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How Changing in Climate Patterns Impact Labor Productivity: Perspectives from Developing Economies in South Asia.

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Abstract

This paper examines the impact of climate change on labour productivity in selected South Asian nations, highlighting the urgent need for adaptive strategies. Climate change poses significant threats to human welfare, particularly through extreme weather events and rising temperatures, which have been linked to decreased worker productivity. Using annual data from 1990 to 2023, this study explores the relationship between labour productivity and variables such as foreign direct investment, renewable energy consumption, urbanization, trade openness, and climate change. Employing an ARDL model, the study reveals that heat exposure leads to health issues such as dehydration and cognitive decline, significantly affecting sectors like agriculture, manufacturing, and construction. The findings indicate that labour productivity could decline by 10-15% by the end of the century in South Asia due to climate-related factors, with substantial economic implications, including potential GDP losses of up to 8.8% annually. This research underscores the necessity for targeted policies to mitigate these impacts and promote sustainable development.

Keyword: Labor Productivity, Foreign direct Investment, Urban population, Renewable Energy Consumption, Climate change, Trade

Introduction

Climate change is becoming a threat to human welfare and health in so many ways; extreme weather events that get more intense and frequent leading to sever diseases which are likely to spread (Ebi, K. L., 2022).

Heat exposure is said to be one of the most persuasive and frequent health concern which is being associated with climate change. This has resulted in the reduction of workers productivity. It has also increased the cost of climate change expenses (Dara, C., 2012). It is said that in 2021, heat has affected and resulted in 470 billion missed works hours around the globe (Countdown, L., 2022). This has resulted in the loss of 72% GDP globally. It is also estimated that in many of the regions, labours will have a double impact because of heat and will be 2.7 °C global temperature shift (Kjellstrom, T., et al., 2018). One of the most important measures of the economic development is said to be labour productivity. For us, it has been impossible to ignore the bad heat affects on workers and its productivity (ILO, 2019). It is also obvious that for an economic success, labour productivity is one of the major and most important drivers. Most of the economists have devoted their most of attention to enhancing, understanding and measuring productivity (Bosworth & Collins, 2008; Jorgenson, Ho, & Stiroh, 2008; Van Ark, O'Mahoney, & Timmer, 2008). This is why the impacts of climate on the labour have been a very important concern both socially and economically. If we have any changes on the labour productivity, it will always have direct impacts on individual as well as national incomes. For low income/wages countries, climate change can result in undermining strategies related to poverty reductions and also goals rela6ed to sustainable development.

Since 2015/16, the world has recorded a record-breaking temperature. Every month was observed to be hottest in 2016 globally than all the previous recorded temperatures which resulted in the biggest jump in atmospheric CO2. This is why millions of people have been noted to be impacted by climate change. Many people have also been observed to be displaced from their homes because of extreme weather. This is one of the reasons that the situation in regarded as one of the biggest humanitarian crises since the second world war. Most of the countries, in the near future, will have many negative effects on human performance both at work and on their economy due to the extreme heat brought by the climate change. Rise in temperature is said to be one of the main predictable consequences and this is expected to rise so much significantly as forecasted already. The next century will face the consequences of worst global policies of today. Many are of the view that the climate change has its significant impacts over the labor productivity in the south Asian countries. They are of the view that the region is highly vulnerable because of the rise in temperature and extreme weather events. Some of the main factors that contribute to the impacts of the climate changes are as described as follows. With the rise in temperatures results in the heat stress for so many south Asian countries in various sectors of life. It has its huge impact on the outdoor activities like manufacturing, agriculture and construction. If one gets prolong exposure to heat, it may result in dehydration, heat related illness, cognitive abilities and fatigue.

Most of the study show that the rise in temperature has resulted in the decrease of labour and their physical activities. Due to rise in temperature, we have experienced many diseases like vector borne diseases named as dengue and malaria making respiratory related issues because of having worsened air quality around us in the environment. This is the reason that illness lower the participation of the workforces leading to decrease in the labour. In most part of the south Asia, have agriculture as one of the major employers making livelihood easier for the people. Rainfalls, floods and drought have its direct impact of the food security and the agriculture related labor within the south Asian society. Hence, we get reduced income and thus resulting to migrations. Cyclones, storms, floods and damage to infrastructure have made people impacted in both rural and urban areas. Displacement and migration have its huge impact on the workforce of a society and whenever we have these kinds of impacts on any society then we see lots of impacts on that society. Water scarcity has been one of the major worsening issues in the south Asian countries because of the climate change. When there is limited access to water then it has huge impacts of industries like energy production and agriculture. Hence workers are being forced in these sectors to operate in strained conditions leading to labor deficiency and it will also make increased production costs. These factors will lead to poverty and poverty will lead to reducing access to technology, education and healthcare, hence it will hamper the development of highly developed workforce.

According to research, labor productivity could decline by up to 10-15% in key sectors in South Asia by the end of the century if climate change continues unabated. Countries like India, Bangladesh, and Pakistan are expected to face severe productivity losses, especially in heat-exposed industries. The economic implications of these productivity losses are substantial. A report by the Asian Development Bank (ADB) estimates that South Asia could lose around 8.8% of its gross domestic product (GDP) annually by 2100 due to climate-related damages, with a significant portion of this loss attributable to reduced labor productivity (ADB, 2021).

These findings highlight the urgent need to explore the relationship between climate change and labor productivity in South Asia and to identify adaptive strategies to mitigate these impacts. Evidence from South Asia highlights the seriousness of this issue. In India, where approximately 50% of the population depends on agriculture, studies have shown that rising temperatures and shifting monsoon patterns have led to a 10-15% decline in agricultural productivity (Hussain & Qamar, 2020). The International Labor Organization (ILO) projects that by 2030, India could lose the equivalent of 34 million full-time jobs due to heat stress, primarily in sectors requiring heavy labor (ILO, 2023). Similarly, in Pakistan, extreme heat waves in recent years have reduced productivity in both urban and rural areas, especially among outdoor workers, contributing to increased health costs and economic losses (Zaman et al., 2019). Bangladesh, another heavily agrarian economy, is expected to face significant declines in labor productivity due to frequent flooding and cyclones, which not only disrupt agricultural cycles but also displace millions of workers, increasing urban unemployment (Rahman & Hossain, 2021). In China, although the overall risk is somewhat mitigated by its size and diversity, labor-intensive industries in the southern and eastern regions are also grappling with the effects of increased heat, humidity, and heat-related illnesses (Bosworth & Collins, 2008). In the Philippines, the effects of climate change on labor productivity are particularly evident in the agriculture and construction sectors, where workers are more exposed to extreme heat and weather events (Pallante et al., 2021).

Problem Statement

Climate change has impacted the productivity of labours in manufacturing, agriculture and construction. Extreme weather events and rise in temperature have resulted in reducing the work efficiency of many people leading to the loses relating to economics. Many south Asian and south east Asian countries like China, Pakistan, India, Bangladesh and Philippines are said to be vulnerable due to being exposed to floods, droughts and, heatwaves. These have threatened the poverty reduction and economic growth in the mentioned countries.

Objectives of the Study

1. To highlight and expose how the rise in temperature, extreme events, and climate related changes have to do with the disruption of labours in many south Asian and south east Asian countries.
2. To make identify the sectors and regions having to do with their vulnerability due to climate related labour losses.

Research questions:

1. How can climate change affect the labour productivity of many sectors such as manufacturing, agriculture and construction in south and south east Asia?
2. What sectors and regions are most affected by climate change?
3. what could be the results of social and economic aspects of reduced labour productivity in south Asian countries like India, Pakistan and Bangladesh?

Significant of the Study

The study is significant in so many ways as it mainly focusses on the impacts of climate change on labour productivity. This study is significant because it focuses on impacts in labour intensive sectors such as manufacturing, agriculture and construction. South and south east Asia are said to be highly vulnerable to the rise in temperature and extreme weather events. This study will also highlight very constructive insights to developing strategies and policies that has to do with the workforce and adverse effects on heat stress. The results of the study deal mainly with the climate adaptation policies having to do with poverty reduction, climate and also the achievement of the United Nations Sustainable Development Goals (SDGs).

Literature Review

There has been a huge impact of climate change on the productivity of labour when it comes to industries. It has been resulted in the reduction of working hours, increasing health problems, economic loses among the various people and communities. Xu et al. (2023) believes that due to the climate change, there has been huge increase in the heat exposure as well as weather events which has caused reduction in the working hours of labour leading to economic losses. Ebi (2022) is of the view that the rise in temperature have resulted in so many problems dealing with heat related problems like stress and illness. It also results in cognitive performances. He argues that these problems have been experienced in most of the south Asian countries where high heat exposure, along with intense climate events, creates direct or indirect consequences for economic growth and development. India, Pakistan, Bangladesh, China and Philippine have been on the front when it comes to climate changes because there has been huge rise in the temperature as well as increase in the frequency related to extreme weather events. Agriculture, and construction sectors in India, Pakistan and Sri Lanka have been noticed to be vulnerable to heat stress. This issue has not only resulted in the reduction of productivity but is being noticed as a health risk to outdoor workers and their activities.

Different people have different opinions regarding the global and worldwide implications of heat stress on the economy and its growth. The International Labour Organization (2023) believes that industries like constructions and agriculture will be hugely affected due to the rise in temperatures and such high temperatures are detrimental mostly in most of the areas/regions. Low-income countries have been hugely impacted by the rise in temperatures in south Asia.

It is forecasted by Hsiang and Kopp (2023) that by the end of 2050, we could witness almost 20% reduction within the labour productivity if we have the same level of rise in temperature. They forecast that India, Bangladesh, Sri Lanka will be the hardest to be hit by these changes. Dara (2012) argues that we had the climate change loss resulting in losing 470 billion work loads in 2021. Additionally, projections by Kjellstrom et al. (2018) indicate that labor productivity in tropical regions, including countries like India, Bangladesh, Sri Lanka, and the Philippines, could be halved with a 2.7°C global temperature rise, a scenario that is highly concerning given the region's reliance on agriculture and outdoor work. Khan et al. (2023) opines that many of the south Asian and south east Asian countries are said and projected to be more vulnerable to heat and its effects. They argue that the socio-economic aspects of these countries have been deeply impacted due to the rise in weather events and its temperature related incidents. All these countries have their reliance on agriculture, construction and manufacturing and thus having experienced disruptions on the labour-intensive sectors.

Iqbal and Javed (2023) are reporting that the waves of the heat have significantly affecting Pakistan in its main two sectors like construction and agriculture. Same goes for India where they have studies that outdoor workers are getting more prone to heat related issues and illnesses. This has also increased health related costs and thus making it difficult for the middle and lower middle classes. China could also face the same situation although the impacts are believed to be less than the other countries (Somanathan et al., 2022). During the recent days, significant health impacts have been noticed which has hugely affected labour productivity. Lundgren et al. (2023) argues that the pro long exposure to heat can result in many heats related illnesses like heat exhaustion, dehydration and heatstroke mainly in most of the south Asian and south east Asian countries. Such issues have led to the shortage of labour and its productivity.

The World Health Organization (2022) argues that climate change has resulted in the increase of many vectors borne diseases in most of south Asian countries. Diseases related to climate change have resulted in decreasing the labour productivity of these countries. Kjellstrom et al. (2018) is of the view that weather related incidents have been reducing both cognitive and physical labour productivities. For the critic, outdoor activities will be prudent to all such changes and will thus create economic pressure on the households. Many studies have been

conducted on the economic costs being associated with climate and it loses. The Asian Development Bank (2023) argues that the south Asian countries could soon face GDP loses by the end of 2100 upto 10% on annual basis. They believe that these loses could result in many health and weather-related problems. There is another critic Somanathan et al. (2022) who is of the view that agriculture sector which is said to be sector relying on human force or labour could soon face a loss or reduction of 20% till the mid century.
There is another critic Ahmed et al. (2023) who notes that we have already noted a loss in the agriculture sector which has been resulting in reducing the incomes for workers in most of the rural area of Pakistan, India, Philippines, Sri Lanka and Bangladesh. He opines that such a loss results in increasing the number of poor people making inequality crisis.

Data and Methodology

The labor productivity of South Asia is impacted by several interrelated factors. Although its effects rely on stable policies and infrastructure, foreign direct investment (FDI) can increase workforce efficiency by bringing capital, technology, and skills. Because it affects infrastructure, agriculture, and health, climate change poses serious risks to labor productivity, particularly in economies that are already vulnerable and dependent on climate-sensitive industries. Sustainable development can be achieved through the use of renewable energy, which lowers costs, boosts productivity, and lessens the effects of climate change. The demand for infrastructure and jobs is driven by urban population growth, but efficient urban planning is necessary to guarantee a trained and efficient labor force. Through technology transfer and access to international markets, trade integration can increase productivity; however, its full potential is frequently hampered by trade barriers and regional tensions. South Asia needs to concentrate on sustainable policies, renewable energy investments, urban development, and regional cooperation to address these interrelated issues in order to increase labor productivity. As a result, the primary goal of the current study aims to figure out the relationship between LP, FDI, REC, UP, CE and Trade.

Data and its source

We used annual data for South Asian economies from 1990 to 2023 to investigate the long-term and short-term dynamic relationships between labor productivity is the Labor productivity growth rate Chansarn, S. (2010) and variables like trade, urban population, renewable energy consumption, FDI, and climate change. The word bank and world development indicators source of data are used to collected data.

Table 1: Description of Variables

S. No	Variables	Symbol	Measurement Units	Source
1	Labor Productivity	LP	Labor productivity growth rate	World Bank
2	Foreign direct Investment	FDI	Foreign direct investment, net inflows (% of GDP)	World Development Indicators
3	Urban population	UP	Urban population (% of total population)	World Development Indicators
4	Renewable Energy Consumption	REC	Renewable energy consumption (% of total final energy consumption)	World Development Indicators
5	Climate change	CE	PM2.5 air pollution, mean annual exposure (micrograms per cubic meter)	World Development Indicators
6	Trade	Trade	Trade in services (% of GDP	World Development Indicators

Methodology

$$LP = f\ (FDI, REC, UP, CE\ and\ Trade)$$

Labor productivity is function of $FDI, REC, UP, CE\ and\ Trade$

Econometric Form of the Model

$lnLP_t = \beta_0 + \beta_1 FDI_t + \beta_2 REC_t + \beta_3\ UP_t + \beta_4 CE_t + \beta_4 Trade_t$ ….. (1)

Where LP is labor productivity, FDI is stand for Foreign direct investment, REC is represented for Renewable Energy Consumption, UP shows Urban Population, CE is stand for Climate Change and Trade shows Trade openness and t is the period i.e., 1990 to 2022.

The ARDL model was used to examine the symmetric influence of variables in both the short and long term. The following ARDL equation shows the linear relationship between the independent and dependent variables in the study,

$$lnLP_t = \eta_0 + \sum_{i=1}^{q} \eta_1 (lP)_{t-1} + \sum_{i=1}^{q} \eta_2 (FDI)_{t-1} + \sum_{i=1}^{q} \eta_3 (REC)_{t-1} + \sum_{i=1}^{q} \eta_4 (UP)_{t-1} + \sum_{i=1}^{q} \eta_5 (Trade)_{t-1} + \mu_t \quad \text{…. (2)}$$

Now we can re-specify the equation 2 and we will get Autoregressive Distributed Lag (ARDL) model equation.

$$lnLP_t = \eta_0 + \sum_{i=1}^{q} \eta_1 (LP)_{t-1} + \sum_{i=1}^{q} \eta_2 (FDI)_{t-1} + \sum_{i=1}^{q} \eta_3 (REC)_{t-1} + \sum_{i=1}^{q} \eta_4 (\text{UP})_{t-1} + \sum_{i=1}^{q} \eta_5 (\text{Trade})_{t-1} + \lambda_1 (\text{LP})_{t-1} + \lambda_2 (\text{FDI})_{t-1} + \lambda_3 (\text{REC}) + \lambda_4 (\text{UP})_{t-1} + \lambda_5 (\text{Trade})_{t-1} + \mu_t \quad \textbf{…. (3)}$$

λ and η, shows long-term and short representation of variables respectively while n represents lag of the independent variables in the model.

Descriptive statistics

Descriptive Statistics are used to present quantitative descriptions in a manageable form. Descriptive Statistics is good way which is used to describe the behavior of different variables.

Table: DescriptiveStatistics

Variable	Obs	Mean	Std. Dev.	Min	Max
FDI	272	1.534	2.55	-0.639	16.783
TRADE	272	18.991	23.599	3.338	102.55
UP	272	26.871	8.098	8.854	44.35
REC	272	50.095	28.218	1.2	95.9
LP	272	3.026	3.775	-18.55	19.7
CE	272	45.757	18.663	10.809	79.037

Authors own tabulations

The descriptive statistics show a variety of patterns across the variables. Foreign Direct Investment (FDI) has an average of 1.534, with some variation (standard deviation of 2.55). The minimum value of the FDI is -0.639, possibly due to money leaving instead of entering, while the highest value reached 16.783, showing significant inflows in certain periods or regions. Similarly, Trade Openness (TO) averages 18.991, with wide variation (standard deviation of 23.599). The lowest value is 3.338, indicating minimal trade activity, while the highest, 102.55, reflects economies highly involved in trade. Urban Population (UP) has an average of 26.871, with moderate variation (standard deviation of 8.098). It ranges from 8.854 mean minimum which mean less urbanized areas while the maximum value is 44.35 which represent more urbanized regions. Renewable Energy Consumption (REC) averages 50.095 and varies widely (standard deviation of 28.218). Minimum value of renewable energy is 1.2, while maximum value is 95.9. Labor Productivity (LP) averages 3.026 and standard deviation is 3.775, with values ranging from -18.55 (minimum value of labor productivity) to 19.7 (high/maximum value labor productivity gains). Lastly, climate change (CE) average 45.757, with standard deviation of 18.663. the minimum value is 10.809 while the maximum value is 79.037, reflecting different environmental impacts.

Correlation analysis

Correlation analysis helps us understand how two variables are related. This relationship can be positive, negative, or neutral. We represent these relationships in a correlation matrix, which is like a table. The correlation values range from +1 to -1. A value near +1 means a strong positive relationship, while 0 shows no relationship, and values close to -1 indicate a strong negative relationship. Table 4.2 shows the correlations between the chosen variables (Abbasi. et al, 2020)

Table: Results of Correlation analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) FDI	1.000					
(2) TRADE	0.803	1.000				
(3) UP	0.414	0.258	1.000			
(4) REC	-0.537	-0.594	-0.451	1.000		
(5) LP	-0.108	-0.192	-0.021	0.136	1.000	
(6) CE	-0.508	-0.610	-0.112	0.148	0.062	1.000

Authors own tabulations

This study does have certain limitations, though, as it simply explains the existence of a link between two variables rather than the positive association between them. Some of the variables in this table have a positive correlation with one another, whereas other variables have a negative correlation.

From the above table Labor productivity (LP) shows weak relationships with other variables. It has a slight negative link with FDI (-0.108) and trades (-0.192), suggesting that higher foreign investment and trade openness may slightly reduce productivity, possibly due to structural inefficiencies. The connection between UP (Urban population) and LP is almost zero (-0.021), indicating no significant impact of Urban population on productivity. However, REC (renewable energy consumption) has a small positive link with LP (0.136), suggesting that more labor productivity more will be renewable energy consumption. Similarly, CE (climate change) has a weak positive link (0.062), indicating that higher labor productivity lead to more climate change.

Slope heterogeneity

To test for slope homogeneity, researchers often compare the sum of squared residuals between cross-section specific ordinary least squares (OLS) and pooled OLS with unit-specific fixed effects. The primary issue with this test is its unreasonable assumption of homoscedastic and serially uncorrelated mistakes. Most of the panel literature show that problem of homoscedasticity and autocorrelation is unimportant. So, the heterogeneity testing get no attention more (Bertrand et al., 2004)

Testing for slope heterogeneity

H0: slope coefficients are homogenous

	Delta	p-value
	2.994	0.003
adj.	3.359	0.001
Variables partialled out: constant		

Authors own tabulations

The above table show that both the value of delta and adjusted delta is significant at 5%. Then we reject null hypothesis of homogeneity and show that the slope of coefficient is heterogeneity (Pesaran, Yamagata. 2008. Journal of Econometrics).

Cross-Section dependency test

Panel estimation focuses on determining if variables have a unit root. To test for the presence of unit roots in panel data with cross-sectional dependency. If the hypothesis is denied, cross-sectional dependence is assumed (Çınar, 2010). The cross-section dependency test is used to check that whether variables exit cross section dependency or not. It depends on four test (Breusch-Pagan LM, Pesaran scaled LM, Bias-corrected scaled LM and Pesaran CD) to decide. When there is a greater number of significant than insignificant test, it means variable exist cross-section dependency while less number show cross section independence. When both significant and insignificant test are equal, it depends on situation to make dependent or not. The significancy of test depends on p-value. When p-value is less than 0.05 than we reject null hypothesis and accept alternative.

- **Null hypothesis: No cross-section dependence (correlation)**
- **Alternative hypothesis: Cross-section dependence (correlation)**

Name of tests	t-state, probability
Pesaran's test of cross-sectional independence	= 2.023, Pr = 0.0430
Friedman's test of cross-sectional independence	= 44.692, Pr = 0.0000
Frees' test of cross-sectional independence	= 0.218, Pr = 0.0002

Authors own tabulations

According to the above results are variables exist cross section dependency because all the test are significant according to the p-value. As the p-value of all the test is less than 0.05. So, we reject null hypothesis and accept alternative hypothesis. It suggests that data exist cross sectional dependency.

2nd generation unit root test

CIPS & CADF

The existence of cross-sectional dependence in the panel enables first-generation unit root testing ineffective. The cross-sectionally augmented Im-Pesaran-Shin (CIPS) panel unit root test, proposed by Pesaran (2007), was applied to assess the series' stationarity. The CIPS test statistics are calculated by taking the sample averages of the individual cross-sectionally augmented ADF (CADF) statistics. The panel's CIPS and CADF test results are shown in the given Table.

CIPS and CADF test results tables

Variables	CIPS At Level t-state	At 1st difference t-state	At 2nd difference t-state	CADF At Level t-state P-value	At 1st difference t-state P-value	At 2nd difference t-state P-value
FDI	-3.225*	--------	-------	-2.447* 0.007	------	-------
Trade	-1.673	-5.323*	-------	0.931 0.824	-4.977* 0.000	--------
UP	------	-------	-4.332*	3.492 1.000	4.272 1.000	-3.427* 0.000
REC	-1.968	-5.752*	-------	-0.652 0.257	-7.159* 0.000	-------
LP	-4.551*	--------	--------	-4.747 0.000	10.852* 0.0000	--------
CE	-5.933*	---------	--------	1.742 0.959	8.492* 0.000	-------

Note: The null hypothesis for the test is the presence of a unit root in panel data with cross-sectional dependency in the form of common factor dependence. According to Pesaran (2007, pp. 280-81), the critical values for N = 30, T = 20 are −2.32 (1%) ***, −2.15 (5%)

**, −2.07 (10%) * for the model with intercept, and −2.83 (1%), −2.67 (5%), −2.58 (10%) for the model with intercept and trend. max lag = 2 and bg lag = 2 (^= trend).

The above table show the result of Pesaran Panel Unit Root Test with cross-sectional such as CIPS (Cross-sectionally augmented Im-Pesaran-Shin) and CADF (Covariate Augmented Dickey-Fulle). The test contains maximum number of lags is 2 and bg lag is also 2. The foreign direct investment, climate change and labor productivity are stationary at level. While trade and renewable energy consumption are non-stationary at level. Now after 1st difference it become stationary at all level of significance. Urban population is non-stationary at level and also at 1st difference but after taking second difference it become stationary. Now by applying CADF panel unit root test all the variables are non-stationary at level except FDI but stationary at 1st difference while urban population is non-stationary at level and 1st difference but stationary at 2nd difference (Kappler 2006 & Abbasi et al, 2020).

Panel Cointegration Analysis

Pedroni (1999a) suggested a mechanism for determining if a cointegrating link exists. Essentially, it uses three group panel statistics to compare the null hypothesis of no cointegration with the alternative hypothesis of cointegration. When the number of significant test greater than insignificant then we interpret that there is cointegration and vice versa.

Table Panel Cointegration

Test	t-status	P-value
Modified Phillips–Perron	-0.4289	0.3340
Phillips–Perron	-4.6791	0.0000
Augmented Dickey–Fuller	-4.9488	0.0000

Authors own tabulations

The table 4.4 verify that test like Phillips–Perron and Augmented Dickey–Fuller are significant while test such as modified Philips-perron are insignificant even after including trend in our panel analysis. So, the number of significant test greater than insignificant test. So, reject null hypothesis and conclude that there is cointegration (Maddala and Wu 1999).

Regression Analysis

In tenacity, panel co-integration tests were used to assess the presence of long-run correlations between the variables. Table 5 shows the results of three panel cointegration tests: the Pedroni test (1995), the Kao test (1999), and the Westerlund test (2008). The results of all tests show that the model has a co-integration connection among the study variables. Meanwhile, there is cross-sectional dependency among the panel datasets, therefore the wasteland panel co-integration test was used to validate the Kao test result Zhang et al, (2023). Based on the p-values in table 5, the null hypothesis may be rejected, indicating that there is a co-integration connection between the variables in the panel data set.

Short Run Equation

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
COINTEQ01	**-1.059132**	**0.319384**	**-3.316176**	**0.0014**
D(LP(-1))	0.010150	0.193216	0.052532	0.9582
D(FDI)	-0.254255	0.632847	-0.401763	0.6889
D(FDI(-1))	2.509499	1.481216	1.694216	0.0940
D(FDI(-2))	1.178086	1.769630	0.665724	0.5074
D(FDI(-3))	1.379319	1.241479	1.111029	0.2698
D(CE)	0.005843	0.122740	0.047605	0.9621
D(CE(-1))	-0.269908	0.450195	-0.599537	0.5504
D(CE(-2))	-0.058964	0.307454	-0.191781	0.8484
D(CE(-3))	-0.058495	0.383288	-0.152615	0.8791
D(REC)	-2.730064	2.420398	-1.127940	0.2626
D(REC(-1))	-2.159841	2.067682	-1.044571	0.2993

D(REC(-2))	-1.390329	1.401839	-0.991789	0.3242
D(REC(-3))	-0.380284	0.213979	-1.777203	0.0792
D(TRADE)	0.539365	0.502375	1.073631	0.2861
D(TRADE(-1))	-0.072315	0.297663	-0.242941	0.8087
D(TRADE(-2))	0.181109	0.512281	0.353534	0.7246
D(TRADE(-3))	0.124385	0.442223	0.281271	0.7792
D(UP)	21.35331	46.97453	0.454572	0.6506
D(UP(-1))	-39.36946	97.89050	-0.402179	0.6886
D(UP(-2))	28.13733	41.37463	0.680062	0.4984
D(UP(-3))	-14.58376	47.38944	-0.307743	0.7590
C	-25.27607	10.95551	-2.307155	0.0235

Authors own tabulations

According to the ARDL short results labor productivity shows an insignificant dynamic relation with all except of the D (FDI (-1)) and D (REC (-3)) at 10 % of significancy. It means that change in FDI has improve the labor productivity by 2.5%. while change in REC reduce the labor productivity by 0.38%.

The results of the ECM model show that the value of the ECM coefficient is negative and significant (-1.05*) This value of ECM indicates that around 100% of deviations are adjusted per year. The ECM coefficient is quite a large value implying that the adjustment of short deviation around the long run time path is very quick.

ARDL Analysis; Long Run Equation

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
FDI	-0.367929	0.154438	-2.382377	0.0195**
CE	0.224218	0.013166	17.03001	0.0000***
REC	0.106732	0.040114	2.660728	0.0094**
TRADE	-0.092180	0.041419	-2.225570	0.0288**
UP	0.605326	0.083010	7.292210	0.0000***

Authors own tabulations

$$\ln EFP_t = -0.36FDI_t + 0.22CE_t + 0.11REC_t - 0.09trade_t + 0.61UP_t$$

In the long run, FDI has a negative impact on labor productivity (LP), meaning that change in foreign direct investment tends to reduce productivity by 36% . These results are also consistent with Saha, S. K. (2024), which examine that there is inverse relationship between FDI and LP. It means the rise in FDI causes LP to decrease. On the other hand, climate change (CE) and Renewable Energy Consumption both positively affect labor productivity, suggesting that change in climate change and renewable energy consumption is linked to increased productivity by 22% and 11%. These results are confirmed by (Kuo & Chang 2024), which suggest that when labor productivity increase it more effect the air quality, however, air quality directly affect the climate change and (Makieła et al, 2022), renewable energy consumption (REC) have a dynamic effect on productivity. The positive linkage is a developing region while the negative link is a developed country, meaning more REC can reduce labor productivity. In case of negative relation between renewable energy consumption and labor productivity are also supported by Polcyn et al., (2021).

The Trade has also negative impact on labor productivity (LP), meaning that more trade and imports of products tends to reduce 9% of the labor productivity. As Melitz, M. J. (2003) studied that lowering trade or product imports has a much greater impact on productivity and the labor productivity if the countries raise with declining of imports due to labor jobs opportunity. Lastly, urbanization percentage (UP) has a strong positive relationship with labor productivity, meaning that as urbanization increases, labor productivity improves by 61% significantly. The more urbanization means more effective and efficient labor to do more work and increase the productivity. The results are consistent with Simon, H. A. (1947) and Weintraub, R. E. (1955) both the study analyzed that labor productivity raises when urbanization get more importance. The labor getting knowledges, skills and experiences and increased the economic growth of the countries.

Conclusion And Recommendations

The analysis highlights that climate change poses a substantial threat to labor productivity in South Asia, with significant socioeconomic implications. Sectors such as agriculture, construction, and manufacturing are particularly vulnerable, leading to reduced output, health challenges, and increased poverty. The findings reveal complex relationships: while urbanization and renewable energy consumption positively impact labor productivity, foreign direct investment and trade openness have adverse effects under current structural inefficiencies. The study underscores the critical need for targeted policies to address the challenges posed by climate change, especially for low-income nations where economic resilience is limited. Without immediate action, the region risks exacerbating inequalities and missing sustainable development goals.

Policy Recommendations

1. Develop guidelines and regulations to protect outdoor workers from extreme heat exposure, including mandatory breaks and access to cooling facilities.
2. Prioritize investments in infrastructure that can withstand climate impacts, particularly in vulnerable sectors such as agriculture and construction.
3. Encourage the adoption of climate-smart agricultural techniques that enhance productivity while reducing vulnerability to climate change.
4. Improve access to healthcare services focusing on heat-related illnesses and mental health support for workers affected by climate stressors.
5. Increase public awareness about the effects of climate change on labor productivity and promote community engagement in adaptation efforts.
6. Integrate climate adaptation strategies into national development plans, ensuring alignment with international frameworks like the Sustainable Development Goals .

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