moreover, the cascading effects of TI will help nations to excel in new ideas and inventions and become more competitive in international markets by patenting new ideas and innovations produced by R&D operations [1].

In this phase, this study will accentuate the TI competitiveness of Bangladesh. With the target of being a full-fledged digital economy by 2041, TI is a potential aspect to be explored for Bangladesh prospects. In doing so the study will unfold the impacts of TI on the economic potentiality in the country. Accordingly, the following sections of the research will develop the concept of smart Bangladesh, relevant literature review, methodology, study findings, and conclusion and recommendations sequentially.

2. Smart Bangladesh

The notion of a “smart country” is an extension of the “smart city” idea that IBM popularized in the late 2000s. A smart city is a high-tech, sophisticated metropolis that uses new technologies to connect people, information, and city aspects to make it more innovative, competitive, sustainable, and livable [3].

Smart Bangladesh is about being inclusive, about the people, the citizens of Bangladesh. Built on the 4 pillars of Smart Citizens, Smart Government, Smart Economy, and Smart Society, it is about bridging the digital divide by innovating and scaling sustainable digital solutions that all citizens, regardless of their socio-economic background, all businesses, regardless of their size, can benefit from. Building on the launch pad created by Digital Bangladesh, Smart Bangladesh is the next major step towards realizing Bangabandhu’s dream of Shonar Bangladesh, a Golden Bangladesh [4].

In the Smart Bangladesh plan, the government is placing the highest importance on increasing financial inclusion through the development of citizens’ technological skills. To this end, the “Smart Bangladesh Taskforce”, led by Prime Minister Sheikh Hasina, has planned to expand the use of technology extensively in the economy, society, and government system [5].

The consistent pillars are supposed to facilitate shaping a seasoned society that nurtures technology, partnerships, and growth. The master plan of a Smart Economy is powered by modernization, a stable ecosystem, and an advanced technology-driven foundation. It contains the elements of the Fourth Industrial Revolution (4IR) that foster startups, Information and Communications Technology (ICT) that encourages smart commerce, and a robust technology and infrastructure backbone [6].

In this respect, the status of Bangladesh can be unfolded compared with global status to pinpoint our future goals.

2.1. Status of Bangladesh in comparison with the global standard

The measure of global innovation ecosystems is done by the Global Innovation Index (GII) today. In 2022 GII captures the performance of the innovation ecosystem of 132 economies and accounts the most recent global innovation trends. For the twelfth consecutive year, Switzerland tops the GII in 2022. The US, Sweden, the UK, and the Netherlands move up to the second, third, fourth, and fifth places, respectively. While North America and much of Europe lead the world in innovation, many Asian nations – particularly Korea, Singapore, China, Japan, and Hong Kong – are outperforming their Western counterparts in terms of innovation trends. These nations rank

sixth, seventh, eleventh, thirteenth, and fourteenth, respectively. After China, India is ranked 40th as well. However, Bangladesh, which is ranked 102nd out of 132 countries in the GII index, is far away from these nations. In terms of innovation, Bangladesh ranks quite near the bottom of the list of innovative nations. Even other SAARC nations like Sri Lanka with GII 85, and Pakistan at GII 87, are in better shape than Bangladesh. Following Bangladesh Nepal is at number 111. In this region no data for Bhutan or the Maldives was available.

The sectoral innovation of Bangladesh is detailed in different prioritized areas including institutions, infrastructure, market, business sophistication, creative outputs, knowledge and technology outputs, human capital, and research, to compare higher to lower-ranking situations in Bangladesh's innovation. Due to the unique nature of these fields, institutional setup exhibits innovation relative to other measurement domains (score 44.1 %, rank 87th). Our research and human capital condition, which ranks 127th and scores 10.8 %, is the poorest [7].

3. Literature review

The major impacts of innovation are identified by a literature review of many scholarly articles on Bangladesh and abroad. The core impacts of TI are jotted down from the review of many academic researchers. The streams of impacts are mainly aligned with organizational, individual, and environmental domains. The secondary data have been disclosed here and are mentioned in the following table with their specific contributions. The literature review is spanning with the research including the period from 1970 to 2022. The area of the study consists of emerging, and developing economies, Latin American countries, Advanced economies, and Asia.

Table 1. Researchers' evidence of scopes of technological innovation

Technological innovation scope	Impacts of TI	Literature Source
Individual level	Job creation, income inequality, productivity, cultural and political consciousness, cultural attitude, choices facing people, welfare level of future generation, human capital in R & D, and well-functioning labor market	[8]; [9]; [10]; [11];[12]; [13]; [18]
Organization level	Partnership between industry and educational institutions, R&D investment in high-tech industries, entrepreneurship in terms of new density and the potential of innovation, utilization of newly invented inputs, intellectual property right, patent application, patent-intensive industries, factor accumulation, and raising productivity, provision of good governance, and reassuring institutions, the endowment of information and communication technology (ICT), venture capital funding and stronger linkage and interface between publicly funded research institutes and private companies, the importance of competition and firm entry and exit barriers, well-functioning financial market, production, marketing, and customer acquisition and customer satisfaction of firms, capital accumulation, international competitiveness, quality of scientific research organization, trade volume, barriers to entry (Market Accessibility)	[8]; [14]; [9]; [16]; [17]; [12]; [18]; [1]; [19]; [13]; [20]; [21];[15]
Environmental level	Physical environment: Use of natural resources, renewable energy use, CO ₂ emission, environmental protection, green economic development, ecological footprint Social Environment: Culture, and religious belief, social and environmental condition, solid political stability	[2]; [21]; [16]; [22]; [23]; [24]; [13]

The review of literature explored three scopes of the possible impacts of technological innovation. It was found that through the individual, organizational, and environmental levels TI can impact an economy. The individual impact is operationalized as such that it will directly

impact the individual traits of the labor force and impact their productivity. The organizational impact is portraying those impacts that will change the organizational performance. It helps to change the efficiency of the organization by changing its productivity, cost of production, and working strategies. Finally, the environmental impacts are categorized by the researchers as physical environmental and social environmental. The physical environment explains how technological innovation ensures natural environmental sustainability while the social environment displays the cultural and political impetus of technological innovation in an economy.

Accordingly, it was found that technological innovation helps to mold the individual traits of the citizenry of a nation. It reduces unemployment [8], enhances people's choice options, and productivity, plans for future generation welfare, and ensures the market accessibility of the labor force [9]. It further impacts cultural attitudes towards technology and thus shapes the standard of living of the labor force [10]. In this regard, the pervasive technical and tertiary education to augment the absorptive capacity of labor to get benefitted from technological innovation is required [13].

The organizational impacts of TI signify how it facilitates an organization to excel. The high-tech export sectors are crucial for TI [14]. TI facilitates the organization in having productivity gain, capital accumulation and international competitiveness [9]. It is done through the performance of production, growth, marketing, and customer acquisition and customer satisfaction of firms [15]. TI influences the domain of strategic industries, such as environmental protection, microchips, and high-end instruments industries [16]. TI further guides the organizations to protect the Patent rights to have faster growth through both factor accumulation and raising productivity [19]. In this vein to allow more organizational impetus through TI, literature explores the need for good governance, and reassuring institutions, the impressive endowment of information and communication technology (ICT), provision of venture capital funding, and stronger linkage and interface between publicly funded research institutes and private companies from the organizations' end [13]. Moreover, the partnership between industry and educational institutions is considered as a way out as well [8]. The need for financial market stability is also reiterated in the literature to avail the benefit from TI [20].

The third impact of TI is categorized as environmental impact. The physical environment includes the sustainable use of environmental resources, while the social environment impacts include the cultural and political capacity to absorb TI outcomes. The change in renewable energy production per capita is a possible impact of TI intervention [21]. It isolates the impact of green economic development as well [22]. Accordingly, TI to ecological footprint to CO₂ emissions are significant concerns to an economy [23, 2].

The social environmental arena requires TI to simultaneously promote economic progress and advance social conditions [24] In this aspect TI pursues to mold the culture and religious beliefs [2]. For instance, solid political stability is a prerequisite to perform organizational efficacy which is aligned with TI [13].

4. Methodology

Finding, assessing, and interpreting all relevant literature on a given research question, topic area, or phenomenon of interest is possible through the use of a Systematic Review (SR) [26]. Additionally, it is described as a methodology that condenses the steps involved in gathering, organizing, and evaluating the body of literature already in existence in a review topic [22]. Given the goal of the study, which is to pinpoint knowledge gaps in the field and make recommendations for further investigation, an SR was deemed suitable [27-28]. It is thought to provide a substantial contribution to our understanding of the field by pointing out gaps and outlining potential future study topics [29].

This review study is directed by several collective guidelines that were recognized by Kitchenham and Charters (2007) and Ali and others in 2021 [25, 30]. The guidelines include three

consecutive stages namely planning, execution, and reporting. Rules applied for the planning stage include the identification of the need for an SR, defining research questions, classification framework, and research strategies. The execution step involves keyword search, applying filters, reading title and abstract, reading full articles, backward snowball, and quality assessment. In the reporting step, this review included classifying the selected articles and discussing the results. The guideline of SR is presented in the following flow chart below:

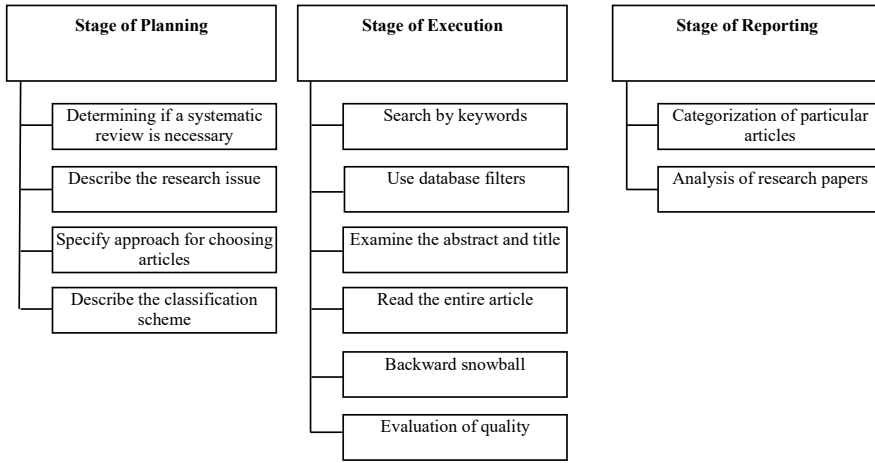


Fig. 1. Stage of systematic review

The SR further allows the researchers to obtain the articles from the previous step meticulously for relevant information in the following screening process.

Table 2. Article selection characteristics

Characteristics	Included	Excluded	Rationale
Type of Publication	Scholarly publications	Resources which are not academic	In order to guarantee that the study obtains data from scholarly sources
Evaluated by peers	Evaluated by peers	Books, dissertations, and abstracts which have not been reviewed	To ensure that the used papers are of a high quality
Year of Publication	Articles published starting in 2008	Papers published prior to 2007	The current review covers the years 2007-2023, but no papers are included in the study that were published before to this time
Language of articles	Language included English only	Any language except English	Research publications must be written in English

The authors applied a qualitative research method to address the research targets. The secondary Literature was accordingly targeted which is original, pertinent, and useful for future researchers. These criteria were essential to provide valuable and significant contributions to the research community. These selected studies were classified according to their main research aims, methods, contributions, and results. This categorization has enabled us to identify, extract, classify, and synthesize data responding to research issues.

The current review study took place from 2007 to 2023, following the research protocol stated in the planning stage. The initial search, based on the defined keywords, identified 60 articles. After applying all the steps, 45 research articles met the quality assessment criteria.

5. Study findings

The study findings focus on the TI impact on the Bangladesh economy through the channel of individual level, organizational level, and environmental level. These three channels are considered standard since these sources are identified from the scrutiny of the literature review on various categories of economies of the world. Accordingly, the individual, organizational, and environmental effects of TI in Bangladesh are explored in the following:

5.1. Individual effect

One of the striking findings for Bangladesh is that both product and process innovation spur employment in this region as a whole, regardless of low-tech and high-tech industries, even after controlling for several firm-specific characteristics. Moreover, although both innovation types have significantly positive impacts on the employment growth of all Bangladeshi firms they are important factors for the employment growth of only high-tech Bangladeshi firms [31].

In the context of Bangladesh demographic transition is a driving force for TI. If digitalization is a measure of TI it can be found that, an increase of 1 percentage point in the number of internet users, the GDP would increase by 0.11 %, *ceteris paribus*, while a 10-basis point decrease in the dependency ratio would increase the GDP by 7.2 %, on average. The key driving factors for digitization are the labor participation rate, workers' productivity, and mobile penetration [32]. Accordingly, for the context of Bangladesh, TI can effectively impact on the economic growth once it is empowered by demographic dividend.

Another study findings established bidirectional causality running between financial development and human capital development and unidirectional causality running from ICT investment to human capital development [33]. Therefore, it assumed that human capital development in Bangladesh critically relies on financial sector growth and development in the ICT sector.

5.2. Organizational effect

Our results reveal that Bangladeshi firms' process innovation is an important factor for their labor productivity, whereas the significant effect of product innovation is not clearly established [34].

In this vein, though the macro effects are rarely analyzed a micro perspective can be observed from case studies in Bangladesh. A study investigated the relationship between the intellectual capital efficiency and organizational performance of the pharmaceutical sector in Bangladesh which enjoys Trade-Related Aspects of Intellectual Property Rights (TRIPS) relaxation. Value-added intellectual coefficient components (i.e. human capital, structural capital and capital employed) significantly explained asset turnover and return on assets but failed to predict the return on equity outcome. Additionally, asset turnover was negatively influenced by structural capital and positively influenced by capital employed. The return on assets was mostly affected by variations in human capital. Intellectual capital did not predict market-to-book value or investment decisions [35].

Another case study gauged the impact of information technology (IT) adaptation, voluntary disclosure, and open innovation on sustainable financial performance in bank-based financial institutions in Bangladesh [36]. The study revealed that IT adaptation positively and statistically significantly ties with all the measures of sustainable financial performance, suggesting the validation of the hypothesis that IT adaptation enhances a firm's financial performance.

5.3. Environmental effect

The underlying theoretical framework argues that technological innovation, which is regarded

as an exogenous variable, will increase energy efficiency and lead to reduced energy consumption up to a certain economic output. This theory is validated for Bangladesh for both the short and long run. Another study revealed that in the short run, infrastructure and technological innovation both have a positive and significant impact on industrial growth. Thus, indirectly this study also follows the Environmental Kuznets Curve (EKC) hypothesis and supports the dynamics of GDP per capita and trade openness on energy consumption in Bangladesh [37-38].

A different study investigated the influences of green energy, technological innovation, economic growth, urbanization, and labor force, on the low-carbon economy in Bangladesh. The empirical results revealed that a 1 % increase in economic growth, urbanization, and labor force would lead to 1.09 %, 1.14%, and 0.19 % increase in carbon economy in the long run while 1.67 %, 1.50 %, and 0.29 % increase in the short run, respectively. However, the findings indicated that a 1 % boost in green energy utilization and technology innovation would result in a 0.21 % and 0.18 % decline in the carbon economy in the long run whereas 0.15 % and 0.10 % drop in the short run, respectively. The outcomes of the investigation demonstrated that economic growth, urbanization, and labor force all impact adversely to accomplish the low-carbon economy, making green energy utilization and technological innovation the best crucial approaches to maintain environmental sustainability [39].

A similar study estimated that, a long-run coefficient of technological innovation is negative but not significant, implying that a 1% increase in technological innovation results in a 0.07 % reduction in CO₂ emissions. The empirical findings reveal that economic growth increases CO₂ emissions in Bangladesh while increased renewable energy use and technological innovation help to achieve environmental sustainability by reducing CO₂ emissions [40].

TI reinstates environmental well-being by curbing Bangladesh's emission figures. It is seen to moderate the relationship between petroleum consumption and carbon emissions by jointly reducing the emissions with petroleum consumption [41]. TI also plays an important role in promoting energy intensity where it is influenced by financial development and trade openness [42].

6. Conclusion

There is a huge domain of research that addresses the impact of TI in the economy either directly or indirectly. Most of the publications focus on TI's impact through some specific channels on the economy. This study avails a TI framework consisting of three directions, precisely the organizational, individual, and environmental impact. In this vein, this study unfolded the various dimensions of the effects of TI in the world. Among them, the individual level is specified as the individual productivity of the citizenry of a nation through ensuring TI. Job creation, income equality, productivity, cultural and political consciousness, cultural attitude, choices facing people, welfare level of future generations, human capital in R&D, and well-functioning labor market are the attributes found in the individual level impacts.

In Bangladesh's context, the direct macro-level literature linking human capital and technological innovation is scanty. It is visible indirectly at the micro level like in the manufacturing sector, agriculture sector, etc. But to explain it at the national level no study was found evident. On the contrary, the macro perspective opines that a demographic dividend may empower technological innovation in the country. Since the R&D investment is very negligible in Bangladesh the TI may not reflect on human capital. Bangladesh's economy has been growing at a striking rate in the last decade on the back of low-paid workers in the manufacturing and service sectors but innovation has played an insignificant role in the development journey. The main factor behind this poor innovation is a lack of investment in research and development (R&D) in both public and private sectors of the economy [43].

Secondly, organizational performance also is an impact of TI that includes many attributes. They include partnerships between industry and educational institutions, R&D investment, entrepreneurship in terms of new density, patent application, patent-intensive industries, factor

accumulation, good governance, a splendid endowment of information and communication technology (ICT), venture capital funding and stronger linkage and interface between publicly funded research institutes and private companies, importance of competition and firm entry and exit barriers, well-functioning financial market, production, marketing, and customer focus, capital accumulation, international competitiveness, quality of scientific research organization, trade volume, barriers to entry (Market Accessibility).

In exploring the role of TI on organizational performance many studies showed that it is not technology alone but a combination with other inputs that helps technology to impact in Bangladesh. Accordingly, the environmental, and organizational factors help the technological factors to impact on organizational performance in Bangladesh [44-45].

Accordingly, a study identified that in a developing country like Bangladesh, funding challenges are the main barriers to innovation in small and medium-sized enterprises (SMEs). It also blamed human resource barriers and external barriers to a certain extent. Furthermore, in some cases, organizational barriers also create obstacles to innovation.

Finally, the environmental impact of TI is directed into two streams. They are physical and social. The use of natural resources, renewable energy use, CO₂ emission, environmental protection, green economic development, ecological footprint are the physical impacts of TI. On the contrary, TI also impacts socially through culture, and religious belief and political consciousness.

In Bangladesh TI with infrastructural capacity has shown a major and favorable short-term influence on industrial growth [38]. Another study showed that the use of renewable energy and TI would, over time, cause the carbon economy to shrink both in the long run and in the short term [36]. Green energy utilization and technological innovation are found to be the best crucial approaches to maintain environmental sustainability in Bangladesh [39].

The interlinkages between environmental, economic, organizational, and individual effects of TI are visible in the context of Bangladesh. It is found that organizations are unable to avail of technological adaptation and innovation due to a lack of funding, expertise and a positive mindset. On the contrary, the labor force will not be ready until the potential R&D on research is there to empower them. In response to the individual and organizational effects of TI the environmental effects is visible in a very discontinuous and negligible manner in the context of Bangladesh.

The study provides insights to assist the government and policymakers in framing a roadmap on how Bangladesh could utilize the various channels of TI and make the best use of it. TI is the potential backup for an economy in ensuring an efficient labor force, organizational excellence, and environmental sustainability. It can pursue economic goals by providing a quality labor force, organizational excellence, and a sustainable environment. Accordingly realizing the true potentiality of TI policy policymakers should frame their policies to make the best economic impact out of it. The public and private sector R&D funding and its implementation is the ultimate strategy the government should follow considering the nascent TI status of the country.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contributions

Tabassum Zaman: conceptualization, formal analysis, funding, acquisition, investigation, methodology, project administration, resources, supervision, validation, visualization, writing-

original, draft preparation, Writing-Review and Editing. Soma Bhattacharjee: data curation, formal analysis, funding, acquisition, investigation, methodology, software, validation, visualization, writing – review and editing. Fahmida Sultana: investigation, methodology, resources, software, visualization, writing – review and editing.

Conflict of interest

The authors declare that they have no conflict of interest.

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