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INEQUALITY IN THE LABOR MARKET AMID THE ADOPTION OF THE FOURTH INDUSTRIAL REVOLUTION TECHNOLOGIES IN DEVELOPING COUNTRIES

Exploring the Relationship between the Labor Policies, the Digital Gap, and Inequality Outcomes in a Cross-country Analysis

Dissertation submitted by

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in partial fulfillment of the requirements for the degree of

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Abstract

This thesis explores the role of labor market policies and the inequality in labor markets resulting from the adoption of digital technologies amidst the fourth industrial revolution in developing countries. It aims to determine whether stronger labor market policies are negatively associated with the digital gap in these nations. Additionally, the study postulates that a larger digital gap is positively associated with inequality outcomes in the labor market, including labor income shares and unemployment. To begin, it develops a Digital Gap Index by calculating the gap between the digital opportunities and their attainment. It adopts a mixed method approach to explore the association between the digital gap and the role of active labor market policies, as well as its correlation with inequality consequences. Quantitative data is analyzed using a panel data regression analysis with random effects model, while qualitative case study techniques are applied to investigate the digital gap in developing countries. The study focuses on lower-middle income countries categorized by the World Bank. Findings reveal that the digital gap does not exhibit a strong correlation with labor market policies. Furthermore, inequality consequences are not significantly associated with the digital gap across developing countries implying their unpreparedness to utilize the digital opportunities. This paper contributes to the global measurement of digital gap and extends our understanding of its association with labor market policies and its impact on inequality consequences in developing country contexts. Scholars and policymakers can benefit by this research to further explore post-digitalization labor market inequality.

Key words: Digital Opportunities, Digital Gap, Labor Market Policy, Inequality, Developing Country

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List of Abbreviations

ALMP	Active Labor Market Policy
4IR	Fourth Industrial Revolution
UNCTAD	United Nations Conference on Trade and Development
IV	Independent variable
DV	Dependent variable
ILO	International Labour Organization
WB	The World Bank
ITU	International Telecommunication Union
WEF	World Economic Forum
GDP	Gross domestic product
WDI	World Development Indicators
GII	Global Innovation Index
ICT	Information and Communications Technology
GCR	Global Competitiveness Report

Introduction

The era of the 4IR has compelled the adoption of digital technologies that has ushered in the transformative changes through increased digitalization and automation impacting labor market (Buschmaas et al., 2019; Chinoracký & Čorejová, 2019; McKinsey & Company, 2022; Schwab, 2016). Notably, the prevalence of digital gap has become a common phenomenon, exhorting labor market policies and exacerbating inequalities across among income groups, particularly in developing countries (Buschmaas et al., 2019; Choi, 2017).

Governments around the world are grappling with the challenges posed by the rapid labor market transformation, as the advent of the 4IR poses risks to workers and necessitates political intervention to address the unpredictable consequences of technologies (Charles et al., 2022; K. Zervoudi, 2020). While developed countries have already taken the leading role in adapting to these transformational changes through state-of-the art applications, such as digitalization and artificial intelligence (Alonso et al., 2020), developing countries face formidable challenges in catching up with the pace of the technological advancement and taming the best out of it (Choi, 2017). Furthermore, the 4IR is driving an evolving new job market (Waring et al., 2020) that might have implications for various policies, like education policies to cater needs of the new workforce (Holzer, 2022; Kupets, 2015; Sloane & Mavromaras, 2020).

The digital transformation of the labor market in developed countries and its impact on the inequality outcomes are sophistically researched by many scholars with up-to-date data-driven approaches (Bagchi, 2005; Lucendo-Monedero et al., 2019; Rueda, 2015; Vasilescu et al., 2020). However, the same issue in developing countries remains underrepresented in scholarly studies and on the global agenda of inequality and labor rights, where it needs attention (Charles et al., 2022). Worryingly, UNCTAD (2018) reported that only 4% of the Least Developed Countries provide data on how businesses can use ICTs compared to 85% of the developed counterparts.

As the feature of the 4IR is going to be autonomous; thereby, it will change the ways we live and communicate and the way we are involved in production and operation (Ross & Maynard, 2021). With this technological transformations, inequalities may arise among the laborers, calling for labor market policies backed collective bargaining and other market forces to play roles to drive out inequalities (Dreger, 2016; Schwab, 2016). Therefore, it is imperative for research, business, and government in developing countries to collaborate to

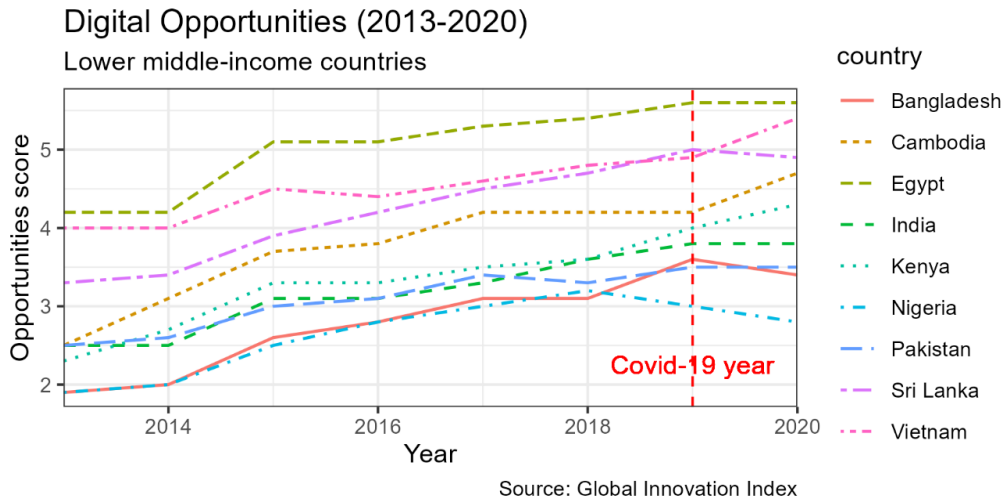
devise better strategies to deal with this burgeoning problem that could potentially exacerbate the inequality consequences (Charles et al., 2022; UN, 2019).

Considering the challenges and prospects, this paper seeks to investigate the effects of digital technologies on labor market and the role labor market policies addressing subsequent inequality in developing countries. By exploring the digital gap's implications and its interplay with labor policies, this research aims to contribute to a deeper understanding of this pressing issue and foster informed policies for addressing inequality in the context of the 4IR.

Problem statement

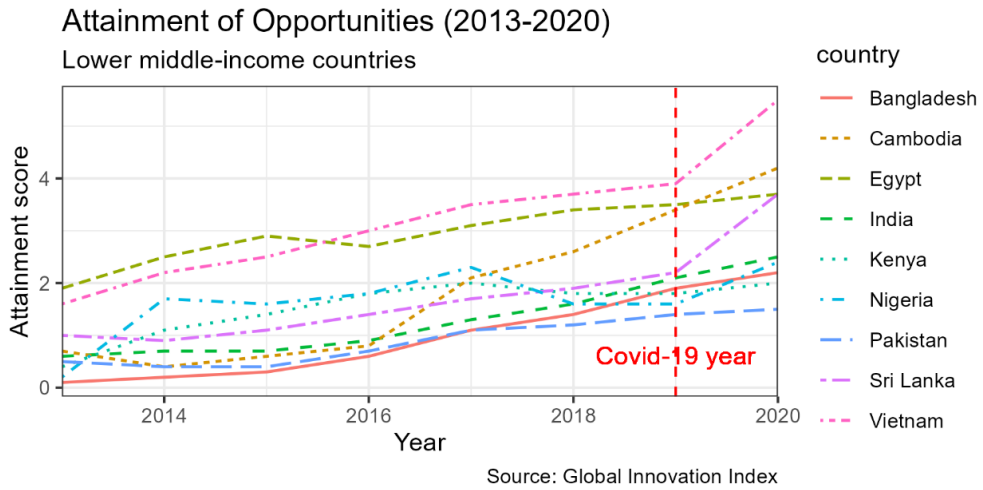
Digitalization is the key drivers in this foreseeable technological change that is happening in every sector, where automation is the most common features to be adopted in the industries (Chung, 2021; McKinsey & Company, 2022) that directly and indirectly can affect the labor market outcome and create inequality in 'societies, on institutions, and economies' (Xu et al., 2018).

Figure 1: Digital opportunities, from 2013 to 2020



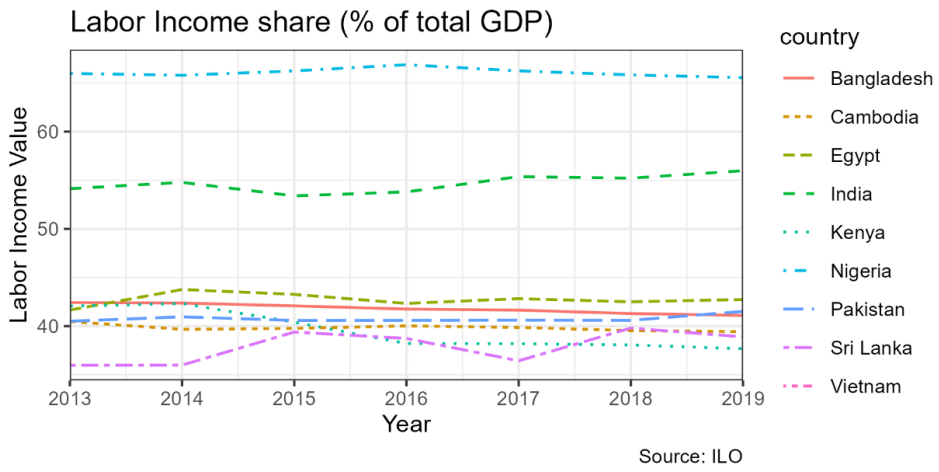
The above Figure-1 shows that there is a rising trend in digital opportunities in developing countries since 2013. For example, Bangladesh starts at the lowest in the beginning and continued to deploy more and more opportunities in the subsequent years until the Covid-19 pandemic year, which is not included in the analysis of this paper. The other countries also manifested their strong commitment to accelerate the allocation of more digital opportunities over the years. The problem arises when people cannot cope with the increasing opportunities that requires new set of skills (Bhorat et al., 2023; Islam et al., 2018; Kupets, 2015).

Figure 2: Attainment of the digital opportunities (2013-2020)



The attainment of the technologies also demonstrates a rising trend over the years (Figure-2) among the developing countries, where Bangladesh begins at the lowest point to the consistently rose surpassing some of its counterparts. There are few countries, which experienced both ups and downs except Bangladesh, India, and Vietnam. Cambodia appears to jump significantly high in the group. Overall, it points out that the developing countries are adopting more digital technologies over the years and trying to attain those opportunities.

Figure 3: Labor income share (% of total GDP) annual



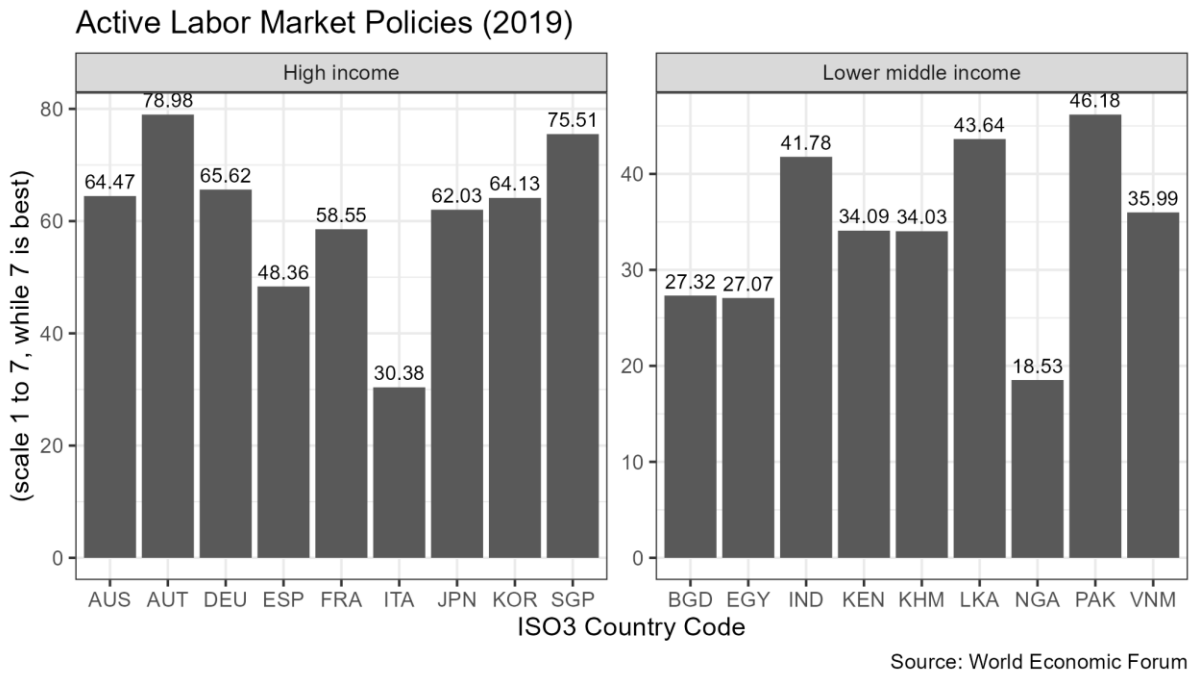
There are some structural labor market problems such as rising unemployment, skills mismatches, declining labor income share, which could be aggravated by the digital gap and weak institutional support (Walwei, 2016). Although the data distribution is less time-variant and nearly static on the trend curve of Figure-3, the graph indicates that the labor income value among the lower middle countries is relatively low, which is higher for their high-income counterparts (Annex). It indicates that the development and economic growth of

whatever forms in those countries does not necessarily help the labor market to increase its income to tame different opportunities introduced over time.

Transformation in developing countries is happening through high economic growth (Annex) and accelerated development, which manifest more industrialization and income growth. Digital technologies are coincidingly being integrated at a fast pace and the gap between the capital and investment benefits and labor benefits are expanding in those countries (Heeks, 2022). Inequality in the labor market in developing countries will be evident mostly due to lack of preparedness, digital infrastructure, proper policies, and regulations (Sirimanne, 2022). For example, the skill gap might displace a lot of low or mid-level employees in each firm, which adopted 4IR technologies. Countries like Germany (Walwei, 2016) and China (J. Y. Lin, 2012) have been trying to support this possible source of inequality by developing policies.

A comparison between the lower middle-income and upper-income countries (ISO3c codes; Annex:1.2.) based on data from 2019 finds that labor market policies are weak in developing countries.

Figure 4: Active Labor Market Policies across Countries



Active labor market policies are very important tools for the developing countries to deal with this situation to facilitate research-firms collaboration, reskilling, and upskilling of the labor, and increasing preparedness for the changed circumstances. However, the question is

whether there are any gaps between the digital opportunities and their attainment. If there exist any digital gaps in-between, what is the performance of the institutions such as labor market policies, digital skills that support the labor market minimize the gap? What is the impact of the digital gap that might impact the inequality consequences in the labor market?

Learning from literature

The emergence of the 4IR, rapid digital transformation and labor market transition

The idea of the 4IR started in Germany in 2013 and has steadily been gaining attention in other advanced economies (Petrillo et al., 2018). Schwab (2016) characterizes the 4IR as a distinct development in industrial history, which is a fusion of technologies through which lines are being blurred between the physical, digital, and biological spheres of humankind with the most common component, such as- Artificial Intelligence, augmented reality, additive manufacturing, and Internet of Things. The third industrial revolution made computers at the forefront of everything and accelerated our ability to function through computerization. This expedited digital development laid the foundation stone for the ongoing transformation of industries to enable the fourth one through the innovation of accessible internet, software, and autonomous machine operation (Bajpai & Biberman, 2019). Subsequent industrial revolutions in the history brought different changes in the roles of jobs and the modes of production (Soh et al., 2020; Xu et al., 2018). For example, the driverless metro or cars are vivid cases of it. International Monetary Fund (2018) finds a drastic decline in the share of jobs in the manufacturing jobs in the last five decades in developed countries. However, developing economies can still hold it flat. The important question is whether it impacts a lot on income inequality and growth distribution (Soh et al., 2020).

After the immediate transition, workers do not have the skill and knowledge, thus, they accept a low-wage job condition; therefore, labor productivity and income growth has been observed to be slow (Acemoglu & Restrepo, 2018b). This wage cut increases the income inequality in the country because of the downsizing of the wage distribution. Whether these displaced workers immediately move to the service sector or remain unemployed for some days could give them a chance to reskill themselves is a fact that cannot be underestimated. Besides, job loss in manufacturing is not the only factor proven to cause income inequality. Studies are needed to identify the others (Novta & Pugacheva, 2019).

Furthermore, Acemoglu & Restrepo, (2018c) argues that the prediction of human replacement by machines by Keynes (2010) cannot be called correct as significant technological unemployment did not happen. A question is asked by Bajpai & Biberman (2019) that is it possible to maintain a stable relationship between humans and machines in the labor market and production (Acemoglu & Restrepo, 2018c) amid the 4IR as it did not happen in the past industrial revolution between horses and machines?

Acemoglu & Restrepo (2019) argues the implications of technological change and their impacts in two ways. In one trend, it shows that the adoption of machines and automation leads to the loss of jobs for many. A mismatch between technology and skills could have multiple effects on employment, productivity, and economic growth. During the severe skill mismatch, the rate of inequality could reach a very high level that could mean a worse situation for the policymakers to solve this problem (Acemoglu & Restrepo, 2018a).

Implications of labor market transition for key policy areas

The WEF is leading the study of the 4IR and its effects on the labor market. It emphasizes the recognition of all types of works emerged after the adoption of new technologies and the employment of new policies to regulate the labor market and ensure the rights, employment benefits and protection of the workers (Schwab, 2016). Various key areas of actions have been identified, such as empowerment of individuals and their protection through policies and regulations (Schwab, 2016; Waring et al., 2020). Furthermore, Waring et al. (2020) researched on the 4IR and its challenges and opportunities where he finds that the job displacement and skill transition are vitally interconnected in the advent of the new job roles.

For highly populated countries, technological change can disproportionately increase the demand for capital and drive to a great job loss due to automation, which, eventually, affect income distribution and deepen the gap between high and low-skilled work force (K. Zervoudi, 2020). Third world countries could face huge challenges in skilling and reskilling the huge population to match with the technological needs due to lack of their capacity (Badiuzzaman & Rafiquzzaman, 2020; Choi, 2017).

Introduction of industrial robots in Germany causes increasing inequality among the ex-ante workers (Dauth et al., 2021). Whoever managed to stay at the factory and whoever needed to leave after the automation will result in a gap because of the drop-in earnings. There is no guarantee for the displaced workers in the newly introduced tasks due to technological advancements. Automation weakens the bargaining power, which is rigid in adjusting the real wages of the workers that increase the fluctuations in unemployment and vacancy rates (Leduc & Liu, 2022). The middle class that grew upon the skills required by the third industrial revolution might take a significant blow as their middle-class status could be threatened by the reduced income. Because of the shift in demand for skills, their wages could be lowered that will lead to income inequality (Bajpai & Biberman, 2019).

Millington (2017) suggests that digitalization does not indicate huge unemployment, rather it widens the income inequality. He maintains that the middle-skilled jobs are prone to be replaced by automation, while the high and low-skilled jobs are experiencing expansion to different extents. On the other hand, less educated people can face huge income inequality due to lack of skills and training, which they cannot avail themselves. Acemoglu & Restrepo, (2019) observes that the historical trends of automation and their impacts do not always imply the displacement of jobs, rather they also created a lot of new jobs that prevail over time. The emergence of new tasks due to technological change, thus, creates reinstatement effects in the labor market (Acemoglu & Restrepo, 2020).

Mitigating the challenges after the transition: actors and factors

A precondition to building 'just societies' implies designing institutions that can support the labor market by creating 'quality jobs with decent wages and working conditions' and can enact policies to assist the unemployed to find work (Dreger, 2016). Governments have a large role to play to ensure that everyone in society can avail themselves of the benefits of 4IR (Dewan et al., 2022; McKinsey Digital, 2016) while also guarantying employment and social safety through policies and regulations. The first target people for the regulatory regimes and employers are the laborers at high risk of displacement due to automation and their smooth transition to the new types of jobs. Otherwise, it will lead to a 'dystopian future' for the labor market (Waring et al., 2020). Acemoglu (2003) exemplifies the decreasing inequality in Europe because of the employment of skilled workers.

Reducing inequality is a complex job and can be solved through effective structural reforms that can lower the disparities at the distribution of income (Hacibedel et al., 2019). Focusing on the labor market of Asia and Pacific, Campbell (2020) identifies policies, regulations and institutions are the key working areas to advance the idea of the 4IR. Most of the population in the region are still out of the reach of the 4IR because of their lack of accessibility to high-speed mobile internet and uninterrupted electricity supply.

There are some prescribed goals of policies, regulations and institutions of labor market, such as social justice, and equity that can steer the direction to more welfare achievements (Van Der Hoeven, 2000). Some countries have already developed policy and legal frameworks to address these issues. For example, "Industry 4.0" of Germany, "Advanced Manufacturing Partnership" of the United States, and "Made in China 2025" of China are noteworthy public policies that can guide the others based on their needs (Asghar et al., 2020).

The labor market in the developing countries amid the 4IR

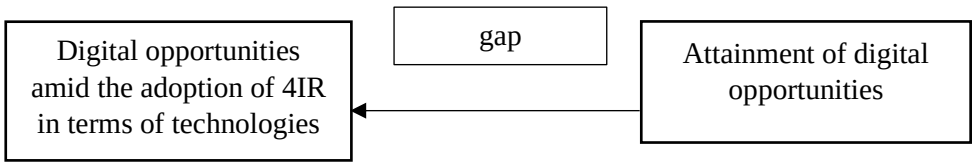
Challenges for the 4IR in developing countries could be manifold like poor infrastructure, cheap and available labor, expensive technologies and lack of knowledge on how to adapt to these new digitalized and automated spheres (Sirimanne, 2022). Lack of support from the government is also a factor that could potentially downgrade the pace of adoption of the 4IR (Islam et al., 2018). One of the major challenges for the developing countries is the skill mismatch that might affect the labor share due to automation (Acemoglu & Restrepo, 2018c). Then, it will increase the inequality in the income share and unemployment. This job polarization and income inequality due to digitalization (Cavenaile, 2021; UN, 2019) could fuel social unrest and class tension in society, especially when it happens in the developing or underdeveloped countries. Nevertheless, Autor et al. (2015) hopes that automation substitutes and complements labor, that means, when it displaces labor, simultaneously, it can create new tasks and roles, increase productivity and earnings, and augment demand for more labor.

Conceptual framework

The *4IR* has brought a lot of changes in the labor market demand, production and operation with new roles and modes replacing the old ones that would require new skills (Bajpai & Biberman, 2019; Islam et al., 2018; Schwab & Zahidi, 2020; Soh et al., 2020). For example, unmanned vehicles are replacing conductors with programmed machines that can autonomously navigate the roads and drive the vehicles. New tasks will emerge because of technological advancement, apparently because of the 4IR in the forms of programming, design and maintenance of high-tech devices and equipment, where applications and software, database management, digital security as well as the task related to automated operation are evident (J. Lin, 2011; Schwab, 2016).

The digital gap implies a gap between the existing digital opportunities in a given society and their attainment (Bagchi, 2005; Dijk, 2017; Heeks, 2022). The scopes and current spheres of the digitalization of the labor market encompass highly dynamic occupations and varieties of implications. For instance, while digital workers are largely reported to be young and male, highly skilled groups are greatly represented in the high penetration of digitalization (Charles et al., 2022). If people cannot cope with technological opportunities, they are excluded (UNESCO, n.d.) and, eventually, underperformers, which eventually creates inequality, which is confirmed by an study in India on the usage of ICTs (Tewathia et al., 2020). The gap between the attainment and the digital opportunities shown in Figure-5 can provide us a picture of to what extent people are taming the benefits of the adoption of the technologies at their disposal.

Figure 5: Digital Gap Mapping

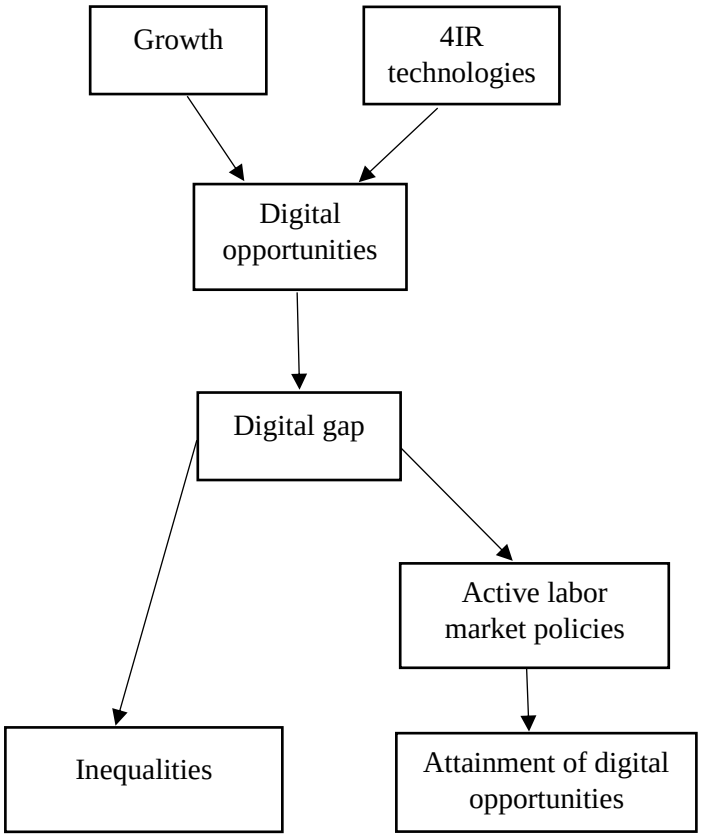


Source: Author

Institutions and support refer to the policy and other institutional support to mitigate the challenges in the labor market (Dreger, 2016) to bridge the gap between the digital opportunities and their attainment. *Active labor market policy* is the most required support to the evolving inequality in the labor market (Calderón & Chong, 2009; Rueda, 2015; Van Der Hoeven, 2000). Strong and active labor market policy can support the industry and educational institutions to collaborate to get the best out of each other to tame the benefits of

the 4IR, such as investing in research and development (Alonso et al., 2020; Calderón & Chong, 2009), and skill and manpower supply (Arthur & Hondo, 2022). *Digital skills* and trainings are the most needed available tools (Charles et al., 2022; Opp, 2021) to deploy to deal with the inequality consequences of the adoption of the 4IR technologies in the labor market in developing countries. Labor market institutions broadly refer to policies and regulations that deals with key issues, such as minimum wage, collective bargaining, the type of employment contract, and working conditions as well as income redistribution towards achieving equality of opportunities (Dreger, 2016).

Figure 6: Digital Gap, Labor Market Policies, and Inequalities Nexus



Source: Author

Inequality in the labor market is a common phenomenon among developing countries due to adoption of the digital technologies (Heeks, 2022) amid the 4IR. They face the most challenging situation as they are in transition from underdevelopment to development. Moreover, the sudden arrival of the new technologies and their required adaptation has compelled them to be into a race in 'new work and institutions' (Cozzens, 2019). Due to changing demand in the job market because of the adoption of digital technologies, the evolving predicaments of inequality in the labor market is an inevitable scenario like in a

quandary (Rodino-Colocino, 2006; Yin & Choi, 2023). Based on the underpinnings, Figure-6 sketches out a testable nexus among the rise of digital opportunities, subsequent digital gap, interventions of the labor market policies that harness the attainment of those digital opportunities. If the labor market policies fail to intervene, the digital gap bypasses the process and will lead the labor market to inequality consequences.

Design of the study

This study applies a mixed method approach to investigate the research question and validate the hypotheses using a newly developed digital gap calculation mechanism as one of the key variables. Specifically, it follows an 'explanatory sequential design' (QUANT -> qual) that follows-up qualitative data to understand and explain results from a primary quantitative study (Morgan, 2014). The quantitative data identifies 'patterns, relationships, and associations' between variables, such as digital gap, relationship between the gap and the labor market policies and inequality consequences. Sequentially, qualitative data helps to understand the context, insights, strengths, and weaknesses of the quantitative findings. Qualitative data has been collected by case studies (Beach & Pedersen, 2018) through reviewing secondary sources like reports, previous research, government policies, newspaper reports, and so forth.

Research question

What is the nature of the relationship between labor policies and the digital gap, and how does the digital gap impact inequality outcomes in the labor market of developing countries? The aim of this research is to explore the inequality in the labor market resulting from the adoption of digital technologies that creates lots of digital opportunities and a gap in their attainment and the role of the labor market policies amid the advent of the 4IR in developing countries. More specifically, it seeks to study the association between the digital gap with the active labor market policies and the inequality consequences like unemployment and labor income share.

Variables and measurements

To investigate the issue, the variable of *digital gap* is identified, which is calculated as the gap between digital opportunities and their attainment (Fink & Kenny, 2003). Digital gap is assumed to be associated with the key labor market institutions and factors such as labor policies and inequality consequences. This variable is represented by the Digital Gap Index (Box-2) developed through this research.

Active labor market policies are interventions that practically target 'all unemployed and inactive individuals' to encourage their reintegration in the labor market through facilitating skilling, job search and matching, and so forth (Arthur & Hondo, 2022; Ekkehard et al., 2022). It is represented by the GCR prepared by the WEF, Executive Opinion Survey that seeks to answer the question "to what extent do Labor market policies help unemployed

people to reskill and find new employment (including skills matching, retraining, etc.)?" (Schwab & Zahidi, 2020). Reponses are given on a scale from 1 to 7, where the score 1 measures the opinion as 'not at all' and 7 reports as the best to a great extent. Presumably, strong policies support the unemployed people to a great extent to obtain skills relevant and necessary for the labor market demand, while the weak ones (Figure-4) cannot, which might widen the digital gap through the underutilization of the digital opportunities due to their inability to support the skills of the workforce (Arthur & Hondo, 2022) (Also see Figure-13).

Inequality consequences in the labor market can be reported and measured by different indicators or a set of indicators. Most of the inequality in the labor market can occur at its outcome like labor income share, unemployment rate, employment, government's expenditure on education coinciding with high GDP growth per capita etc. in developing countries (Leibbrandt et al., 2010). It is evident that developing countries are growingly embarking on high growth (Annex: 4.2.) and industrialization concurring with the rising trend of the adoption of digital technologies amid the arrival of the 4IR. Examining its effects on the inequality in the labor market while it is catching up with the digital opportunities is inevitable (Cooper, 2002).

Labor income share as a percent of total GDP (ILOSTAT, 2022) is a strong inequality indictor apart from the Gini coefficient. This differential of wage reports the existing income inequality in the labor market at the national level. According to ILO modelled estimates, "the labor income share in GDP is the ratio, in percentage, between total labor income and gross domestic product (a measure of total output), both provided in nominal terms". The share of the labor income includes the compensation of the employees and a part of the income of the self-employed because the self-employed also earn from them from the work apart from their capital return. Furthermore, Total unemployment (QoG, WDI and ILO, 2023) as percentage of total labor force indicates a better understanding of the inequality consequences.

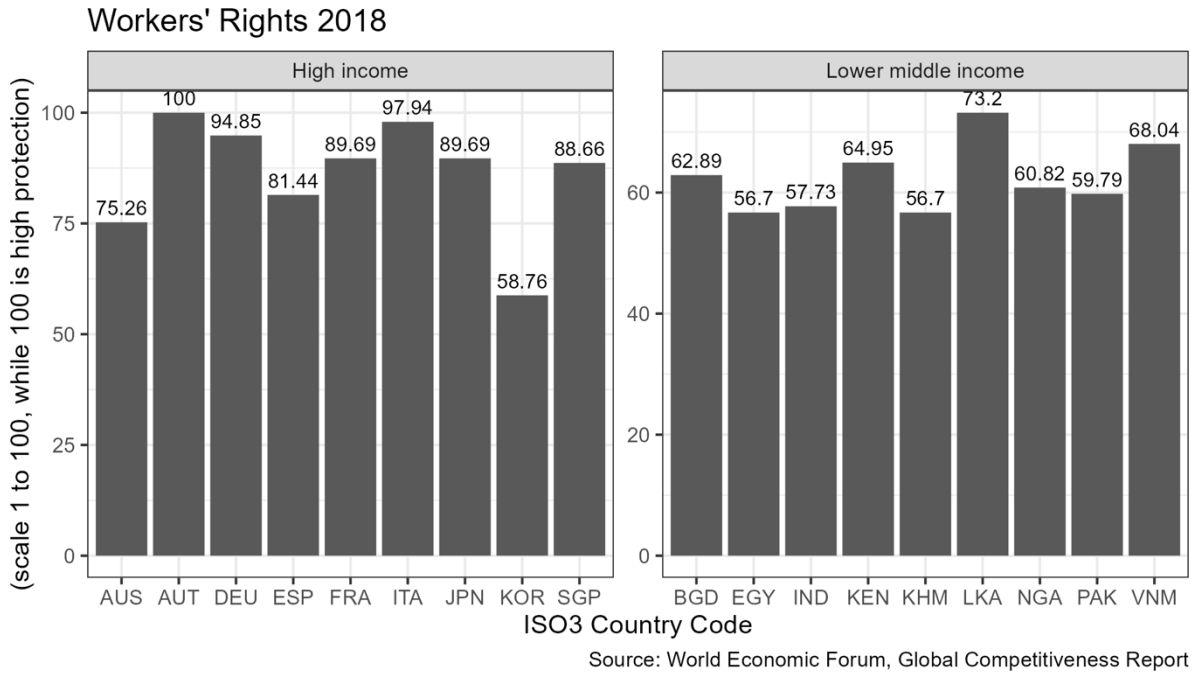
To control the effects of the other factors in the inspection, several variables have been included in the main model, namely GDP growth rate per capita (%), workers' rights, labor productivity, and self-employment. Campbell (2001) finds internet use and per capita GDP is positively correlated among 36 countries and identifies that political and civil rights, level of education, attainment of telecommunication infrastructure facilities are vital predictors of use.

He also delineates that the developing countries are far behind in trailing the progress of ICT than the developed counterparts (Annex: 4.3. and Figure-1).

Government's expenditure on education (% of GDP) (QoG and WDI, 2023) can also have an impact on the reduction of digital gap over the years in a specific country. Here, the government refers to 'local, regional, and central governments. The total expenditure on education as % of GDP can be funded by national government or transfers from international sources.

The worker's rights variable is represented by the GCR of WEF and adapted from the International Trade Union Confederation (ITUC) Global Rights Index. The variable measures "the level of protection of internationally recognized core Labour standards including civil rights, the right to bargain collectively, the right to strike, the right to associate freely, and access to due process rights. It does not take into account any element of firing regulations". (Schwab & Zahidi, 2020). Figure-7 delineates the situation of the workers' rights across the country income groups. It indicates a level of difference in the effectiveness of labor market regulations between the developing and developed countries. High income countries ensure more workers rights around 80, while the lower middle-income group performs fairly poor.

Figure 7: Workers' Rights across Country Income Groups



Labor productivity is an important economic indicator reported by the ILOSTAT (2023) that is 'closely linked to economic growth, competitiveness, and living standards within an

economy'. It is measured as the total volume of output in terms of GDP produced by per unit of labor in terms of the number of employed persons during a given time. This variable reports the efficiency and quality of human capital in the production[1].

WDI reports the ILO estimation of the self-employed as "Self-employed workers are those workers who, working on their own account or with one or a few partners or in cooperative, hold the type of jobs defined as a 'self-employment jobs'. i.e. jobs where the remuneration is directly dependent upon the profits derived from the goods and services produced. Self-employed workers include four sub-categories of employers, own-account workers, members of producers' cooperatives, and contributing family workers" (WDI and QoG, 2023).

Hypothesis

This investigation in the relationship between the digital gap, active labor market policies, and labor market inequality outcomes attempts to assess how the digital gap exacerbates inequality in the labor market and impacts key outcomes. Consequently, it postulates that –

> **H1a:** stronger active labor market policies are negatively associated with the digital gap in developing countries.
>
> **$H1_0$:** there is no significant association between active labor market policies and the digital gap in developing countries.

After analyzing the relationship between the digital gap and the labor policies, it further assumes that –

> **H2a:** a larger digital gap is positively associated with the inequality outcomes in labor market in developing countries, such as increased total unemployment, and a lower labor income share (% of total GDP).
>
> **$H2_0$:** There is no significant association between the digital gap and inequality outcomes in the labor market of developing countries.

Quantitative Methodology

The quantitative data is analyzed to identify the gap that has grown between digital opportunities and their attainment. Furthermore, it compares the digital gap with some other quantitative variables among a group of lower middle-income countries and high-income

[1] https://ilostat.ilo.org/resources/concepts-and-definitions/description-sustainable-development-labour-market-indicators/

countries to examine the trend. It also explores the performance of several institutions related and relevant to the analysis of the inequality in the labor market. Later, the relationship between digital gap and labor market policies and inequality consequences are analyzed in panel data regression analysis. Panel analysis is conducted using the time series longitudinal data taking into consideration the random effects.

There are some high and low performing countries in the data, which is necessary to consider generating a precise estimate of the coefficients. Variance Inflation Factor (VIF) test has been conducted to check the multicollinearity (Daoud, 2017) among the variables in the models (Annex-2.1.). The appropriateness of the random effects model for the panel analysis has been confirmed and determined by the Hausman test (Annex-2.2.) (Amini et al., 2012). Therefore, the validity, reliability, and robustness of the data are well-checked.

Based on the quantitative and qualitative findings, the analysis on the topic concludes the paper by emphasizing the gravity of the existing digital gap and the weak institutional arrangements and supports and the urgency of the bridging efforts for the gap to mitigate the inequality consequences. Meta inference concluding the analysis of the findings considers both the quantitative and qualitative findings fully integrated into the study.

Panel data analysis

Panel data refers to when we observe one unit over more than one point of time. Panel analysis allows us to study the time-varying and individual-specific effects in a longitudinal study (Amini et al., 2012; Baltagi et al., 2013). Variables like unemployment, labor productivity, and labor income share do not have immediate time-varying observations in a short-period of time, panel analysis helps to capture the limited time span of the data in this study.

Different regression models have been developed and applied to see the multi-dimensional impact of data over the DVs, digital gap and labor market inequality. Firstly, I have conducted the regression modelling cross-country comparison. They are composed of three models, where Model-1 consists of lower middle-income countries, Model-2 includes lower and upper middle-income countries, and Model-3 demonstrates the high-income group (Table-1 & 2). The time duration of the data for hypothesis-1 is from 2017 to 2019 due to unavailability of the data on active labor market policies, while hypothesis-2 covers a longer period from 2013 to 2019.

Box-1: Formula for panel regression analysis – random effects model

Hypothesis 1

The first hypothesis examines the association between the digital gap and the active labor market policies, while keeping workers' rights, government's expenditure on education, and labor productivity as control.

$$DG_{it} = \beta_0 + \beta_1 almp_{it} + \beta_2 wr_{it} + \beta_3 gexe_{it} + \beta_4 lpr_{it} + \alpha_i + \varepsilon_{it}$$

Here, *i* = country; *t* = year; *DG* = digital gap; *almp* = active labor market policies; *gexe* = Government's expenditure on education; *wr* = worker's rights; *gpc* = GDP growth per capita annual %; *lpr* = labor productivity; $\alpha_{i=}$ individual-specific unobserved random effects for individual-specific heterogeneity which is not explained by the observed variables; ε_{it} = error term for individual *i* at time *t*, which are the random variations and factors not accounted for in the model.

Hypothesis 2

It investigates the association between the labor income share and other independent variables, such as the digital gap and total unemployment, while it controls the self-employed, government's expenditure on education, and GDP per capita (annual %).

$$lincv_{it} = \beta_0 + \beta_1 DG_{it} + \beta_2 u_{it} + \beta_3 se_{it} + \beta_4 gxe_{it} + \beta_5 gpc_{it} + \alpha_i + \varepsilon_{it}$$

Here, *i* = country; *t* = year; *DG* = digital gap; *lincv* = labor income share; *u* = unemployment; *se* = self-employed; *gxe* = Government's expenditure on education; *gpc* = GDP growth per capita annual %: $\alpha_{i=}$ individual-specific unobserved random effects for individual-specific heterogeneity which is not explained by the observed variables; ε_{it} = error term for individual *i* at time *t*, which are the random variations and factors not accounted for in the model.

Box 1: Formula for panel regression analysis - random effects model

Statistical programming software R has been used to conduct this panel analysis and other quantitative data analysis and visualization on this thesis.

Qualitative Case study

Based on the relationship between the digital gap and variables, such as labor market policies and inequality consequences, a case study on the same variables in developing countries focusing on the quantitative results can help us to capture its correlation with other factors in the labor market. The aim of this study is to examine the association; therefore, the qualitative case study (Baskarada, 2014; Gammelgaard, 2017) on this topic of digital divide can shed light on specific associations between these variable and other potential factors in the developing countries. Thematic analysis on the case with focus on the countries performed notable in the trends has been conducted based on the topics of digital divide, labor market policies, and labor market inequalities in developing countries.

Limitations of the design

The Covid-19 and post-pandemic years have been excluded from the analysis due to their sensitivity to the emergency. Thus, it cannot capture the temporal scope of the post-Covid change in digitalization, forced policy changes and their implications at the outcome. Besides, finding up-to-date data on digital opportunities distinguishably capturing the labor market outcomes is very difficult, especially for the developing countries (UNCTAD, 2018).

In addition, limited time-variant data demonstrate the status of the association and a common evolving trend; however, it would be stronger if the analysis could include more observations in more years, which is less publicly available. Instead of using labor income share as an explanatory variable, Gini coefficient could have been more reliable to measure the inequality. However, the time-variant data on Gini index is not consistently available with the dependent variable, which might measure a very unreliable relationship.

Furthermore, multiple imputation methods can also complement the insufficient data on the developing countries by using many different methods through statistical software (Annex-3.2. & 3.3.). As the dependent variable is observed to have a significant amount of missing data on the lower middle-income countries, I have applied an imputation technique to check whether it increases the robustness of the result using R programming software. It finds that the significance level has changed after applying this method (Annex-3.5.). Therefore, it is recommended for future research that multiple imputation method can lead the quest for studying the developing countries without solely focusing on the developed countries, where data is more available.

The Digital Gap Index

Digital gap refers to the difference between the available digital opportunities (Buschmaas et al., 2019) and their attainment calculated from the GII report 2020[2]. Digital opportunities (Figure-1) are represented by ICT Access Index[3], which is calculated based on the coverage of population by the mobile network, subscription of the mobile cellular telephone, international internet bandwidth per user, the percentage of household internet access, and lately added, percentage of household with the computer. Attainments of digital opportunities (Figure-2) is represented by the ICT Use Index[4] that includes the percentage of individual internet use, fixed broadband internet subscription, and mobile broadband subscription. Both calculations by GII are based on the World Telecommunication/ICT Indicators Database[5].

Firstly, the digital gap is computed as the ratio between the attainment and actual opportunities using the formula in Box-2. It divides the actual attainment by the actual opportunities for each digital opportunity to calculate the ratio. This ratio represents the proportion of the opportunity that has been achieved or utilized. The resulting ratio (Figure-9) explains that high ratio is higher utilization or attainment of digital opportunities and vice versa. This ratio can provide insights into the level of utilization or effectiveness of the opportunities in relation to the achieved outcomes. If the ratio is low, it may indicate a need for interventions to improve utilization or remove barriers. Conversely, high ratios may indicate areas of success that can be replicated or scaled up.

When a higher ratio is represented as a digital gap, although it means low, it might be misleading for the readers. Therefore, a normalization of the ratio to a normal scoring index is necessary to make it more understandable. Therefore, the normalization formula for the digital gap ratio has been applied in the second step (Box-2).

[2] https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII_2020_Executive_R_58.pdf
[3] https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017/methodology.aspx
[4] https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017/methodology.aspx
[5] https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx

Box-2: Steps and Formula for the Digital Gap Index

Step-1: calculating the utilization ratio of the digital opportunities

$$UR_{it} = \frac{AA_{it}}{AO_{it}}$$

Here, *UR* denotes the Utilization Ratio for the *i*th entity (e.g., country) at time (e.g., year) *t*. *AA* stands for the Actual Attainment and *AO* denotes the Actual Opportunity for the *i*th entity (e.g., country) at time (e.g., year) *t*.

Step-2: Normalizing the ratio to the Digital Gap Index[6]

Converting utilization ratio into digital gap through normalization can provide a very strong insight of the digital gap. The formula for the process is as follows:

$$DG_{it} = 1 - UR_{it}$$

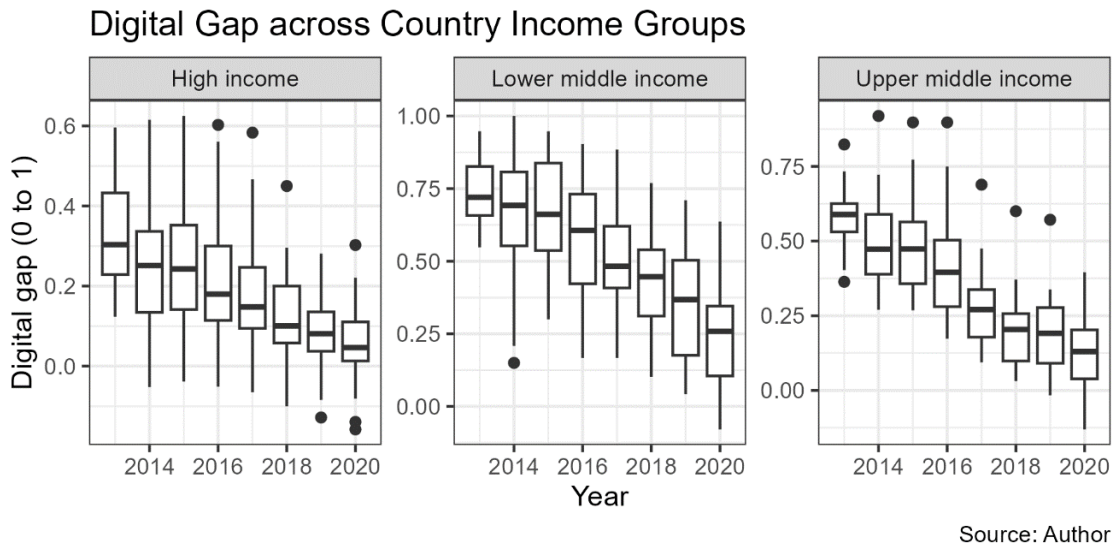
Here, *DG* denotes Digital Gap for the *i*th country at time *t* and *UR* denotes the Utilization Ratio for the *i*th entity (e.g., country) at time (e.g., year) *t*.

Box 2: Steps and Formula for the Digital Gap Index

After the digital gap index is normalized, the higher score means higher digital gap and poor and underutilization of the digital opportunities, where lower score means lower gap and effective or efficient utilization at a significant level. This gap data can help to identify the disparity between the opportunities and their attainments because of the increased digitalization in a country amid the proven gradual introduction of the 4IR technologies and their increased adoption. Figure-8 shows the median of the country income groups from 2013 to 2020 in the reduction of the digital gap with a gradual decreasing trend. The most common trend is the consistent and continued reduction of the digital gap across the countries, irrespective of their income group. It shows a very optimistic picture of a globally unique trend, either for urgency or for efficiency. Moreover, the high-income countries have shown the best performance by bringing their median position close to zero (0).

[6] Note: this index is developed based on the existing digital opportunities and their attainment. Therefore, the existing availability level of digital opportunities can vary by country and be considered as another important point of research.

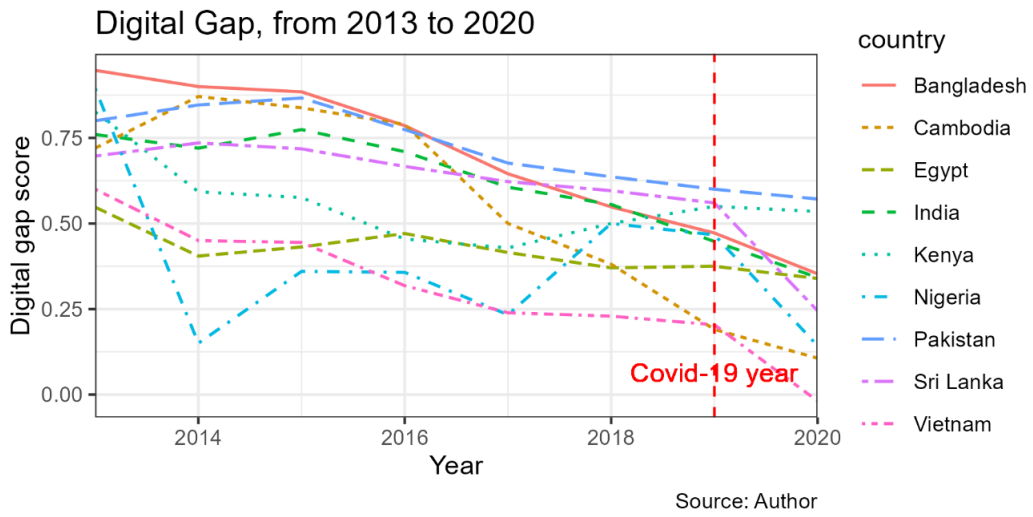
Figure 8: Digital Gap across Country Income Groups (median)



Source: Author

The graph below (Figure-9) shows that the digital gap went down to a substantial level as a previous trend (Fink & Kenny, 2003). However, among the lower middle-income group, only Bangladesh maintained a consistent reduction in the digital gap, while other countries experienced fluctuations. Yet, the overall trend refers to the reduction in the gap between the digital opportunities and their attainment over time as shared by the same trend among the digitally capable developed countries (Annex-4.3.).

Figure 9: Trend of Digital Gap among Developing Countries (lower middle-income group)



Source: Author

However, the gap index only captures the existing digital opportunities at a point of time in a given country. Therefore, the level of digital opportunities, should it be higher or lower, can be another point of research by scholars or actions by policymakers if a country is considered to have failed to adopt more digital technologies and opportunities.

Findings of the study

Quantitative findings

Table 1: Association between the Digital Gap and The Active Labor Market Policies

	Model 1	Model 2	Model 3
(Intercept)	0.64 ***	0.63 ***	0.47 ***
	(0.16)	(0.11)	(0.05)
act_lab_p	-0.00	-0.00	-0.00 ***
	(0.00)	(0.00)	(0.00)
workers_rights	-0.00	-0.00 **	-0.00
	(0.00)	(0.00)	(0.00)
gov_exp_edu	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)
lab_product	0.01	0.01 *	0.00
	(0.00)	(0.00)	(0.00)
s_idios	0.10	0.09	0.05
s_id	0.16	0.16	0.07
R^2	0.07	0.10	0.26
Adj. R^2	0.01	0.07	0.24
Num. obs.	74	155	135

*** p < 0.001; ** p < 0.01; * p < 0.05

(Model-1: Lower middle-income, Model-2: Upper and Lower middle-income, Model-3: High income)

In Table-1, three different regression models (Model 1, Model 2, and Model 3) are presented with digital gap as DV and few IVs. The coefficient for the active labor market policies is -0.00, which means that a one-unit change in the labor policies is associated with -0.00 change in the digital gap. The standard error is 0.00 that indicates no variation in the estimation of the coefficients. No independent and control variables are statistically significant on the model 1. For combined lower and upper middle-income countries, the statistical significance slightly changes in workers' rights and labor productivity. However, the coefficients are value low and indicate poor relationship. For high income countries, active labor market policies become statistically significant with the coefficient -0.00. This value cannot predict a relationship either. For the r squared and adjusted squared value, only high-income countries are explained by 26% and 24% observations. For lower income countries and the combined model 2, the variance is very low at 1% and 7% respectively. The number of observations is also low for the lower income countries that means that there are some missing values for these countries. Nevertheless, the correlation only considers the data for three years for the labor market policies, from 2017 to 2019. Although the data on the digital gap and active

labor market policies have significant variation across countries in times, showing no relationship means either the effect of the digital gap is not being felt at the bottom or the performance of the developing countries are lower at taming the best out of the digital opportunities at hand by supportive labor market policies.

Table 2: Association between the Labor Income Share and the Digital Gap across Country Income Groups

	Model 1	Model 2	Model 3
(Intercept)	31.19 ***	39.34 ***	45.95 ***
	(3.41)	(1.88)	(2.26)
digital_gap	-0.72	-0.44	-6.93 ***
	(1.01)	(0.61)	(1.21)
unempl_total	0.36 *	0.14	0.13
	(0.17)	(0.07)	(0.08)
semp_total	0.17 ***	0.08 **	0.23 *
	(0.05)	(0.03)	(0.10)
gov_exp_edu	0.40	0.53 ***	0.82 **
	(0.21)	(0.16)	(0.28)
gdp_pc_grw_an_prc	-0.08	-0.12 **	-0.16 **
	(0.07)	(0.04)	(0.06)
s_idios	2.09	1.81	1.69
s_id	6.48	6.23	8.08
R^2	0.35	0.28	0.18
Adj. R^2	0.33	0.27	0.16
Num. obs.	230	455	316

*** p < 0.001; ** p < 0.01; * p < 0.05

(Model-1: Lower middle-income, Model-2: Upper and Lower middle-income, Model-3: High income)

Table-2 represents the result for hypothesis-2, given the DV is labor income share (% of GDP). In model 1, the digital gap is negatively associated and not statistically significant. The coefficient means one-unit change in the digital gap is associated with 0.72 decrease in the labor income share. On the other hand, the digital gap is very strongly related to the decrease in the labor income share across the high-income countries at the p-value $p < 0.001$. For another inequality outcome variable being within the model as IV, increase in the total unemployment is associated with the 0.36 increase in the labor income share for lower middle-income countries at the significance level $p < 0.05$. For model 2 and 3, it is not significant in the relationship with the DV. Self-employed number is very significantly correlated with the 0.17 increase in the labor income share for the lower middle-income countries. However, for the other models, the significance levels have decreased. Other control variables, such as government's expenditure on education, and per capita GDP growth are significantly associated with the DV for models 2 and 3, not for the lower middle-

income countries. Furthermore, 35% of the variations in the labor income share is explained by the IVs in model 1. These results also show that the lower middle-income countries have missing values on the variables. Overall, the labor income share is not explained by the digital gap in developing countries with statistical significance.

In addition, Annex-3.1. reports the same regression analysis with the group of countries with the panel analysis fixed effects models. It reveals that the selection of the random effects model has improved the results than the fixed effect models and shows almost no correlation between the IVs and the DVs.

Step-by-Step regression for lower middle-income countries

This section provides another opportunity to recheck with only considering the lower middle-income countries in the model in a step-by-step regression analysis. First, the models will only add the specific IV, which are active labor market policies for hypothesis-1 and the digital gap is for hypothesis-2.

Hypothesis-1

Table 3: Association between the digital gap and the active labor market policies (lower middle-income countries)

	Model 1	Model 2
(Intercept)	0.42 ***	0.64 ***
	(0.08)	(0.16)
act_lab_p	0.00	-0.00
	(0.00)	(0.00)
workers_rights		-0.00
		(0.00)
gov_exp_edu		-0.01
		(0.01)
lab_product		0.01
		(0.00)
s_idios	0.10	0.10
s_id	0.16	0.16
R^2	0.01	0.07
Adj. R^2	-0.00	0.01
Num. obs.	84	74

*** p < 0.001; ** p < 0.01; * p < 0.05

In the step-by-step regression on Table-3, the two models do not show any improvement in the results. Only 1% of the variations in the active labor market policies data explain the DV

here, which is also very statistically insignificant at the p-value. This table specifies that there is no correlation between the DV and digital gap in developing countries.

Hypothesis-2

Table 4: Association between the labor income share and the digital gap

	Model 1	Model 2	Model 3
(Intercept)	44.56 ***	43.36 ***	31.19 ***
	(1.23)	(1.57)	(3.41)
digital_gap	-0.00	-0.05	-0.72
	(0.90)	(0.90)	(1.01)
unempl_total		0.20	0.36 *
		(0.16)	(0.17)
semp_total			0.17 ***
			(0.05)
gov_exp_edu			0.40
			(0.21)
gdp_pc_grw_an_prc			-0.08
			(0.07)
s_idios	2.16	2.16	2.09
s_id	7.41	7.32	6.48
R^2	0.25	0.24	0.35
Adj. R^2	0.25	0.23	0.33
Num. obs.	248	247	230

*** p < 0.001; ** p < 0.01; * p < 0.05

Table-4 also explains the same trend of no correlation like the previous one, except the control variable self-employment. It presents a strong correlation with the labor income share at the p-value 0.001. It means that one unit change in self-employment is associated with the 0.17 increase in the labor income share.

Therefore, the above-mentioned examination of the variables in two hypotheses testing, no one could reject the null hypothesis, as no relationship has been proven. The only variable that stands out for the developing countries is self-employment. The following qualitative findings will shed more light on what the status of the digital gap in the developing countries is, considering the role of active labor market policies and the inequality consequences. It will also touch upon the case of the self-employed in Bangladesh.

Qualitative findings

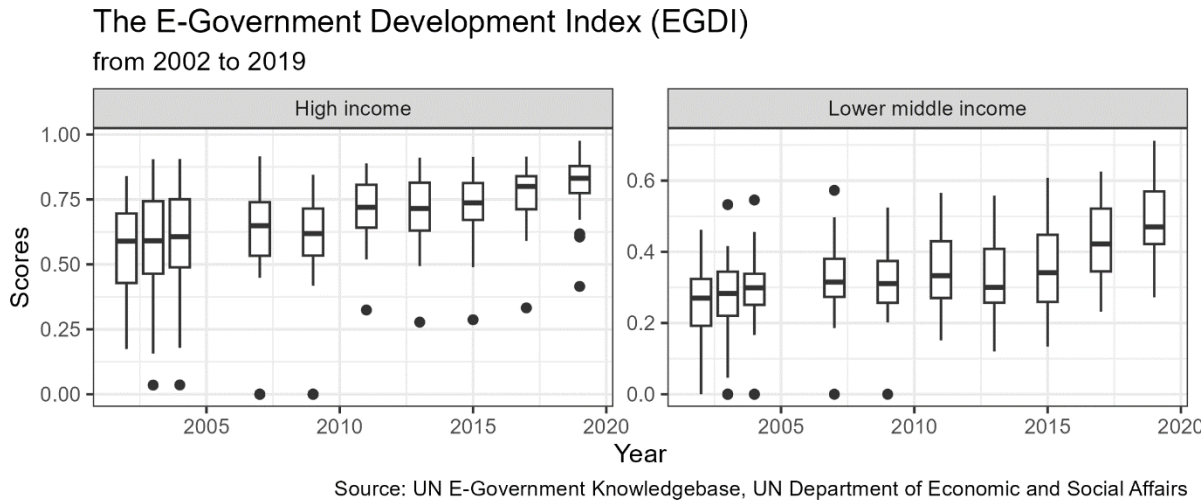
Digital gap and labor market in developing countries

Signé (2023) researched on the digital divides at the global level and demonstrates that there is a gap in the 'research, infrastructure, and education' that have cyclical effects. He outlines that the developed countries are attracting more 4IR investments that is leading them to

achieving a competitive digital economy higher labor income share (Annex-4.1.), while developing countries are falling behind. For instance, developing and emerging economies are hosting the higher number of self and informal employment compared to their advanced counterparts, which is prone to be affected by digitalization (Bhorat et al., 2023).

If we look at the following E-government index results at the median in Figure-8, it demonstrates the same insight as the lower middle-income countries are far-behind the high-income countries in terms of digitally empowering their governments. Digitally weak governments are difficult to be considered as the efficient players to support the digital labor market transition.

Figure 10: The E-Government Development Index across Country Income Groups

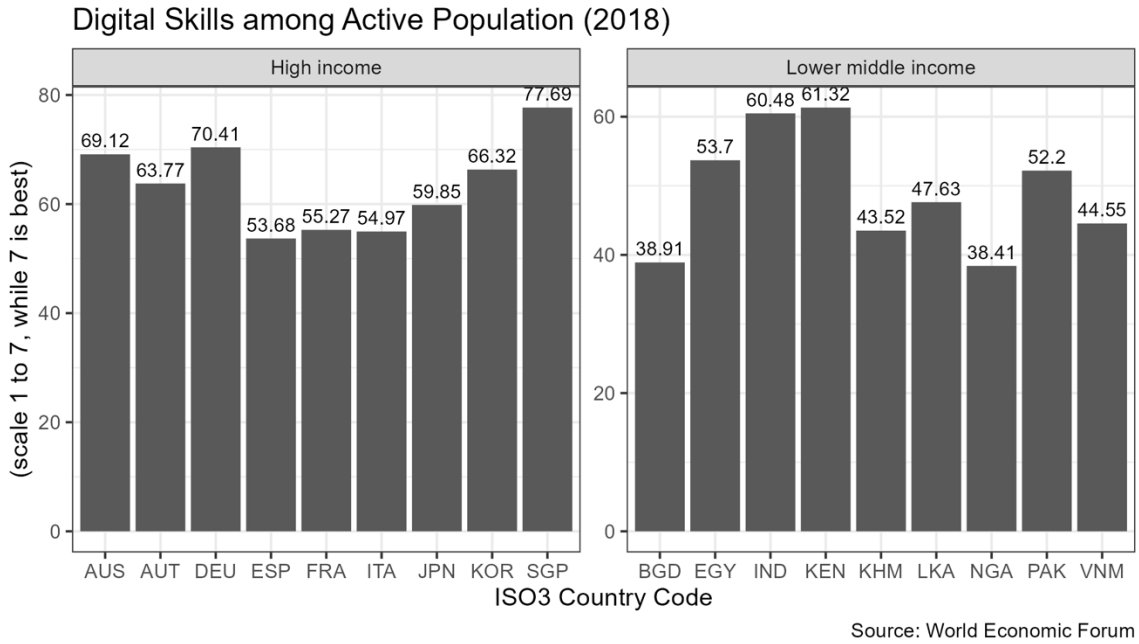


In the case of Asia, which hosts a number of developing countries with rising and transition economy, Arthur & Hondo (2022) found that the components of ALMPs are 'underfunded' and largely 'underutilized' in the region. While studying the case of Indonesia, Wijayanti & Turgel (2021) outlines the role of the government in investing the human capital (UN, 2019) to support competition in the economy from the bottom. Their findings were based on the assumptions that the simultaneous positive and negative implications of technological development on economic growth and productivity.

For instance, Bangladesh has the second largest online platform-mediated freelancers in the world, and it is helping many people to easily get working opportunities and the government to earn foreign money to support its development programs. However, it is not recognized as formal employment in the country, which significantly reduces their rights as a formal worker in the labor market. On the other hand, ADB & ILO (2016) finds that the education level

does not contribute to the income inequality in the country, which is supported by the fact that the lower level of digital skills are not impacting the labor market and the labor-intensive sectors like the manufacturing and the construction sectors have become 'job-rich'. Looking at the human capital in the developing countries, Figure-12 shows that the digital skills among active population are different between the developed and developing countries. However, the gap is not extreme on the bar.

Figure 11: Digital Skills among Active Population across Country Income Group

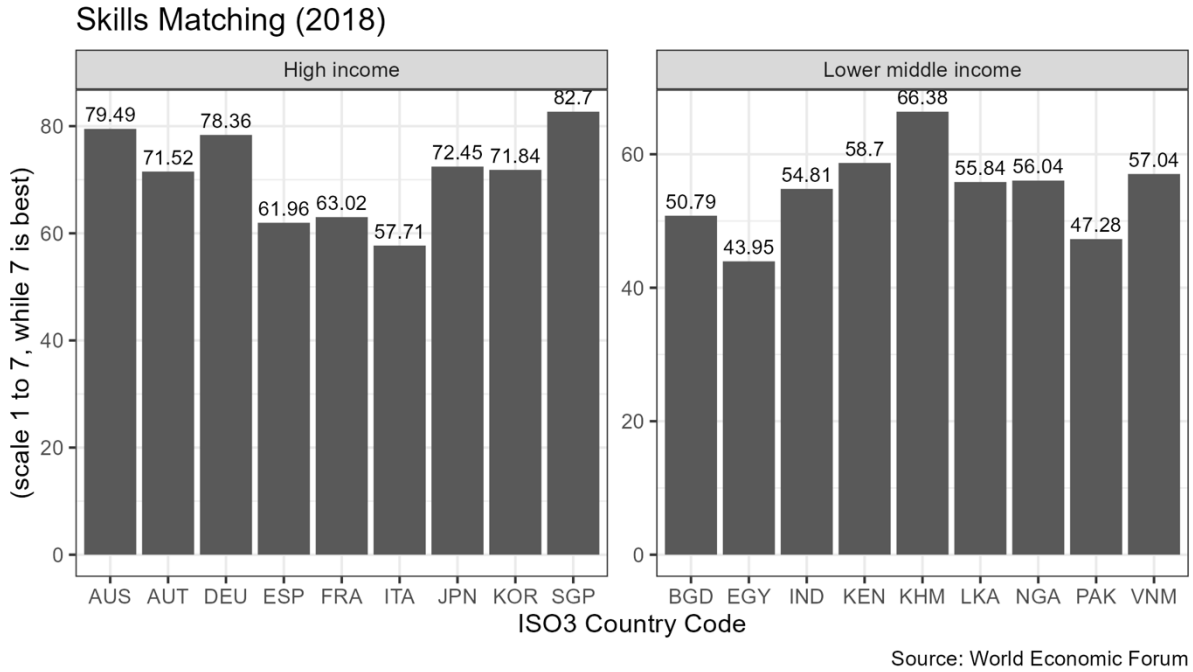


Therefore, the real challenge is to grow productivity and wages of those sectors through skilling, and upskilling by active labor market policies, where the capacity of the government plays a significant role in structural transformation.

The rising trend of informal work in India is another example of the effects of digitalization on the labor market and its qualitative transformation. More gig-workers based on digital platforms and technologies can contribute to the income; however, it counters the fact that formal labor market regulations and legal social protection for them are absent. It demonstrates a clear risk of labor market transition through digitalization in developing countries (Mayfield, 2021). Apart from access to and use of digital opportunities, right to education and skills are important to bridge gap in the digital divide (Dewan et al., 2022). Arthur & Hondo (2022) sheds light on the active labor market policies while explaining the case of India. They delineate that global trend of interest in ALMPs is demonstrated by the National Policy for Skill Development and Entrepreneurship (NPSDE) of India that aims to

employ the growing number of incoming young people in the job market. Its primary goal is to scale up the training and skilling activities of all types that fulfill the skilling requirements of international standard. The inequalities in labor market in India exist in terms of wages, earnings, and quality of work across sectors, where labor market institutions need to intervene to shape the behavior of firms and employment for the betterment of the workers (Dev, 2018). Like many developed countries, developing countries are also advancing plan and strategies at the national and regional levels, such as African Union's Digital Transformation Strategy, the Digital India Programme aiming to improve the infrastructural and technical capacities on digitalization aligning with social and economic goals (Signé, 2023).

Figure 12: Skills Matching across Country Income Groups



Skills mismatch (Figure-13) occurs the most among the lower middle-income countries than the high-income group. It indicates that the skills are falling behind the job market demand, which is gradually changing fast due to the advent of digital technologies.

"Self-employed?": online platform-mediated freelancers in Bangladesh

The arrival of hybrid home-based workspace such as freelancing has created many employment opportunities, where employees work remotely using their digital devices. The emergence of this new work has been facilitated by the development of digital technologies and new models of business around the world. Nevertheless, it has also challenged the

existing jurisdiction of labor rights norms, policies, and legislative protections. The 'non-compliance with the labor standards' can be a big challenge for this newly evolved kind of job. (ILO and OECD, 2020; OECD, 2019)

The Labor Law of Bangladesh does not say anything about these freelancing jobs, although it engages a lot with the ILO in developing labor rights in the country. European Commission, (2021) recognizes the importance of digital labor platforms as the driving force for more sources of income having more accessibility (Stefano et al., 2021). However, lack of legally protected employment status might make this new source of jobs and incomes precarious inequality for the workers. As the Global Commission on the Future of Work (2019) points out, without a globally integrated community driven initiative, the governance of this new forms of work cannot be regulated and the protection of rights and benefits of the labor market cannot be ensured. A clear definition of an employment relationship is particularly important to understand the overall picture of labor rights protection in the digital platforms that reiterates the fact that labor law should address the point of 'what could constitute an unequal bargaining position between the parties in an employment relationship' (ILO and OECD, 2020).

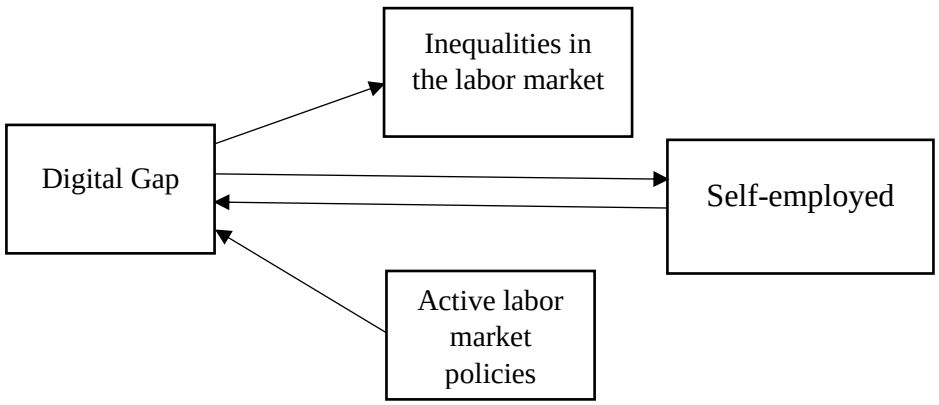
Bangladesh, like many other developing countries lacks specific regulations, policies, and laws for the gig workers regarding the protection of labor rights and social security, such as minimum wage, health security prescribed by the scholars (Hadwiger, 2022). Without any sufficient regulations, it will cause discrimination and injustice in the labor market (Kabir, 2022). Misclassification of freelancers as self-employed should be eliminated and their labor rights should be ensured by policies and laws, and international norms. The employment relationship should always be clearly defined and established so that no scope for unfair treatment of the freelancers is left.

Discussion and conclusions

The assumed interactions between the digital gap and the labor market policies and the inequality consequences has not been strongly proven for the developing countries. Composition of lower and upper middle-income countries as developing countries also did not improve the relationship on the panel analysis. However, the high-income countries demonstrate a comparatively better result in terms of interaction with the other variables. This change in the outcome can be impacted by the regular reporting of their inequality outcomes, role of labor policies and the necessary data to find out the digital gap. Although there are

some interactions reported among the variables in the case of lower middle-income countries, the relationships are not statistically significant for these countries. However, it does not rule out that the problem is absent. Qualitative data finds out the roles of the labor market policies and the inequality consequences through the different forms of digital employment, such as self-employment, which is already indicated by the panel analysis results. The figure-11 shows an interaction map where there is another small issue explains a better correlation with the outcome variable.

Figure 13: Digital Gap Interaction Map for self-employed persons in Developing Countries



Source: Author

From the existing scarce evidence, a huge gap between the developed and developing countries is observed. Nevertheless, Yin & Choi (2023) finds a heterogeneous impact of digitalization on the reduction of income inequality across income groups and concludes that digitalization alleviates income inequality while interacting with 'trade openness and foreign direct investment'. Their evidence shows that there is a 'greater effect on middle-income countries' in narrowing income gap, while the high-income group experience the opposite. From the bottom, Adhikari (2020) summarizes few major challenges for adaptation to this transformation- one is the lack of resources to provide basic 4IR relevant education and the other is the 'rigid and inflexible' education system that is less adaptive to skill market and requires strong political commitment to reform accordingly.

Although quantitative findings do not explicitly demonstrate the association among the digital gap and labor policies and inequalities, the qualitative data indicates a gap that is impacting on the labor market in different forms, such self-employment in Bangladesh. Bottom-up approach can be set like emphasizing on individual achievements as focus while studying these three key issues in the labor market. As in the case of the developing

countries, there is no significant correlation found. Therefore, it can conclude that looking at the top of the inequality or policy consequences cannot provide good insights without large set of data with high time-variance.

The 4IR is a very new phenomenon in developing countries and the arrival of its features and their efficient and effective adoption and implications are still largely under researched. Most of the studies related to the features of the 4IR in terms of technologies are studied and reported in OECD, EU, and other developed countries. Furthermore, most of the labor market data which is related to inequality and digitalization are only available in the developed countries. Developing countries are still walking behind to report their progress on dealing with the indicators of inequality in labor market that has been created due to the adoption of the 4IR technologies (UNCTAD, 2018).

Finding theoretical framework and proper conceptualizations to examine the inequality in the labor market amid the advent of widespread digital technologies in developing countries is difficult (Singla, 2022; Van Dijk, 2006). However, there are some econometric studies on the topic but not exclusively focused on the developing countries. Moreover, deciding on the key variables is very challenging, given that the labor market inequality is reported under many categories and subcategories. In addition, it is very difficult to find time-variant data on digitalization and the 4IR technologies associated with the labor market institutions and affecting the inequality outcome among the selected country group.

Unlike the previous industrial revolutions, the 4IR offers an open window for the developing countries to get the benefits of it. It provides accessibility to technologies, affordability to choose the suitable ones and their applications (Lee, 2021). The 4IR opens a huge opportunity to adapt to this new reality that could help to reduce poverty and to achieve sustainable futuristic development. For the developing countries, the very first challenge before analyzing the impact of 4IR is the accessibility to its technologies like the internet (Adhikari, 2020; Dimaggio et al., 2004) and their proper and timely utilization. Developed economies might keep their innovations strictly protected and costly to achieve like patent (UN, 2019). That means it is an issue of affordability too. Second is the lack of institutions and infrastructures to enable the actors to employ themselves in the proper utilization of the technologies. Even if they could manage accessibility and affordability, applications of those features require necessary skills and progressive and welfare-centric policies and regulations.

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Annex-1: List of the countries, income groups, and variables

1.1.List of the countries based on the income groups by the World Bank

Income group	Name of the countries
Low-income	Afghanistan, Korea (Dem. People's Rep), South Sudan, Burkina Faso, Liberia, Sudan, Burundi, Madagascar, Syrian Arab Republic, Central African Republic, Malawi, Togo, Chad, Mali, Uganda, Congo (Dem. Rep), Mozambique, Yemen (Rep.), Eritrea, Niger, Ethiopia, Rwanda, Gambia, The Sierra Leone, Guinea-Bissau, Somalia
Lower-middle income	Angola, Jordan, Philippines, Algeria, India, Samoa, Bangladesh, Iran (Islamic Rep), São Tomé and Principe, Benin, Kenya, Senegal, Bhutan, Kiribati, Solomon Islands, Bolivia, Kyrgyz Republic, Sri Lanka, Cabo Verde, Lao PDR, Tanzania, Cambodia, Lebanon, Tajikistan, Cameroon, Lesotho, Timor-Leste, Comoros, Mauritania, Tunisia, Congo (Rep.), Micronesia, Fed. Sts. Ukraine, Côte d'Ivoire, Mongolia, Uzbekistan, Djibouti, Morocco, Vanuatu, Egypt (Arab Rep.), Myanmar, Vietnam, Eswatini, Nepal, Zambia, Ghana, Nicaragua, Zimbabwe, Guinea, Nigeria, Haiti, Pakistan, Honduras, Papua New Guinea
Upper-middle income	Albania, Fiji, North Macedonia, Argentina, Gabon, Palau, Armenia, Georgia, Paraguay, Azerbaijan, Grenada, Peru, Belarus, Guatemala, Russian Federation, Belize, Indonesia, Serbia, Bosnia and Herzegovina, Iraq, South Africa, Botswana Jamaica, St. Lucia, Brazil, Kazakhstan, St. Vincent and the Grenadines, Bulgaria, Kosovo, Suriname, China, Libya, Thailand, Colombia, Malaysia, Tonga, Costa Rica, Maldives, Türkiye, Cuba, Marshall Islands, Turkmenistan, Dominica, Mauritius, Tuvalu, Dominican Republic, Mexico, West Bank and Gaza, El Salvador, Moldova, Equatorial Guinea, Montenegro, Ecuador, Namibia
High income	American Samoa, Germany, Oman, Andorra, Gibraltar, Panama, Antigua and Barbuda, Greece, Poland, Aruba, Greenland, Portugal, Australia, Guam, Puerto Rico, Austria, Hong Kong SAR, China, Qatar, Bahamas, The Hungary, Romania, Bahrain, Iceland, San Marino, Barbados, Ireland, Saudi Arabia, Belgium, Isle of Man, Seychelles,

Bermuda, Israel, Singapore, British Virgin Islands, Italy, Sint Maarten (Dutch part), Brunei Darussalam, Japan, Slovak Republic, Canada, Korea (Rep.), Slovenia, Cayman Islands, Kuwait, Spain, Channel Islands, Latvia, St. Kitts and Nevis, Chile, Liechtenstein, St. Martin (French part), Croatia, Lithuania, Sweden, Curaçao, Luxembourg, Switzerland, Cyprus Macao SAR, China, Taiwan, China, Czech Republic, Malta, Trinidad and Tobago, Denmark, Monaco, Turks and Caicos Islands, Estonia, Nauru, United Arab Emirates, Faroe Islands, Netherlands, United Kingdom, Finland, New Caledonia, United States, France, New Zealand, Uruguay, French Polynesia, Northern Mariana Islands, Virgin Islands (U.S.), Guyana, Norway

1.2.ISO3c country codes for selected countries for visualization

Lower middle-income		**High income**	
ISO3c code	**Country name**	**ISO3c codes**	**Country name**
BGD	Bangladesh	AUS	Australia
EGY	Egypt	AUT	Austria
IND	India	DEU	Germany
KEN	Kenya	ESP	Spain
KHM	Cambodia	FRA	France
LKA	Sri Lanka	ITA	Italy
NGA	Nigeria	JPN	Japan
PAK	Pakistan	KOR	Korea
VNM	Vietnam	SGP	Singapore

1.3.List of variables

Name	Description	Source of data
	Hypothesis-1 (year: 2017-2019)	
	DV: digital gap	
digital_gap	Digital gap score	The Digital Gap Index prepared by the author
act_lab_p	Active labor market policies	The World Economic Forum, The Global Competitiveness Report 2019
workers_rights	Workers' rights	The World Economic Forum, The Global Competitiveness Report 2019
gov_exp_edu	Government's expenditure on education	World Development Indicators (WDI)
lab_product	Labor productivity	ILO statistics
	Hypothesis-2 (year: 2013-2019)	
	DV: labor income share	
lab_inc_value	Labor income share	ILO statistics
digital_gap	Digital gap score	The Digital Gap Index prepared by the author
unempl_total	Unemployment, total (% of total labor force) (modeled ILO)	World Development Indicators (WDI) and ILO statistics
semp_total	Self-employed, total (% of total employment)	World Development Indicators (WDI) and ILO statistics
gov_exp_edu	Government's expenditure on education	World Development Indicators (WDI)
gdp_pc_grw_an_prc	Variable: GDP per capita growth (annual %)	World Development Indicators (WDI)

Annex-2: Validity Test

2.1. Variance Inflation Factor (VIF) test for variables for hypothesis- 1 & 2

Table: VIF Test Results for Hypotheses

	Hypothesis	VIF_Value
act_lab_p	Hypothesis-1	1.076587
workers_rights	Hypothesis-1	1.131745
gov_exp_edu	Hypothesis-1	1.152460
lab_product	Hypothesis-1	1.107532
digital_gap	Hypothesis-2	2.151082
unempl_total	Hypothesis-2	1.122774
semp_total	Hypothesis-2	2.256866
gov_exp_edu1	Hypothesis-2	1.152349
gdp_pc_grw_an_prc	Hypothesis-2	1.045743

2.2. Hausman test for validating the selection of the random effect model

Hypothesis-1

```
        Hausman Test

data:  digital_gap ~ act_lab_p + workers_rights + gov_exp_edu + lab_product
chisq = 3.1814, df = 4, p-value = 0.5279
alternative hypothesis: one model is inconsistent
```

Hypothesis-2

```
        Hausman Test

data:  lab_inc_value ~ digital_gap + unempl_total + semp_total + gov_exp_edu +  ...
chisq = 15.221, df = 5, p-value = 0.009457
alternative hypothesis: one model is inconsistent
```

Coefficients summary table

	Hypothesis-1	Hypothesis-2
(Intercept)	0.64 (0.16) ***	31.21 (3.40) ***
act_lab_p	-0.00 (0.00)	
workers_rights	-0.00 (0.00)	
gov_exp_edu	-0.01 (0.01)	0.40 (0.21)
lab_product	0.01 (0.00)	
digital_gap		-0.71 (1.01)
unempl_total		0.36 (0.17) *
semp_total		0.17 (0.05) ***
gdp_pc_grw_an_prc		-0.08 (0.07)
s_idios	0.10	2.09
s_id	0.16	6.44
R^2	0.07	0.35
Adj. R^2	0.01	0.33
Num. obs.	74	230

*** p < 0.001; ** p < 0.01; * p < 0.05

Annex-3: Robustness check with missing and imputed data

3.1. Panel regression with fixed effects model across income groups

Hypothesis-1 (Model-1: Lower middle-income, Model-2: Upper and Lower middle-income, Model-3: High income)

	Model 1	Model 2	Model 3
act_lab_p	-0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
workers_rights	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)
gov_exp_edu	0.01	0.00	-0.03
	(0.01)	(0.01)	(0.02)
lab_product	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
R^2	0.01	0.01	0.04
Adj. R^2	-0.80	-0.65	-0.57
Num. obs.	74	155	135

*** p < 0.001; ** p < 0.01; * p < 0.05

Hypothesis-2 (Model-1: Lower middle-income, Model-2: Upper and Lower middle-income, Model-3: High income)

	Model 1	Model 2	Model 3
digital_gap	-0.17	0.25	-7.64 ***
	(1.55)	(1.02)	(1.72)
unempl_total	-0.42	-0.02	0.14
	(0.30)	(0.09)	(0.09)
semp_total	0.46 ***	0.35 ***	0.16
	(0.09)	(0.06)	(0.13)
gov_exp_edu	0.41	0.51 **	0.62 *
	(0.22)	(0.17)	(0.29)
gdp_pc_grw_an_prc	-0.08	-0.09	-0.15 *
	(0.07)	(0.04)	(0.06)
R^2	0.16	0.13	0.17
Adj. R^2	-0.10	-0.10	-0.03
Num. obs.	230	455	316

*** p < 0.001; ** p < 0.01; * p < 0.05

3.2. Number and percent of Missing values in the variables (lower middle-income countries) (n_missing = number of missing values; prc_missing = percent missing)

Hypothesis-1

variable	value
country_code_n_missing	0.000000
country_n_missing	0.000000
income_n_missing	0.000000
year_n_missing	0.000000
digital_gap_n_missing	26.000000
act_lab_p_n_missing	2.000000
workers_rights_n_missing	0.000000
gov_exp_edu_n_missing	12.000000
lab_product_n_missing	0.000000
country_code_prc_missing	0.000000
country_prc_missing	0.000000
income_prc_missing	0.000000
year_prc_missing	0.000000
digital_gap_prc_missing	23.423423
act_lab_p_prc_missing	1.801802
workers_rights_prc_missing	0.000000
gov_exp_edu_prc_missing	10.810811
lab_product_prc_missing	0.000000

Hypothesis-2

variable	value
country_code_n_missing	0.0000000
country_n_missing	0.0000000
income_n_missing	0.0000000
year_n_missing	0.0000000
digital_gap_n_missing	81.0000000
lab_inc_value_n_missing	0.0000000
unempl_total_n_missing	7.0000000
semp_total_n_missing	7.0000000
gov_exp_edu_n_missing	30.0000000
gdp_pc_grw_an_prc_n_missing	1.0000000
country_code_prc_missing	0.0000000
country_prc_missing	0.0000000
income_prc_missing	0.0000000
year_prc_missing	0.0000000
digital_gap_prc_missing	24.6200608
lab_inc_value_prc_missing	0.0000000
unempl_total_prc_missing	2.1276596
semp_total_prc_missing	2.1276596
gov_exp_edu_prc_missing	9.1185410
gdp_pc_grw_an_prc_prc_missing	0.3039514

3.3. Imputation method for missing values of the variable digital gap (lower middle-income countries)

Hypothesis-1 (post imputation)

	Column	Missing_Count_h1	Missing_Percentage_h1
.imp	.imp	0	0.0000000
.id	.id	0	0.0000000
country_code	country_code	0	0.0000000
country	country	0	0.0000000
income	income	0	0.0000000
year	year	0	0.0000000
digital_gap	digital_gap	26	3.9039039
act_lab_p	act_lab_p	2	0.3003003
workers_rights	workers_rights	0	0.0000000
gov_exp_edu	gov_exp_edu	12	1.8018018
lab_product	lab_product	0	0.0000000

Hypothesis-2 (post imputation)

	Column	Missing_Count_h2	Missing_Percentage_h2
.imp	.imp	0	0.00000000
.id	.id	0	0.00000000
country_code	country_code	0	0.00000000
country	country	0	0.00000000
income	income	0	0.00000000
year	year	0	0.00000000
digital_gap	digital_gap	81	4.10334347
lab_inc_value	lab_inc_value	0	0.00000000
unempl_total	unempl_total	7	0.35460993
semp_total	semp_total	7	0.35460993
gov_exp_edu	gov_exp_edu	30	1.51975684
gdp_pc_grw_an_prc	gdp_pc_grw_an_prc	1	0.05065856

3.4. Panel analysis with variables with imputed values

Hypothesis-1 (DV: digital gap) (Model-1: random effects; Model-2: fixed effects)

	Model 1	Model 2
(Intercept)	0.69 ***	
	(0.06)	
act_lab_p	-0.01 ***	0.00
	(0.00)	(0.00)
workers_rights	-0.00 ***	-0.00 *
	(0.00)	(0.00)
gov_exp_edu	-0.02 *	-0.00
	(0.01)	(0.01)
lab_product	0.01 **	0.01 *
	(0.00)	(0.00)
s_idios	0.08	
s_id	0.13	
R^2	0.25	0.04
Adj. R^2	0.24	-0.53
Num. obs.	318	318

*** p < 0.001; ** p < 0.01; * p < 0.05

Hypothesis-2 (DV: labor income share) (Model-1: random effects; Model-2: fixed effects)

	Model 1	Model 2
(Intercept)	45.46 ***	
	(1.25)	
digital_gap	-1.14 *	-1.58 ***
	(0.49)	(0.47)
unempl_total	0.07	-0.06
	(0.05)	(0.05)
semp_total	-0.01	0.34 ***
	(0.02)	(0.05)
gov_exp_edu	0.64 ***	0.59 ***
	(0.13)	(0.13)
gdp_pc_grw_an_prc	-0.15 ***	-0.14 ***
	(0.03)	(0.03)
s_idios	1.77	
s_id	7.09	
R^2	0.16	0.12
Adj. R^2	0.16	-0.07
Num. obs.	867	867

*** p < 0.001; ** p < 0.01; * p < 0.05

3.5. Panel analysis with missing and imputed values for variable the digital gap

(Model-1: random effects missing; Model-2: fixed effects missing values; Model-3: random effects imputed values; Model-4: fixed effects imputed values)

Hypothesis-1 (DV: digital gap)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	0.64 ***		0.69 ***	
	(0.16)		(0.06)	
act_lab_p	-0.00	-0.00	-0.01 ***	0.00 **
	(0.00)	(0.00)	(0.00)	(0.00)
workers_rights	-0.00	0.00	-0.00 ***	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
gov_exp_edu	-0.01	0.01	-0.02 *	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)
lab_product	0.01	-0.00	0.01 **	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
s_idios	0.10		0.08	
s_id	0.16		0.13	
R^2	0.07	0.01	0.25	0.04
Adj. R^2	0.01	-0.80	0.24	-0.54
Num. obs.	74	74	318	318

*** p < 0.001; ** p < 0.01; * p < 0.05

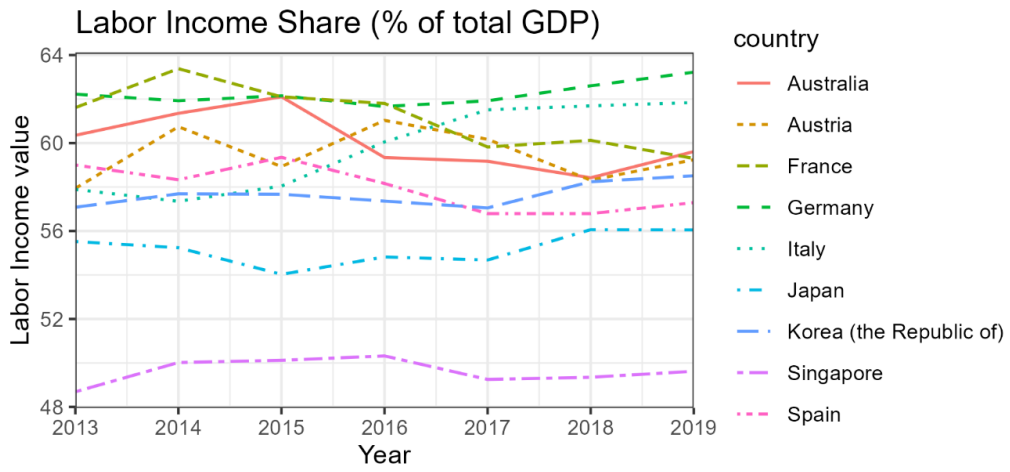
Hypothesis-2 (DV: labor income share)

	Model 1	Model 2	Model 3	Model 4
(Intercept)	31.19 ***		45.46 ***	
	(3.41)		(1.25)	
digital_gap	-0.72	-0.17	-1.14 *	-1.10
	(1.01)	(1.55)	(0.49)	(0.75)
unempl_total	0.36 *	-0.42	0.07	-0.04
	(0.17)	(0.30)	(0.05)	(0.05)
semp_total	0.17 ***	0.46 ***	-0.01	0.35 ***
	(0.05)	(0.09)	(0.02)	(0.05)
gov_exp_edu	0.40	0.41	0.64 ***	0.60 ***
	(0.21)	(0.22)	(0.13)	(0.13)
gdp_pc_grw_an_prc	-0.08	-0.08	-0.15 ***	-0.13 ***
	(0.07)	(0.07)	(0.03)	(0.03)
s_idios	2.09		1.77	
s_id	6.48		7.09	
R^2	0.35	0.16	0.16	0.12
Adj. R^2	0.33	-0.10	0.16	-0.08
Num. obs.	230	230	867	867

*** p < 0.001; ** p < 0.01; * p < 0.05

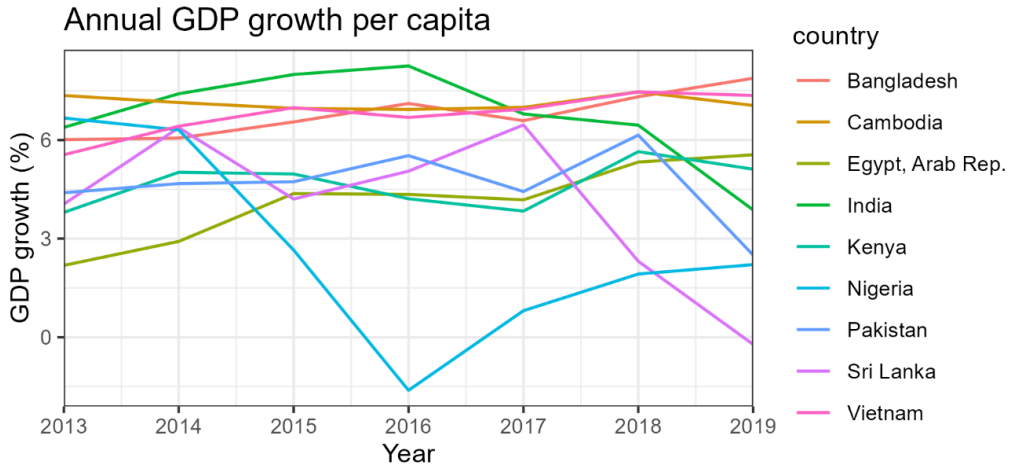
Annex-4: Cross-country variations and trends

4.1. Lower labor income share across high income countries



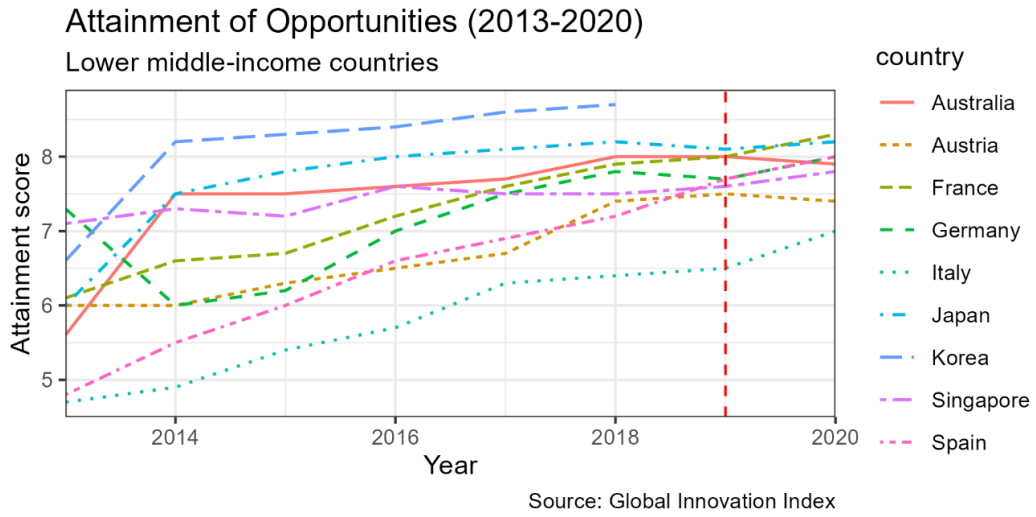
Source: ILO

4.2. GDP growth per capita (annual %)



Source: WDI

4.3. Attainment of Digital Opportunities by the High-income Countries



Annex-5: Thesis report

Detailed Thesis Proposal for Mundus MAPP

Contents of the Submission

1. Topic and Introduction
2. Literature review
3. Methodology
4. References
5. Proposed thesis work plan - timetable

Submitted by: Ikhtiarul Arefeen

Topic: The Fourth Industrial Revolution and Labor Market Inequality in Developing Countries: Cross-country comparison and mixed method analysis with Bangladesh case

1. Introduction

1.1 Problem statement

Bangladesh is a miraculous case among the developing countries in the world with its outstanding performance in growth and development. From a war-torn country to a fast-growing economy, it has achieved a lot of milestones in its journey. According to The World Bank, Bangladesh is one of the fastest growing economies in the world and leading its path to development in terms of several social and economic indicators. Bangladesh's recent transformation is defined by Hossain & Sheikh (2021) as a shift from rural-based agrarian economy to urban-based manufacturing and service-based economy with two determinants on the rise- income and job. It lays the foundation for the transformation to the fourth industrial revolution through the adoption of technologies. Women empowerment is one of the remarkable indicators it has achieved in recent years, while even outperforming its neighboring countries. Participation of women in labor force, especially in the garments sector has brought an astounding socio-economic revolution. Due to high economic growth, massive infrastructural development, and incoming high number of investments, the country is experiencing a huge transformation in its industrialization and businesses. Recently, the government, businesspeople and research in Bangladesh have been floating the idea of the advent of fourth industrial revolution (4IR) in the country.

Fourth industrial revolution is a reality among the scholars and practitioners. The wave of automation, which is already happening in the world, and some countries have already taken the leading role in transforming their industrial operation to the next level based on artificial intelligence (AI). The key features of the upcoming industrial revolution are projected to be shifted from 'smart' to autonomous and sentience. Thereby, the 4IR is going to change the ways we live and communicate with each other in society. It will change the way we are involved in production and operation (Ross &Maynard, 2021). Frey & Osborne (2013) predict based on their research on technological unemployment that almost half of the US employment categories are at high risk of automation. Krueger (1993) finds that workers who use computers can earn more than 10 to 15 percent than those who do not use computers. Hence, the 4IR technologies could make the situation more dynamic, competitive, and inequal.

Bangladesh is rapidly embracing the features of the 4IR in every sector, irrespective of their role and place. The expanding use of 'AI, digitalization, biotechnology, and global connectivity' has significantly impacted governance, management, and the system of production (Shibli, 2022). Likewise, Nedelkoska & Quintini (2018) outlines the prospect and challenges of 4IR as a high number of jobs are at risk because of automation in the coming days as the adoption of modern technologies will significantly change the nature and role of jobs.

The labor market and labor force in Bangladesh would face a lot of challenges, transformations, and crises locally and globally after the new stage of industrial development arrived. Two of the Bangladesh's key labor force groups are directly connected to international cooperation-one is the apparel industry which hosts one of the largest women labor forces in the country and the other is expatriates and migrant workers, given the fact that remittance and

employments in ready-made garments sector are notable driving force behind Bangladesh's astonishing socio-economic development. The apparel industry is one of the very labor-intensive industries in the country that plays vital role in woman empowerment offering many jobs to low and no-skill female workers. Because of gigantic employment opportunities, it has attained social, economic, and political importance and has helped Bangladesh outperform the other neighboring countries in the competition. One basic question could be how challenging it would be for the apparel industry to embrace the change that occurred due to the 4IR, considering that the country's income inequality is increasing amid the high economic growth (Chowdhury & Hossain, 2019). This ongoing technological transformation of work can also interact with the COVID-19 pandemic shock resulting in fewer jobs for the less educated and low-skill workers as well as further decline in the labor share of national income. External shocks like a pandemic can make the situation worse when the automation is still taking place and its effects are being felt by the labor market in a country or globally. It is observed that the low skilled workers and informal sector employees are displaced in this situation (Petropoulos, 2021).

The shift from human-driven to machine-driven production would be a precise example of the predicted situation in this industrial revolution period. The demand side of this sector would shift because of this exogenous shock as new investments and the introduction of modern technologies would occur. Because of the change in demand and other transformation, inequalities may arise among the laborers (Schwab, 2016), where collective bargaining and other market forces could play a significant role in driving out the market failures and inequalities. Furthermore, this industrial revolution might bring new needs in the job market (Warning et al., 2020) that might have implications for national education policy (Kupets, 2015; Sloane & Mavromaras, 2020). Higher education is closely related to the transition process to the fourth industrial revolution; thus, the transition has an enormous impact on education. The basic question could be how challenging it would be for the apparel industry to embrace the change that occurred due to the 4IR.

The national industrial policies of developing countries are still failing to incorporate the ensured opportunities for everyone in the labor market, while many of them have not embarked on developing a policy framework yet. For example, national industrial policies of South-East Asian countries are still under scrutiny of the scholars that they could not address the issue of job loss due to automation, data safety and security sufficiently (Homma, 2022). In case of Bangladesh as a leading developing country, it has adopted some legal measures to safeguard and regulate the labor market and welfare. National Labour Policy, 2012 and the Bangladesh Labour Act, 2006 are the main catalysts here. Relevant are the Bangladesh National Education Policy and the Bangladesh Population Policy that emphasizes and directs the education and training programs for the development of human resource according to the needs of the 21st century. However, any policy which is directly addressing the 4IR is still out of sight.

Therefore, it is imaginable that the changes due to the introduction of the 4IR, either gradual or dramatic, would have significant effects on labor market and subsequent inequality. The impact of automation on human jobs should be researched and not be ignored or underestimated by the relevant stakeholders (Badiuzzaman & Rafiquzzaman, 2020). That being the case, it is imperative for research, business, and government in developing countries to coalesce to sort out better strategies to deal with it.

1.2 Objectives of the study

The aim of this paper is to identify the challenges for the labor market ahead of the projected industrial transformation in developing countries exemplifying the case of Bangladesh. This study will examine the cross-country experiences of the 4IR and labor market transformation that causes inequality. It will also seek opinion of the stakeholders in Bangladesh so that it could help the country develop sustainable and equitable plan of action to grab the best of the opportunities and mitigate the forthcoming challenges.

2. Literature Review

2.1 The Fourth Industrial Revolution (4IR): A short introduction

Schwab (2016) characterizes the 4IR as a distinct development in industrial history, which is a fusion of technologies through which lines are being blurred between the physical, digital and biological spheres of humankind. Adhikari (2020) identifies four key emerging technologies as components of 4IR, such as- Artificial Intelligence, augmented reality, additive manufacturing, and Internet of Things. **N**ew tasks will emerge as a result of technological advancement, apparently as a result of the 4IR in the forms of programming, design and maintenance of high-tech devices and equipment, where applications and software, database management, digital security as well as the task related to automated operation are evident (Lin, 2011).

2.2 Historical emergence of industrial revolutions

Subsequent industrial revolutions in the history brought different changes in the roles of jobs and the modes of production. For example, the second industrial revolution replaced the traditional modes of production, operation and transportation through the introduction of steam engines, railroads and cranes etc. These technologies displaced some workers from the job, but employed new people of engineers, machinist, managers, conductors and repairmen and so on and so forth. Acemoglu & Restrepo (2018) argues that the prediction of human replacement by machines by Keynes (1930) cannot be called correct as significant technological unemployment did not happen. However, the increase in per capita income was proven to be true, given the steady growth rate of the global economy. The 4IR has brought a lot of changes in the labor market, production and operation with new roles and modes replacing the old ones. Engineering, programming and automations are again changing the previous status quo in the market that employs people with new skills. For example, unmanned vehicles are replacing conductors with programmed machines that can autonomously navigate the roads and drive the vehicles.

The idea of the 4IR started in Germany in 2013 and has been gaining steadily increasing attention in other advanced economies (Petrillo et al., 2018). The third industrial revolution made computers at the forefront of everything and accelerated our ability to function through computerization. This digital development laid the foundation stone for the ongoing transformation of industries to enable the fourth one through the innovation of accessible internet, software and autonomous machine operation (Bajpai & Biberman, 2019). A question can be asked that is it possible to maintain a stable relationship between humans and machines in the labor market and production amid the fourth industrial revolution as it did not happen in the past industrial revolution between horses and machines? As in the case of horses, the previous industrial revolutions replaced them with new machines. As 4IR

challenges the place of humans in the factories and/production, one argument is that the human has comparative advantage of supplementing or complementing other new jobs while horses didn't.

2.3 The Fourth Industrial Revolution and labor market transition

Often termed as the Second Machine Age (Bajpai & Biberman, 2019), the 4IR will replace humans by introducing and accelerating machine-driven operations. It will restrict humans to work mostly in creativity, human interaction and management, while autonomous robots will take care of the rest. For example, the driverless metro or cars are vivid cases of it. Sharma (2018) finds a drastic decline in the share of jobs in the manufacturing jobs in the last five decades in developed countries. However, developing economies can still hold it flat. The important question is whether it impacts a lot on income inequality and growth distribution. The emergence of non-market services like government, health and education are new features in developing countries. But the market-related sectors like manufacturing and construction still have the lion share of labors there. Yet, income and productivity has been observed as slow when the labor market shifts from manufacturing to the service sector.

Moreover, job transition from manufacturing sector due to automation means it moves to service sector that requires skills and training on using technology and software, given the fact that the manufacturing sector job is taken over by automation. After the immediate transition, workers do not have the skill and knowledge, thus, they accept a low-wage job condition (Acemoglu & Restrepo, 2018c). This wage cut increases the income inequality in the country because of the downsizing of the wage distribution. Whether these displaced workers immediately move to the service sector or remain unemployed for some days could give them a chance to reskill themselves is a fact that cannot be underestimated. Besides, job loss in manufacturing is not the only factor proven to cause income inequality. Studies are needed to identify the others (Novta & Pugacheva, 2019).

Acemoglu & Restrepo (2019) argues the implications of technological change and their impacts in two ways. In one trend, it shows that the adoption of machines and automation leads to the loss of jobs for many. However, the effects of previous industrial revolutions as they replaced some of the roles with new roles and skills while employing a lot of people within short time. A mismatch between technology and skills could have multiple effects on employment and economic growth. The adjustment of labor demand could be slowed down by the mismatch and can contribute to inequality that eventually decreases productivity. During the severe skill mismatch, the rate of inequality could reach a very high level that could mean a worse situation for the policymakers to solve this problem (Acemoglu & Restrepo, 2018b).

2.4 Impact of automation and technologies on labor market

The World Economic Forum (2020) is leading the study of the 4IR and its effects on the labor market. It emphasizes the recognition of all types of works emerged after the adoption of new technologies and the employment of new policies to regulate the labor market and ensure the rights, employment benefits and protection of the workers. Various key areas of actions have been identified, such as empowerment of individuals and their protection through policies and regulations. Warning et al. (2020) researched on the 4IR and its challenges and opportunities where he finds that the job displacement and skill transition are

vitally interconnected in the advent of the new job roles. Making the workforce trained for working with automated technologies with data protection and privacy is a key concern.

The range of automation and technology usage is expanding everywhere at a faster rate nowadays. It does not confine itself to industry, rather to management of operation of taxes, inventories, research, financial transactions, reporting and diagnosis and so on and so forth. Introduction of industrial robots in Germany causes increasing inequality among the ex-ante workers. Whoever managed to stay at the factory and whoever needed to leave after the automation will result in a gap because of the drop-in earnings. There is no guarantee for the displaced workers in the newly introduced tasks due to technological advancements (Dauth et al., 2021). Wright & Schultz (2018) discusses a very important aspect of the implications of automation. Ethical concern in business automation and artificial intelligence affects the many in labor market through potential manipulation of data. It could disregard the mental health and wellbeing of the employees.

Millington (2020) suggests that digitalization does not indicate huge unemployment, rather it widens the income inequality. He maintains that the middle-skilled jobs are prone to be replaced by automation, while the high and low-skilled jobs are experiencing expansion to different extents. On the other hand, less educated people can face huge income inequality due to lack of skills and training, which they cannot avail themselves. Acemoglu & Restrepo (2019) observes that the historical trends of automation and their impacts do not always imply the displacement of jobs, rather they also created a lot of new jobs that prevail over time. The emergence of new tasks due to technological change, thus, creates reinstatement effects in the labor market. As reinstatement is the total opposite to the displacement, it brings positive result to the job shares.

2.5 Risk of inequality and scopes for mitigating actors

As a key feature of the 4IR, new automation will cause displacement of workers and inequality more than the older generation of automation. Real estate, administration, arts, entertainment, recreation and sports are seen as highly human-centric occupations. However, they could be impacted by the technological advancements of other professional expertise; thus, their clients could avoid it while they cannot get the expected accelerated service that they get from gadgets or other tech-experts (Bajpai & Biberman, 2019). Automation weakens the bargaining power, which is rigid in adjusting the real wages of the workers that increase the fluctuations in unemployment and vacancy rates (Leduc & Liu, 2022). The middle class that grew upon the skills required by the third industrial revolution might take a significant blow as their middle-class status could be threatened by the reduced income. Because of the shift in demand for skills, their wages could be lowered that will lead to income inequality (Bajpai & Biberman, 2019). Recent research (Acemoglu & Restrepo, 2020) finds the strong correlation between changing industrial demands due to automation and its subsequent displacement and reinstatement effect. It refers to Tinbergen's (1974) approach to inequality that bases the technological change and the role of education in raising the supply of skills to the industries indicating the impact of 4IR.

Acemoglu (2003) exemplifies the decreasing inequality in Europe as a result of the employment of skilled workers. He develops a theory that demonstrates that the European labor market has been planned to create more wage compression that lowers the wage gap between the new and old workers, and simultaneously, increases investment in technologies

that harness the productivity of less-skilled workers through a less-skill biased technological change than the US. To explain the differential inequality trends in European case, Acemoglu (2003) identifies the traditional approaches as the rapid increase in the supply of skills that drives out the inequality and the role of wage-setting institutions there. Due to these factors, actors like firms contribute to achieve wage compression by changing their demand for more skilled workers then less skilled in the European market. Eventually, it helps to reach equilibrium.

Galle & Lorentzen (2021) discusses the impact of technology on inequality and gender gap. Apart from overall inequality, gender-based inequality is another point of concern for the policymakers, especially in developing countries, where the capacity to drive off these inequalities is comparatively low. Economic growth and gender equality have a positive relationship. Rodriguez (2017) shows that growth rate and female/male participation in labor market are positively associated with very robust relationship.

Governments have a large role to play to ensure that everyone in society can avail themselves of the benefits of 4IR while also guarantying employment and social safety. Holzer (2022) identifies designing education and training according to the needs is the most important challenge. The first target people for the regulatory regimes are the laborers at high risk of displacement due to automation. Ethical concerns need to be taken into significant consideration in decision making as AI can do harm to the workers at different levels. For the employers, they have a large role to play in ensuring that their employees are getting trained in 4IR technologies and their implications in the operation to make a smooth transition to the new types of jobs. Otherwise, it will lead to a 'dystopian future' for the labor market (Warning et al., 2020).

2.6 The key issues of labor market inequality and their measurement factors

Minimum wage is a proven mechanism (Giupponi & Machin, 2022) that can reduce the income inequality at lower-tail in the long-run amid the technological change that favors the skilled workers while displaces low or unskilled workers. Most of the inequality in labor market can occur at its outcome like labor force participation rate, unemployment rate, employment status of paid, unpaid and self-employed, wage distribution and job positions. Sources of data for the labor market outcome are population census, labor force survey, wage and income distribution survey, household or employer survey. These variables should be controlled by similar levels of education, work experience, and job types (Schachter, 2007).

German labor market transition is a valuable example for learning the implications of 4IR. Walwei (2016) delineates some key points on exampling that labor market while terming it as smart automation. This smart automation can avoid job losses, rather it can shift the structure of the employment to a sustainable one through reskilling of employees and reorganizing and reorienting of the industries while also considering the needs of the market. Minimizing the risk of inequality is not a simple task and can be effectively dealt with through the abovementioned strategies. Dauth et al. (2021) finds German as a benchmark to study the effects of how labor markets adjust to automation due to its advanced robotic technologies and capabilities to adopt it. Longitudinal data is necessary to displacement and reinstatement of the labor forces in different sectors over time after the automation started. Implications of automation for wages, employment, productivity, and inequality can be easily studied if more of this kind of data could be gathered and analyzed.

Many developing countries like Bangladesh and Pakistan could be good cases to study its challenges and opportunities in adapting to technology. The labor market is one of the three challenges identified by Stiglitz (2012) that plays a significant role in the unemployment rate. By the rate of unemployment, income inequality and its causes could easily be dig into (Hacibedel et al., 2019). Howell & Kalleberg (2022) emphasizes using competitive market forces like bargaining power and need-based skill supply (Kupets, 2015) to reduce the inequality in the labor market. Labor market regulations can work as an effective tool to reduce inequality including employment protection laws, labor taxes, proportion of income taxes and their social contribution, and the minimum wage policies (Tjong & Schmillen, 2019).

In developing countries, agriculture is still a dominant sector for livelihood and covers a lion share of low and unskilled labor, which could be further jeopardized using AI. However, it could also help those unskilled people to speed up and increase productivity, for example, through using surveillance drones for protection and fertilization. The development of trusted and reliable blockchain in agriculture could help the local farmers to get access to bigger markets, thus, it will increase productivity gains (Adhikari, 2020).

2.7 The countervailing forces to labor market inequality

Reducing inequality is a crucial and complex job and can be solved through effective structural reforms that can lower the disparities at the distribution of income. Structural reforms can include emphasizing other sectors like informal employment and self-employment. Lack of strong social safety net programs, protection of employment and unemployment benefits are mandatory to solidify the equality in the labor market. As youth unemployment is one of the main channels of inequality, this group should be targeted to reduce their vulnerabilities through proper training (Hacibedel et al., 2019). Countervailing forces, for example, the reduction of production cost due to automation might help to increase the production activity and capital accumulation, that can be invested in more tasks and jobs (Acemoglu & Restrepo, 2018b).

For highly populated countries, industrial automation could be a curse in disguise with lots of visible and hidden impacts. Technological change can disproportionately increase the demand for capital and drive to a great job loss due to automation, which, eventually, affect income distribution and deepen the gap between high and low-skilled work force (Zervoudi, 2020). Third world countries could face huge challenges in skilling and reskilling the huge population to match with the technological needs. Deployment of automation and skill migration needs to be consistent so that the creation of gaps and mismatch does not occur. Developing countries are more vulnerable to suffering than the developed ones in this case due to lack of their capacity (Badiuzzaman & Rafiquzzaman, 2020).

Focusing on the labor market of Asia and Pacific, Campbell (2020) identifies policies, regulations and institutions are the key working areas to advance the idea of the 4IR. The anticipated changes in this area will occur after the advent of this industrial transformation that would face the hassles to mitigate the social protection challenges. As 4IR will reduce the physical barriers in people's daily life and work, it will significantly impact on the shape of the economy with its new types of activities, while quantity, quality, location and nature of work will be changed and challenged in different ways. Most of the population in Asia and Pacific region are still out of the reach of the 4IR because of their lack of accessibility to

high-speed mobile internet and uninterrupted electricity supply. The region has plenty of cheap labor supply, however, in terms of adapting to the technologies of 4IR, they will need to be reskilled, otherwise it will disincentivize this labor surplus that is not helpful (Campbell, 2020).

There are some prescribed goals (van der Hoeven, 2000) of policies, regulations and institutions of labor market that can steer the direction to more welfare achievements. Those are the improvements in allocative efficiency that matches supply and demand, the development in efficiency through increasing quality of labor force, and the maintenance of social justice and equity. Due to the increasing share of informal sector in labor market, income inequality rises. So, the elements of growth and redistributive policies should prioritize the dynamics of equality, equity and social cohesion. Some countries have already developed policy and legal frameworks to address these issues. For example, "Industry 4.0" of Germany, "Advanced Manufacturing Partnership" of the United States, and "Made in China 2025" of China are noteworthy public policies that can guide the others based on their needs (Asghar et al., 2020).

2.8 The 4IR and labor market transitions in developing countries

Challenges for the 4IR in developing countries could be manifold like poor infrastructure, cheap and available labor, expensive technologies and lack of knowledge on how to adapt to these new digitalized and automated spheres. Lack of support from the government is also a factor that could potentially downgrade the pace of adoption of the 4IR (Islam et al., 2018). Nonetheless, with the adaptation to the new technologies and tasks with different modes of operation, inequality in the labor market might increase as a consequence. One of the major challenges for the developing countries is the skill mismatch that might affect the labor share due to automation (Acemoglu & Restrepo, 2018). Then, it will increase the inequality in the income share and unemployment. In this case, high-skilled workers will get more preferred roles than the less-skilled ones. It could be the opposite, when high-skilled workers become displaced due to the arrival of the new technologies, where they are replaced by another set of high-skilled workers. Here, the less skilled workers might prevail due to their less important roles and positions. Investing in replacing the less important low skilled roles could not be cost-effective; thus, they are sometimes less vulnerable than the skilled positions. However, it depends on the job sector and factories.

A further most vital impact on employment due to technological change is the change in wage composition, where the wage gap between the high and low skilled workers deteriorates. This job polarization and income inequality could fuel social unrest and class tension in society, especially when it happens in the developing or underdeveloped countries. Nevertheless, Autor (2015) hopes that automation substitutes and complements labor, that means, when it displaces labor, simultaneously, it can create new tasks and roles, increase productivity and earnings, and augment demand for more labor.

Adhikari (2020) also identifies few major challenges- one is the lack of resources to provide basic 4IR relevant education and the other is the 'rigid and inflexible' education system that is less adaptive to skill market and requires strong political commitment to reform accordingly. Unlike the previous industrial revolutions, the 4IR offers an open window for the developing countries to get the benefits of it. It provides accessibility to technologies, affordability to choose the suitable ones and their applications. The 4IR opens a huge

opportunity to adapt to this new reality that could help to reduce poverty and to achieve sustainable futuristic development. For the Least Developed Countries (LDCs), the very first challenge before analyzing the impact of 4IR is the accessibility to its technologies. Developed economies might keep their innovations strictly protected and costly to achieve like patent. That means it is an issue of affordability too for the LDCs. Second is the lack of infrastructure to enable the actors to employ themselves in the proper utilization of the technologies. Even if they could manage accessibility and affordability, applications of those features require necessary skills and progressive and welfare-centric policies and regulations.

Overall, Zervoudi (2020) summarizes four challenges of 4IR- one is how much technology can threaten human labor, second one inquires the factors that exposes workers to automation risk, the third challenge is the identification of jobs at risk, and the fourth one relates to the political intervention that can deal with the unpredictable consequences of technologies.

2.9 The 4IR in Bangladesh and its effect on labor market

Ali (2018) reflects on Bangladesh's experience and expectations on the advent of the 4IR while referring to it as a transformation in everywhere and everyone needs to take preparation to cope with the radical changes it will bring. He exemplifies Union Digital Center as a bold step towards embracing technological change even in the rural areas of the country. Thus, it is shown as a preparation mechanism for 4IR. Islam et al. (2018) identifies few specific challenges for Bangladesh, such as lack of government support, knowledge, infrastructure and the cost of the installation of technologies. The country needs to mitigate these challenges to harness the maximum opportunities of 4IR in its capacity (Asghar et al., 2020). A recent study by a2i (2019) suggests that 40% of all jobs in Bangladesh are at risk of automation by 2041. Most vulnerable sectors are ready-made garments, agro-processing, furniture, leather sector and tourism sectors are at risk of being automated, where women and youth at the entry level is more at risk of job losses. However, the high rate of educational attainment could offset this negative trend to the positivity even in the high adoption of 4IR technologies (Khatun & Saadat, 2020). In developing countries like Bangladesh, labor market variables and income inequality indicators could be complex to study as they are imperfect with huge share of informal employment, absence of trade unions and collective bargaining, large agriculture-based employment, migrant workers and flow of remittances and lack of transparency in transferring social benefits to the poor and so on and so forth. That's where, the pattern of change and its nature in developed and developing countries is different.

Bangladesh is a labor-abundant capital-scarce country. Its labor-intensive production mode is highly vulnerable to higher displacement, should it adopt the technologies and automation. Due to the advent of the 4IR, it is expected that Bangladesh is advancing towards a more capital-intensive production from a labor-intensive one. This potentially changed occupational and structural transformation needs a careful study of how it is going to contribute to the income distribution (Bidisha et al., 2021). Due to high prevalence of lower mid-skilled workers in Bangladesh's labor market, it is a reality that higher growth of GDP is not distributed equally. Because of the lower educational level, the returns of economic growth to them are low, while those with higher tertiary education can ace out. Hence, the education attainment is equally important along with the high GDP growth to ensure the equality of gains. Bangladesh has experienced an increase in the number of high-skill workers as a result of the overall increase in the rate of educated people. With skill-biased training, the country needs to regulate the minimum wage in favor of the workers and to

encourage collective bargaining through legal provisions. Bidisha et al. (2021) reports an impact of foreign remittances on rural inequality in Bangladesh. Other factors like farming, self-employment and non-agricultural sector could play a role in equalizing inequality. If migrant workers who are low or unskilled from rural areas have a significant contribution to income inequality. That might be impacted if there is any shift happen in the destination countries due to the 4IR, when they would no longer need human support to provide services or continue production.

3. Methodology

3.1 Research Approach

The methodology will follow the mixed method approach with significant focus on both qualitative and quantitative data. By applying this method, this paper aims to ensure more validity in the results, given the fact that the 4IR is still not fully achieved in developing countries like Bangladesh; thus, experts' in-depth opinion is also needed to identify the gaps and further actions in dealing with inequality in labor market.

3.2 Research Question

The central question of this research is: What are the causes that create inequality in the labor market in the advent of the Fourth Industrial Revolution in the developing countries and how to mitigate those challenges? To find out the answer, the following questions will be employed in the whole study.

1. what are the challenges the labor market will face amid 4IR in developing countries like Bangladesh?
2. What did the other countries do to tackle the inequality in the same situation?
3. what is the policy option the Bangladesh government can forge with the relevant stakeholders to drive out the inequality while maximizing the achievements of the objectives of the 4IR?

3.3 Part I: summary statistics for cross-country analysis

Cross-country experiences will be delineated through summary statistics including mean, median and standard deviation. For cross-country analysis of labor market inequality due to the forthcoming impact of 4IR, it is better to identify the existing gap between developing countries and already developed countries which have better experiences of embracing the aspects of 4IR. In addition, countries that are facing similar types of economic growth and socio-economic situations are good samples for comparison. Their experiences in labor market transformation due to 4IR could help Bangladesh and other developing countries to better prepare themselves. For example, Bangladesh, Vietnam and Pakistan are the countries that have similar economic situation and are trying to adopt the technologies in their production system; thus, their comparison would be valuable to identify what to do to tackle the inequality in labor market. On the other hand, Germany and Japan are two well developed technologically advanced countries which has the significant level of experience of adopting the technologies in production and operations and, at the same time, have adopted policies to drive out inequality.

3.3.1 Proxy variables for the cross-country analysis

There are number of variables that can describe the labor market inequality in developing countries with the specific example of Bangladesh. Key variables for the labor market in the 4IR are skill mismatches, lack of infrastructure and lack of policy frameworks. Some proxy variables can be employed, such as Gini index, consumption per capita, skill gap like ratio of STEM graduates, ratio of female STEM graduates, number of workers in formal and informal sector, available policy options and so on and so forth.

3.2 Part II: regression correlation between labor market inequality in Bangladesh and independent variables (Dependent variable; independent variable; control variable; dummy variable)

Some correlational operation through R programming could also be applied if deemed necessary during the study. Technological changes affect inequality in terms of wages, profits, and jobs that are related to productivity of firms and inequal distribution of wages (United Nations Economic and Social Council, 2022). Vandenberg (2010) shows that the unemployment rate does not have significant correlation with hiring regulations and nature of collective bargaining. He identifies some key areas of labor market institutions, such as- 'hiring, deployment, termination, unemployment insurance and collective bargaining' and so on and so forth. He finds that unemployment insurance with higher benefits and longer time sustenance has an impact on the unemployment rate. Therefore, it is possible for this research to conduct a regression analysis between the labor market inequality and other variables like unemployment rate, inequal distribution of income in Bangladesh as a sample from developing countries to identify the more robust scenario there.

3.3 Part III: expert opinion on labor market inequality and how to deal with it, and content analysis from the newspapers based on searching by key words

After setting the background based on literature review and summary of the cross-country experiences, the study will employ in-depth data collection tools, such as- Key Informant Interview (KII), online interviews, newspaper content analysis. This method will help to engage with the experts and practitioners in the labor market to identify their opinion and proposals for the future. In the previous literature review, it was observed that the lack of policy frameworks is prevalent in developing countries. This analysis will certainly guide the policymakers to identify their focus to deal with the inequality in the labor market.

3.4 Sampling

Cross-country analysis: Lower-middle income countries like Bangladesh, Pakistan, Viet Nam, Nigeria, Saudi Arabia (as a expats' destination country), Egypt are the key samples that could be considered to conduct this cross-country analysis and get a sampled picture. Besides, data from Germany and Japan can be used as two leading countries that adopted the 4IR and developed significant policy frameworks and implemented them to deal with the inequality in the labor market.

Expert interview: For key informant interview, participants will be selected by using the convenient sampling method so that targeted people can easily be found and reached, given the fact that, due to their busy schedules, these people are less available to give an interview.

3.5 Sources of data

Different time-series data are needed to conduct the cross-country analysis. Interview data are also from the primary sources. Additionally, secondary sources are significantly included to relate and analyze the collected primary data.

3.6 Findings and analysis

The following questions could be answered in the analysis based on both quantitative and qualitative data. What are the measurable policies that have been taken by the governments? What can be observed through the lenses of those policies; ***Skill mismatch*****:** what are the variations here in the case of the sampled countries; what are the variables that can be measured; ***Low-skilled labor*****: w**hat are the efforts to re-skill them; what are the country variations; is there any example of the country that applied the policies to reskill the low-skilled workers; ***Youth/re-skilling*****:** which countries did what to re-skill the youth workforce according to the needs of the Fourth Industrial Revolution; ***Variation in cross-country*****: w**hich countries are more prepared and which countries are not, in terms of variables like investing in skilling or investing in infrastructure etc.

3.6.1 Summary statistics

The summary statistics will also be presented as the findings of the current status and gaps between Bangladesh and the sampled countries based on the inequality indicators.

3.6.2 Key-Informant interview analysis

The analysis plan will follow the thematic and content analysis.

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Thesis Work Plan

Agenda	**Issues covered**	**Expected Deadline** (not based on program dealines)	**Status**
Detailed Thesis Proposal	Problem statement, Methodology, Literature review and bibliography	15/09/2022	Submitted
Finalizing methodology and initial data collection	Research questions, variables, interview questions and guidelines, start of data collection	31/10/2022 (Based on supervisors' feedback)	
Thesis workshop course	Thesis work plan presentation and feedback	January'23 (depends on class schedule)	
Data collection	Cross-country data, data on inequality variables and newspaper content, expert interview	February'23 - April'23	
Data analysis	Writing analysis and discussion	May'23	
Final report writing	Final version to be submitted to the supervisors for final feedback before submission	June'23	
Final thesis submission			According to the academic program schedule