# Analysing the productive mechanism of human capital in Pakistan: new insights from women's empowerment

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## Abstract

**Purpose** – The purpose of this study is to examine a unique typology of women's empowerment (WE) and its role in enhancing human capital development (HCD) and total factor productivity (TFP) in Pakistan. This study investigates how WE acts as both a moderating and mediating factor between human capital and economic growth, thereby improving the quality of life.

**Design/methodology/approach** – This study uses the Autoregressive Distributed Lag (ARDL) co-integration technique using annual data from 1990 to 2022. This approach allows for analysing both short- and long-run dynamics between WE, HCD and TFP, providing a macroeconomic perspective on the productive role of WE. Granger Causality tests are also applied to determine directional relationships among the variables.

**Findings** – Empirical results indicate that WE has significant moderating and mediating effects on TFP through HCD in both the short and long run. Granger Causality analysis reveals unidirectional causality from WE to TFP and from WE to HCD, highlighting the interactive and dynamic role of WE in fostering economic productivity. The findings of this study suggest that leveraging the potential of Pakistan's female population can enhance human capital and improve the quality of life for future generations.

**Originality/value** – To the best of the author's knowledge, this study is among the first to examine WE as a productive resource influencing HCD and TFP in Pakistan. This study provides novel insights for policymakers, emphasising the social and economic benefits of promoting women's empowerment to achieve inclusive and sustainable economic growth.

**Keywords** Women's empowerment, Human capital development, TFP, Quality of life, Moderation, Mediation, ARDL

**Paper type** Research paper

## 1. Introduction

Human capital plays a crucial role in boosting economic productivity and is the key to achieving sustainable economic growth in the long run (Dias and Tebaldi, 2012; Trostel *et al.*, 2002; Vandenbussche *et al.*, 2006; Wang *et al.*, 2022). All global development initiatives and strategies prioritise human capital formation for sustainable economic growth. Human capital development through inclusive and high-quality education is emphasised in the UN's fourth Sustainable Development Goal (SDG). In addition to being a basic human right, the fifth SDG goal highlights the significance of ending all kinds of discrimination against women and girls for long-term sustainable development. By implementing this goal, the fourth SDG goal can also be streamlined and make significant progress toward creating a fairer and more equitable society. These development goals are chiefly relevant to Pakistan. Women are significantly

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underrepresented as innovators, leaders, civil reformers, decision-makers and political representatives worldwide, particularly in Pakistan, causing these concepts to be associated predominantly with masculinity (Joan *et al.*, 2021; Nainggolan *et al.*, 2022). What kind of society would we have if women were not subjected to such exclusion and discrimination? This research aims to address this question by targeting the potential benefits of women's empowerment (WE) in terms of political, social, economic and civil empowerment, on human capital development (HCD) and total factor productivity (TFP) in Pakistan.

Pakistan's domestic human resource endowment is undermined by gender inequality and uncompetitive human capital. Its demographic trends indicate that women make up more than half of its population. However, the country ranks poorly in gender equality, with the Global Gender Gap Index placing it at 145th out of 146 nations and the Gender Inequality Index ranking it at 161st out of 191 nations (World Bank, 2022; Nam, 2022). These statistics reveal that half of the human capital stock of Pakistan is female human capital, who suffer from sub-optimal protection of freedom, with only a 14% economic participation rate. Pakistan's economy has a slower growth rate compared to other countries on the continent. Pakistan's gross domestic product (GDP) growth rate was 6.49% in 2022, a 0.3% increase from 6.19% in 2021. This sluggish growth can be attributed to high inflation, increasing government debt, inadequate effective human capital stock and slow productivity growth (World Bank, 2022).

There are two primary growth channels in the literature on the impact of human capital on economic growth. The first channel is the "factor accumulation channel," which views human capital as an essential input in the production function (Lucas, 1988; Mankiw and Weil, 1992). This channel explains that the growth rates of different economies are directly related to the rates of their human capital stock. The second channel is the "productivity channel", which explains the mechanism of human capital affecting TFP growth (Howitt and Aghion, 1998; Romer, 1990). A higher level of human capital enhances a country's capacity for innovation and its ability to adapt to existing technologies, thereby affecting overall economic growth. Investing in the education, skills and capabilities of women is a crucial aspect of human capital development that significantly impacts their social and economic participation in the economy (Kaffenberger and Pritchett, 2021; Asaleye and Strydom, 2022; Isaacs *et al.*, 2022). Previous academic literature has primarily focused on the relationship between women's empowerment and economic growth through the factor accumulation channel in Pakistan, such as the correlation of women's access to education and workforce participation to augment economic growth (Abbas and Mujahid-Mukhtar, 2000; Ali *et al.*, 2015; Khan, 2016) and the impact of gender inequality in human capital formation (Akram, 2018; Fatima, 2013; Oluwatosin, 2022; Siegmann and Majid, 2021) in Pakistan. The spillover impact of WE on economic growth through the "productivity channel" remains unexplored. No study has been found on WE as a mediating and moderating factor to influence the economic development of Pakistan through the formation of active human capital.

This study examines the spillover effects of WE in Pakistan through both accumulation and productivity channels. The research aims to fill a gap by analysing two hypotheses: the moderating effect of WE on total factor productivity (TFP) and the mediating effect of WE on human capital development (HCD). Through the factor accumulation channel, WE significantly moderates the relationship between HCD and TFP by increasing the participation of female human capital in the economy. Moreover, WE promotes effective and healthy HCD, which in turn enhances productivity. Consequently, the relationship between WE and TFP is mediated by HCD through a productive channel of human capital. It is important to note that both WE and HCD are typically slow-moving processes that are difficult to measure accurately. Therefore,

theoretical and econometric considerations highlight the need for extensive inclusion of indicators and a comprehensive analysis of the mechanisms involved to understand the associations between our primary variables of interest: WE, HCD and TFP.

For instance, we develop a comprehensive index of WE by including four dimensions. The first is to facilitate women to actively express their opinions and preferences through a variety of civic engagement activities. The second is expanding the opportunities for women in important political decision-making positions, such as the executive and legislative branches (Kabeer, 1999). The third is to strengthen civil rights to increase women's freedom of choice in various sectors (Sundström *et al.*, 2017). The fourth is the economic empowerment interventions of women (Taylor and Pereznieto, 2014). WE enhances economic policymaking by introducing a greater variety of new ideas and the capabilities necessary for implementing the best ideas. In this paper, we investigate how WE facilitates the policymaking process through which HCD influences a country's TFP trajectory.

This paper makes unique contributions and presents distinct differences compared to previous research. First, it covers a broader range of research subjects, specifically focusing on WE, HCD and TFP, along with an examination of their impact mechanisms. Existing studies have primarily explored the connections between HCD and economic growth or between WE and economic growth. Second, this study's empirical research is more comprehensive and robust. Previous research on HCD and economic growth has mainly examined growth perspectives and competition spillover effects (Tsamadias *et al.*, 2019). Notably, there has been a lack of thorough research on the spatial effects of WE as a growth channel for HCD's impact on TFP. For example, we specifically focus on the mediating impact of WE on TFP in Pakistan. Third, this research examines the moderating effect of WE on the relationship between HCD and TFP in Pakistan. Fourth, it considers the empowerment-growth nexus by evaluating economic growth in terms of TFP. Fifth, the calculation of TFP is a relatively scientific process. However, some literature measures TFP solely based on inputs and outputs, which can lead to measurement flaws, such as miscalculating the true productivity of labour and failing to properly adjust for inflation (Afzal *et al.*, 2024). In contrast, this study constructs the TFP index using a growth accounting framework that takes inflation-adjusted input and output measurements into account. Finally, we developed a comprehensive index of WE that considers all its dimensions using the Entropy method. To achieve this, we created a secondary construct by extracting three key indices from the Varieties of Democracy (V-Dem) data set: civil liberty, social civil liberty and political empowerment (Coppedge *et al.*, 2021; Sundström *et al.*, 2017), and we supplement this with a fourth dimension of economic empowerment.

This paper is constructed as follows: Section 2 includes a literature review. Section 3 describes the theoretical framework of the model. Section 4 contains methodological details; Section 5 includes results discussions; and Section 6 concludes with policy suggestions.

## 2. Literature review

Empirical literature demonstrates several economic theories and frameworks that provoke women's transforming role in economic growth and human capital formation. The theories listed in Table 1 support our hypothesis by acknowledging the roles that women play in promoting sustainable development as educators, workers and change agents.

Collectively, these theories highlight that women's education and empowerment act as central drivers of human capital formation and sustainable economic growth. They interconnect through shared mechanisms – enhanced decision-making, intergenerational investment and productivity gains – that support this study's hypothesis that empowering women yields compounding socio-economic benefits via human capital development.

**Table 1.** Theories and mechanisms linking women's empowerment with human capital development and total factor productivity growth

| Theories | Key insights for the study | Mechanism to operate | References |
|---|---|---|---|
| Human capital theory | Education enhances individuals' productivity and earning potential. Educated women invest more in their children's education and health, leading to long-term economic growth through human capital accumulation | Women's education increases their income, awareness and ability to make informed household decisions, creating a multiplier effect on intergenerational human capital formation | Mincer and Polachek (1978) |
| Endogenous growth theory | Sustainable growth stems from knowledge accumulation and innovation, to which women's education and labour participation significantly contribute through human capital development | Female participation in education and skilled employment accelerates technological progress and human capital development, reinforcing self-sustaining economic growth | Osipian (2023) |
| Demographic transition theory | Women's empowerment reduces fertility rates while improving child quality through greater investment in education and health and supports economic growth through the "demographic dividend." | Professional women delay marriage and childbirth, directing resources toward fewer but better-educated children, enhancing human capital and fostering a demographic dividend | Zaidi and Morgan (2017) |
| Capabilities approach | Women's empowerment expands their freedoms to make choices that enhance well-being and productivity | Empowered women improve their own and their families' capabilities (health, skills, education), which strengthens human capital and promotes inclusive economic growth | Sanchiz (2010) |
| Becker's model of family economics | Household decisions about resource allocation are influenced by education and opportunity costs | Educated women allocate resources more efficiently, investing in children's human capital (education, health and nutrition), thereby improving future labour productivity | Pollak (2003) |
| Feminist economics | It recognises the economic value of unpaid care work and gender equity in resource distribution | Women's caregiving and social reproduction roles sustain the health and education of future generations, indirectly strengthening the labour force and productivity | Seguino (2021) |
| Unified growth theory | Human capital accumulation, especially through women's empowerment, transitions economies from stagnation to sustained growth | Gender equality accelerates structural change, leading to higher productivity, innovation and long-term economic expansion | Kawalec (2020)<br>Galor (2011) |
| Solow-Swan growth model (extended versions) | Incorporating gender-related model extensions implies that women's empowerment boosts total factor productivity and steady-state growth | Women's participation in education and employment raises the aggregate efficiency of capital and labour, enhancing output and economic stability | Cayssials and Picasso (2020) |
| Overlapping generations model | Intergenerational transfers of human capital are key to long-run growth | Empowered women invest more in their children's education and health, creating a cumulative cycle of human capital accumulation across generations | Shindo (2023) |

*2.1 Analysis of the moderating impact mechanism of women's empowerment on total factor productivity*

Research has demonstrated that economic indicators, including growth, are significantly associated with gender equality and WE (Cuberes and Teignier, 2014; Kabeer and Natali, 2013). However, socioeconomic factors like female labour participation and educational outcomes are typically the focus of most studies in Pakistan. Parveen and Leonhauser (2005) assert that women's empowerment can be aided by both formal and informal education. It concluded that women's financial and economic circumstances improve because of skill development, which also makes it easier for them to defend their rights.

A theoretical model that emphasises the detrimental economic effects of keeping women out of managerial positions was introduced by Esteve-Volart (2004). This model suggests that by restricting women's access to managerial positions, organisations experience a loss of talent in these positions. This assumption is supported by empirical research on women's success in various business activities (Tiwari and Goel, 2020). Women's exclusion hinders creativity and slows the acceptance of new technologies, which in turn slows the increase in productivity. When women are limited to kinds of work, such as home production, their productivity decreases, resulting in a reduction in income. Sabir and Aftab (2007) examined that Pakistani women's greater employment opportunities may be directly linked to their inferior status in the labour market and may not be empowering them. They note that the gender wage gap widened because of the rise in the supply of female labour during periods of strong growth. Thus, women's exclusion from managerial positions and certain sectors of the workforce results in lower investment in human capital and ultimately leads to lower growth rates. Found that if women are barred from becoming managers, then the talent pool in the economy shrinks considerably, causing a decline in productivity and income levels. Their research suggests that when women are unable to acquire managerial positions, the GDP per capita loss is approximately 12%. However, if women are entirely excluded from the labour market, then this loss increases significantly to about 40%. In countries where exclusion rates are the highest, such as those in the Middle East and North Africa, the estimated income loss (in the mid-2000s) is approximately 27%. This empirical analysis supports our hypothesis about the mediating role of women in improving TFP.

Chaudhry and Nosheen (2009) discovered a strong and positive correlation between empowerment and education as measured by women's capacity for decision-making in Pakistan. The exclusion of women from economically productive activities is closely tied to their high illiteracy rate. Empirical literature commented that gender disparities in educational attainment might have a detrimental effect on economic expansion (V. Swamy, 2014). Furthermore, a study by Imai *et al.* (2014) examined data from rural India from 1992 to 2006 and discovered a correlation between improved nutritional status for children and the mother's educational attainment to the father. Mental and physical health equipped future generations to better balance gender roles to accelerate inclusive economic growth.

Existing levels of gender inequality are undermining the transition to poverty alleviation and inclusive and sustainable economic development. Conversely, there is the opportunity for greater economic stability and growth through improved gender equality and women's workforce participation. Based on gender roles and sex, women and men face differences in vulnerabilities, risks and impact on human capital formation resulting from current economic patterns. Literature shows evidence regarding research on the impact of WE on economic growth, economic development, climate change and vulnerability to climate change. This strand of the literature is substantiated by the studies of Alexander *et al.* (2016), Asongu *et al.* (2020), McCright (2010) and Yavinsky (2012). No study has been found to investigate the contribution of WE in TFP and HCD. This study is a pioneering work in this discipline.

### *2.2 Analysis of the mediating impact mechanism on women's empowerment, human capital development and total factor productivity*

Empowerment is the process by which a person acquires access to the capacity to make more decisions (Kabeer, 1999). WE is frequently linked to effective access to legal rights, health care, education and opportunities to make money. Increased women's participation in household decision-making and resource allocation within the household has two further effects. Firstly, increasing women's participation in household decision-making benefits their children's health, education and nutrition(Todaro and Smith, 2020). This argument supports our hypothesis that improvements in female human capital benefit households, communities and society more generally to increase the quality of life. Chaudhry and Nosheen (2009) found that women's empowerment is crucial for the development of Southern Punjab of Pakistan, and radio, television and other media have been crucial in educating women about their rights and empowering them in Pakistan. Second, the health and development of the child – two essential elements of the child's human capital – are influenced by the mother's health and nutrition – or lack thereof – during pregnancy and lactation. Eliminating malnutrition can improve productivity and health, which can boost a nation's overall economic and human development. In Pakistan, 40% of five-year-old children have stunted growth, which causes them to be underweight for their age. The number of stunted children in Pakistan has significantly increased over the past three decades because of its fast population growth rate. Child stunting is restricting the development potential of Pakistan, as well as its capacity to lower poverty and increase equality of opportunity. We postulate that the accumulation of female (mother) human capital can prevent child stunting and serve as the foundation for a strong future human capital in Pakistan.

The inclusion of women in domestic decision-making as well as the marketplace improves economic growth. However, the effects of women's inclusion as a resource for human capital formation remain unexplored. Gender equality is a complex concept that includes different factors, each with its own impact on growth. According to a study by Mitra *et al.* (2015), developing economies experience growth when there is equality in economic opportunities, which is reflected by literacy, secondary enrolment and fertility rates. The disparity in labour force participation and the percentage of women in parliament, on the other hand, indicates that industrialised economies flourish when economic and political outcomes are equal. However, their study only focuses on women in parliament for a small number of nations (around 100) between 1990 and 2000. Therefore, it is still unclear how women's political empowerment in all its forms impacts the development of human capital and economic expansion. Educating women can have other benefits as well, such as reducing fertility rates and improving child care and survival rates. These benefits improve the future human capital accumulation (Duflo, 2012; Imai *et al.*, 2014; Mitra *et al.*, 2015). In this text, we argue that various aspects of WE have positive implications for HCD and TFP, however, the strength and relevance of this impact mechanism might vary across developing and developed countries.

### *2.3 Theoretical framework*

We adopt the definitions and strategies of Kabeer and Natali (2013) and Sundström *et al.* (2017) to support the mechanisms by which WE affects HCD and TFP. Figure 1 demonstrates the interconnection between different components of WE through which it fosters HCD and TFP. We hypothesise that the complete relationship of WE towards HCD transmits from a combination of all four proposed aspects of WE. First, having more women in politics enhances variety in pertinent attributes like experience and knowledge and expands the pool of political

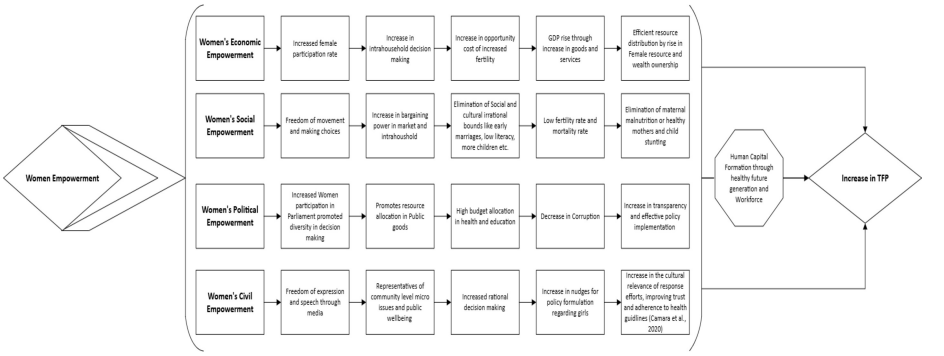


**Figure 1.** Theoretical framework of the study

potential (Sapiro, 1981). It led to such institutional organisations that established associations between the government and its citizens (A. Swamy *et al.*, 2001). Furthermore, increased representation of women in executive and parliamentary institutions is found to be negatively correlated with corruption (Dollar *et al.*, 2001). Women having adequate political representation in national parliaments leads to the formulation of strong policies regarding education and health (Brennan *et al.*, 2020). Healthy and responsible women encourage social welfare at macroeconomic and microeconomic (household) levels when given political power (Achuo *et al.*, 2022). Second, the promotion of civil liberties, including freedom of expression and movement, encourages open and critical communication, which enhances idea exchange and enables better decision-making (Dahlum *et al.*, 2022). Women's social empowerment is positively linked with a healthy female labour force (Doepke and Tertilt, 2018). Such civil liberties increase the female human capital endowment, which will raise the bargaining power of women in intra-household decisions and in the market. Women get technical and skilled education that increases their opportunity cost to have more children in terms of their time allocation towards their jobs. Because of this substitution effect, women will give birth to fewer kids. This trade-off between WE and fertility rate led to effective human capital formation (a transition from the number of children to the quality of children). Ultimately, this phenomenon will trigger a demographic transition toward economic transition (Diebolt and Perrin, 2013). Empowered women create a virtuous cycle, starting with gender equality, low fertility rates, increased life expectancy, eradicated child stunting and skilled HCD, leading to economic growth. Third, enabling women to voice their perspectives through civil society and media empowers policymakers to choose more effective adaptation policies (Evans, 1995; Weldon, 2002). Women's active participation in public administration guarantees the adapted policies for public choices (Cabaleiro-Casal and Buch-Gómez, 2020). For instance, such countries tend to increase their public expenditures on health and education, which leads to a healthy future workforce. Thus, women's representation promotes public goods along with productivity and good governance (DiRienzo and Das, 2019).

Fourth, the participation of women in economic activities will increase the labour force of the economy and, hence, economic growth (Folasade and Olarewaju, 2019). Transforming women into human capital enhances factor accumulation (Mulligan and Sala-i-Martin, 2004). The process of women's economic empowerment improves their capacity to make strategic decisions in life (Kabeer and Natali, 2013) and is an essential objective of human rights. Low participation rate in economic activities has a significant negative impact on the well-being of women (Haile *et al.*, 2016; Jones *et al.*, 2019; Mabsout, 2011) and their children (Chakraborty

and Anderson, 2011; Pratley, 2016; Thorpe *et al*., 2016) because of associated economic and health outcomes. The presented "business case" for WE has the potential to nudge hesitant leaders to empower women, even if for instrumental reasons. All of these factors suggest that the empowerment of women will enhance both growth channels of human capital: the accumulation channel and the productive channel, which will then lead to increased TFP growth. In conclusion, women's empowerment increases TFP by increasing their labour force participation rate and contributing towards the formation of an effective and healthy human capital. The four sub-components of WPE will serve as the foundation for the investigation of potential mechanisms between WE, HCD and TFP. This theoretical framework is represented by the following empirically valuable log-linear model:

$$\mathrm{LNTFP} = (\mathrm{K},\ \mathrm{FR},\ \mathrm{LNEDU},\ \mathrm{REE},\ \mathrm{T},\ \mathrm{WE},\ \mathrm{HCD}) \tag{1}$$

where LnTFP is the natural logarithm of the TFP index, K is gross fixed capital formation, FR is the fertility rate, LnEDU is the natural logarithm of governmental expenditure on education, REE is the real exchange rate, T is total trade, a measure of trade openness, WE is women's empowerment index and HCD is human capital development index constructed by Human Development Reports. WE and HCD are our main independent variables, while K, FR, LNEDU, REE and T are our control variables. Detailed information about the description of variables and data sources is provided in Table A1 (Appendix). We used time series data from 1990 to 2022 for econometric analysis.

## 3. Methodology

The Autoregressive Distributive Lag (ARDL) method of bound testing co-integration approach given by Pesaran *et al*. (2001)is used for the estimation of the model specified in the previous section. The ARDL approach has several advantages over other approaches to co-integration. Firstly, the ARDL procedure can be applied whether the variable has a mixed combination of orders of integration. Secondly, this approach is reliable and gives statistically significant outcomes even in the case of a small data set. Therefore, it is quite applicable, especially for the small time series data of a country. Other techniques of co-integration, such as Engle and Granger (1987). They are not suitable for small data samples. This approach examines the long-run co-integration relationship among the variables within an ARDL framework. Therefore, the following ARDL model is specified:

$$\begin{aligned}\Delta ln\,(TFP)_t = {} & \alpha_0 + \sum_{i=1}^{m} \alpha_{1i}\Delta ln\,(TFP)_{t-i} + \sum_{i=0}^{m} \alpha_{2i}\Delta(FR)_{t-i} + \sum_{i=0}^{m} \alpha_{3i}\Delta(HCD)_{t-i} \\ & + \sum_{i=0}^{m} \alpha_{4i}\Delta(K)_{t-i} + \sum_{i=0}^{m} \alpha_{5i}\Delta ln\,(EDU)_{t-i} + \sum_{i=0}^{m} \alpha_{6i}\Delta(REE)_{t-i} \\ & + \sum_{i=0}^{m} \alpha_{7i}\Delta(WE)_{t-i} + \sum_{i=0}^{m} \alpha_{8i}\Delta(T)_{t-i} + \delta_1 ln\,(TFP)_{t-1} + \delta_2(FR)_{t-1} \\ & + \delta_3(HCD)_{t-1} + \delta_4(K)_{t-1} + \delta_5 ln\,(EDU)_{t-1} + \delta_6(REE)_{t-1} + \delta_7(WE)_{t-1} \\ & + \delta_8(T)_{t-1} + \upsilon_t \end{aligned} \tag{2}$$

In the above equation, the coefficients $\alpha$'s measure the short-run relationship, the coefficient $\delta$ measures long-run multipliers and m is the optimal lag length. Optimal lag length

according to Akike Information Criteria (AIC) is 2 for our model. The relevant hypothesis of co-integration is as follows:

*H0*. $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = 0$ (No Co integration)

*H1*. $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq \delta_8 \neq 0$ (Co integration)

The hypothesis of the presence or absence of long-run co-integration is checked by the value of F-statistics of Wald Test and comparing this with critical values of Pesaran *et al.* (2001) table. If long-run cointegration exists among the variables, then we will use the following equation to estimate the long-run relationship:

$$ln\,(TFP)_t = \delta_0 + \delta_1 \sum_{i=0}^{m} ln\,(TFP)_{t-i} + \delta_2 \sum_{i=0}^{m} (FR)_{t-i} + \delta_3 \sum_{i=0}^{m} (HCD)_{t-i} + \delta_4 \sum_{i=0}^{m} (K)_{t-i} + \delta_5 \sum_{i=0}^{m} ln\,(EDU)_{t-i} + \delta_6 \sum_{i=0}^{m} (REE)_{t-i} + \delta_7 \sum_{i=0}^{m} (WE)_{t-i} + \delta_8 \sum_{i=0}^{m} (T)_{t-i} + \upsilon_t \quad (3)$$

Finally, the short-run association is examined by estimating the following error correction model specified in equation (4):

$$\Delta ln\,(TFP)_t = \delta_0 + \delta_1 \sum_{i=0}^{m} \Delta ln\,(TFP)_{t-i} + \delta_2 \sum_{i=0}^{m} \Delta(FR)_{t-i} + \delta_3 \sum_{i=0}^{m} \Delta(HCD)_{t-i} + \delta_4 \sum_{i=0}^{m} \Delta(K)_{t-i} + \delta_5 \sum_{i=0}^{m} \Delta ln\,(EDU)_{t-i} + \delta_6 \sum_{i=0}^{m} \Delta(REE)_{t-i} + \delta_7 \sum_{i=0}^{m} \Delta(WE)_{t-i} + \delta_8 \sum_{i=0}^{m} \Delta(T)_{t-i} + \psi(ecm)_{t-1} + \vartheta_t \quad (4)$$

where the coefficient $\psi$ measure the speed of convergence towards long-run equilibrium. To assess the model's stability, we used several diagnostic tests, including CUSUM and CUSUM Squares. Additionally, the Ramsey RESET test is used to verify the model's correct functional form, the LM test is used to verify autocorrelation, the B. P. Godfrey test is used to observe heteroskedasticity and the Jarque–Bera test is used to verify the normality of model. We used the pairwise Granger Causality test to ascertain causality between variables.

## 4. Data and benchmark model specification

### *4.1 Construction of total factor productivity index*

TFP is our dependent variable. Its calculation is a complex and scientific process. Previous studies have attempted to measure TFP based on input and output; they often contained measurement flaws, such as inaccurately calculating labour productivity and not adjusting capital and economic growth for inflation. However, this study has adopted the growth accounting framework to construct a TFP index, which considers inflation-adjusted input and output measurements. This index accurately captures labour productivity by measuring the number of hours worked by the employed labour force (Afzal *et al.*, 2020; Afzal and Mushtaq, 2022).

*4.2 Construction of women's empowerment index*

WE is a multidimensional concept, as explained in Table 2, and its measurement is a challenging task (Kabeer, 1999; Kishor and Subaiya, 2005; Mason, 2005). There are some main causes of poor empowerment measurement, such as inadequate integration of theory (Alsop and Heinsohn, 2005) and indicators' selection (Sandberg and Rafail, 2013), a lack of information to comprehensively capture empowerment (Richardson, 2018) and imprecise or partial measurement models based on analytical techniques (Agarwala and Lynch, 2006). However, the V-Dem data set (Coppedge *et al.*, 2021) has thorough measurements that support the theoretical idea of gender-specific components in civil liberty, political representation and civil society participation. These measurements cover a wide range and align well with the concept's core dimensions. V-Dem combines the verification of 3,200 expert ratings from 202 nations using a Bayesian item response measurement methodology. We have developed the Women's Development Index as a second construct using three indices developed by V-Dem's data set: political representation, civil liberties and involvement in civil society.

We also included a fourth indicator of economic empowerment. We use the Entropy Method to develop a comprehensive WE index based on all four indicators of empowerment. A list of all the indicators that are part of each sub-index is given in Table 1. High empowerment is indicated by the aggregate WPE, which ranges from 0 to 1.

## 5. Result discussions

*5.1 Preliminary analyses*

In Table 3, we present the preliminary analysis results of the correlation and descriptive statistics. The correlation analysis indicates a strong and positive association between the pair of variables between TFP, WE and human capital indicators. The descriptive statistics demonstrate that the real exchange rate has the highest mean value of 108.12, while the WE has the lowest at 0.10. Similarly, the real exchange rate has the highest standard deviation, at 9.75, while the WE has the lowest at 0.01.

As shown in Table 3, key regressors (HCD, K and LNEDU) are highly correlated, indicating potential multicollinearity. While this may inflate standard errors and reduce precision, it does not bias the estimated coefficients. The ARDL model's structural stability was confirmed by CUSUM and CUSUMSQ tests, which remained within the 5% significance bounds, indicating robust long- and short-run relationships. Additionally, Granger causality tests support the expected directional relationships among HCD, WE and TFP. Together, these results provide confidence that the estimated effects are reliable and not spurious, despite the presence of multicollinearity.

**Table 2.** Dimensions and indicators of women's empowerment index

| Indicators | Definition | Source |
|---|---|---|
| Women's civil liberties index | Women's access to justice, liberty from enforced labour, domestic mobility and the right to own property | Varieties of Democracy Database (2023) |
| Women's civil society participation index | Engagement in civil society organisations, representation among journalists and freedom of open discussion of political topics | Varieties of Democracy Database (2023) |
| Women's political participation index | Women are equally represented in the legislative bodies and have a fair share of power allocation in all aspects | Varieties of Democracy Database (2023) |
| Women's economic empowerment | Participate in the labour force by providing their skills and services for the production of goods and services within a specified period | International labour organisation (ILO) |

**Table 3.** Descriptive statistics and correlation test

| Statistics | LNTFP | FR | HCD | K | LNEDU | REE | T | WE |
|---|---|---|---|---|---|---|---|---|
| Mean | 4.82 | 4.76 | 0.49 | 24.13 | 13.67 | 108.12 | 31.62 | 0.10 |
| Median | 4.82 | 4.52 | 0.49 | 24.14 | 13.76 | 103.80 | 32.31 | 0.11 |
| Maximum | 5.04 | 6.36 | 0.57 | 24.61 | 14.87 | 126.63 | 38.50 | 0.11 |
| Minimum | 4.61 | 3.47 | 0.40 | 23.72 | 12.00 | 96.48 | 24.70 | 0.08 |
| SD | 0.14 | 0.91 | 0.05 | 0.25 | 0.87 | 9.75 | 4.13 | 0.01 |
| Skewness | 0.38 | 0.32 | −0.04 | 0.16 | −0.35 | 0.40 | −0.04 | −0.44 |
| Kurtosis | 1.88 | 1.81 | 1.65 | 1.71 | 1.93 | 1.63 | 1.76 | 1.31 |
| Jarque–Bera | 2.51 | 2.51 | 2.51 | 2.42 | 2.24 | 3.47 | 2.11 | 5.02 |
| Probability | 0.28 | 0.28 | 0.28 | 0.30 | 0.33 | 0.18 | 0.34 | 0.08 |
| Variables | | | | Correlation analysis | | | | |
| LNTFP | 1.00 | | | | | | | |
| FR | −0.94 | 1.00 | | | | | | |
| HDI | 0.97 | −0.99 | 1.00 | | | | | |
| K2 | 0.96 | −0.92 | 0.94 | 1.00 | | | | |
| LNEDU | 0.92 | −0.98 | 0.97 | 0.91 | 1.00 | | | |
| REE | −0.43 | 0.62 | −0.56 | −0.44 | −0.59 | 1.00 | | |
| T | −0.63 | 0.67 | −0.65 | −0.52 | −0.58 | 0.38 | 1.00 | |
| WE | 0.81 | −0.91 | 0.89 | 0.82 | 0.91 | −0.63 | −0.47 | 1.00 |

To determine the stationarity status of the variables, we used the Phillips–Perron (PP) unit root test and the Augmented Dickey–Fuller (ADF) test. Except for the fertility rate (FR) and GFCF (K), all variables are non-stationary at the level, as presented in Table 4. The PP test indicates that all variables are nonstationary at the level except the fertility rate (FR). We used the ARDL methodology because of the existence of mixed-order integration.

Additionally, the model's diagnostic tests, which are shown in Table 5, show that our data is normally distributed and that there are no instances of multicollinearity, autocorrelation, heteroscedasticity or incorrect functional form.

### *5.2 Estimates of the baseline analysis*

We evaluate the association between TFP with its regressors by applying the ARDL approach. We used 2 lags for the estimation according to the AIC lag selection criteria. The findings of the ARDL estimation are displayed in Table 6, indicating that the government's

**Table 4.** ADF and Phillip–Perron test results

| | ADF | | PP | |
|---|---|---|---|---|
| Variables | Level | I(0) | Level | I(0) |
| FR | 2.970** | | 12.803* | |
| HCD | 0.597 | 5.654* | 0.571 | 5.685* |
| K | 4.742* | | | 3.652** |
| EDU | 1.511 | 5.874* | 1.722 | 5.876* |
| LNTFP | 0.225 | 3.511** | 0.489 | 3.549** |
| REE | 2.158 | 4.287* | 1.940 | 4.140* |
| T | 1.650 | 5.819* | 1.650 | 5.806* |
| WE | 1.325 | 4.490* | 1.321 | 4.380* |

**Note(s):** *, ** and *** indicate significance at 10, 5 and 1% levels, respectively

**Table 5.** Diagnostic tests

| Diagnostics tests | F-statistics | Prob-value |
|---|---|---|
| Ramsey RESET test for model specification | 3.81* | 0.08 |
| LM test for autocorrelation | 2.30*** | 0.14 |
| B. P. Godfrey test for heteroskedasticity | 0.82*** | 0.66 |
| Jarque–Bera for normality | 1.81*** | 0.405 |

**Note(s):** *, ** and *** indicate significance at 10, 5 and 1% levels, respectively

**Table 6.** Results of the Autoregressive Distributed Lag baseline model

| | Short-run estimates | | | Long-run estimates | | |
|---|---|---|---|---|---|---|
| Variables | $\beta$ | *t*-statistics | Prob | $\beta$ | *t*-statistics | Prob. |
| Constant | – | – | – | −0.041 | −0.044 | 0.965 |
| FR | 0.022 | 0.0983 | 0.344 | 0.022 | 0.538 | 0.600 |
| HCD | 2.343*** | 4.811 | 0.000 | 2.343* | 1.828 | 0.092 |
| K | 0.004 | 0.153 | 0.881 | 0.004 | 0.064 | 0.949 |
| EDU | −0.053*** | −6.186 | 0.000 | −0.052*** | −3.570 | 0.004 |
| REE | −0.0004 | −1.560 | 0.145 | −0.0004 | −0.750 | 0.467 |
| WE | 1.776*** | 4.260 | 0.001 | 1.776** | 2.279 | 0.019 |
| T | −0.003*** | 8.534 | 0.000 | −0.003*** | −3.106 | 0.009 |
| ECM | −0.04*** | −11.978 | 0.000 | – | – | – |
| F bound test | 9.56*** | | $R^2$ | 0.92900 | | |
| Wald test | 58.96*** | | Adjusted *R* | 0.8935 | | |

**Note(s):** *, ** and *** indicate significance at 10, 5 and 1% levels, respectively

education expenditure and trade openness have significant but negative effects on TFP. This negative impact can be attributed to the investment's insufficient addressing of the needs of a growing population. Our findings are supported by existing literature, which suggests that low productivity growth is often caused by inadequate public investment in human capital (Li *et al.*, 2016) and a lack of efficient investment channels, such as those aimed at empowering female human capital (Kaffenberger and Pritchett, 2021).

HCD shows a significantly positive correlation with TFP. Specifically, a 1% increase in HCD is associated with a 2.34% increase in TFP, aligned with the literature (Ahmad *et al.*, 2014; Engelbrecht, 2002; Oketch, 2006) that recognises human capital as a crucial driver of TFP growth in Pakistan. The contribution of human capital to economic growth can be observed through two effects: a level effect and a composition effect via the "productivity channel" (Mushtaq *et al.*, 2014; Vandenbussche *et al.*, 2006). The composition effect is evidenced by the positive and significant impact of WE on TFP by a magnitude of 1.77%.

WE enhance TFP through two primary mechanisms. First, it increases TFP by raising women's labour force participation rate and improving effective and healthy human resources through the upbringing of their children. Second, it fosters social, economic, financial and political adaptability, which, in turn, boosts TFP. This leads to development, which further perpetuates women's empowerment, creating a virtuous cycle. This development is transformed into an inclusive and sustainable development when poverty reduction, job creation and social inclusion are achieved through gender equality. Therefore, it has been proven through statistical

analysis that empowering female human capital is essential in Pakistan, which comprises half of the total population and a high proportion of unemployment among women (World Bank, 2022). The negative and significant value of the ECM term shows that the speed of adjustment is 4% towards the long run. The ARDL model's structural stability is confirmed by CUSUM and CUSUMSQ tests in Figure 2, which remained within the 5% significance bounds, indicating robust long- and short-run relationships.

### *5.3 Further analysis*

We have provided an initial analysis of how WE and HCD impact TFP. However, we have examined the specific mechanisms through which these factors influence TFP. This section will explore the relationship between WE and HCD and their impact on TFP through two dimensions: moderating and mediating effects.

*5.3.1 Moderating effect analysis.* To understand how WE and HCD impact TFP, this paper adopts Wen-Chin (2009) verification method. We aim to investigate whether HCD can influence TFP by interacting with WE (Lee *et al.*, 2021). To achieve this, we use a long-run ARDL model, which is presented as follows:

$$ln\,(TFP)_t = \partial_0 + \partial_1 \sum_{i=0}^{m} ln\,(TFP)_{t-1} + \partial_2 \sum_{i=0}^{m} (X)_{t-1} + \partial_3 \sum_{i=0}^{m} (HCD{*}WE)_{t-1} + \upsilon_t \quad (5)$$

The short-run model is:

$$ln\,(TFP)_t = \partial_0 + \partial_1 \sum_{i=0}^{m} ln\Delta\,(TFP)_{t-1} + \partial_2 \sum_{i=0}^{m} \Delta(X)_{t-1} + \partial_3 \sum_{i=0}^{m} \Delta(HCD{*}WE)_{t-1} + \psi(ecm)_{t-1} + \vartheta_t \quad (6)$$

where X represents all control variables of the models. Both equations involve the interaction coefficient of WE and HCD, represented by $\alpha_6$. If the coefficient $\alpha_6$ is significant and greater than 0, then it indicates that HCD can positively impact TFP through its interaction with WE. On the other hand, if $\alpha_6$ is not significant, then HCD can negatively impact TFP through its interaction with WE. The results of the moderating effect test show that the coefficient $\alpha_6$ is positive and significant at a level of less than 1% (Table 7). This implies that HCD has an impact of 5.6% on TFP through its interaction with WE. Therefore, the two factors have a significant and positive joint effect on TFP, suggesting that a moderate effect exists between them. A significant value of the Bound test shows the long-run cointegration among all determinants of the model.

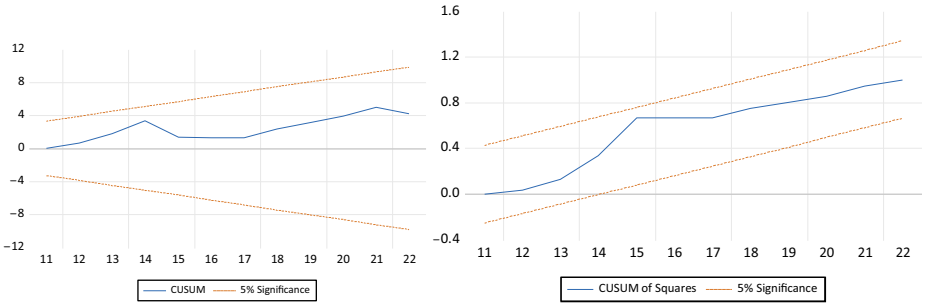


**Figure 2.** CUSUM and CUSUM square of the baseline analysis

**Table 7.** Results of the moderating effect model

| | Short-run estimates | | | Long-run estimates | | |
|---|---|---|---|---|---|---|
| Variables | $\beta$ | SE | *t*-statistics | $\beta$ | SE | *t*-statistics |
| ECM | −0.322*** | 0.0201 | −15.99 | – | – | – |
| FR | 0.053** | 0.0325 | 2.353 | 0.073** | 0.0285 | 2.553 |
| K | 0.054 | 0.03532 | 1.253 | 0.084 | 0.05132 | 1.653 |
| lnEDU | −0.050*** | 0.00843 | −5.973 | −0.053*** | 0.0143 | −3.505 |
| REE | −0.0004 | −0.000254 | −1.5875 | −0.0004 | −0.000401 | −1.0071 |
| WE*HCD | 5.6105*** | 0.778620 | 7.2057 | 5.6105*** | 1.7060 | 3.2886 |
| T | −0.0015** | 0.00088 | −2.3498 | −0.0025** | 0.00099 | −2.5698 |
| Constant | – | – | – | −1.1065 | 0.9951 | −1.11194 |
| F bound test | 18.53*** | | R-Sqaure | 0.90 | | |

**Note(s):** *, ** and *** indicate significance at 10, 5 and 1% levels, respectively. SE stands for Standard Errors

These findings are supported by empirical literature (Dias and Tebaldi, 2012; Van Leeuwen and Foldvari, 2008). However, there is also a different perspective that argues that the effect of human capital on productivity growth is not always positive, as external shocks from various production processes and service delivery may impede its impact (Li *et al.*, 2016). Given this perspective, it is necessary to enhance human capacity to adapt to different economic situations, specifically driven by technology, innovation and research and development. This implies that productivity growth can be improved by enhancing the channels of human capital through WE, as WE is an operative channel of HCD, playing a significant role in fostering innovations and increasing overall output (Brush *et al.*, 2017; Sekhri *et al.*, 2022). Policymakers need to understand WE as an effective channel of human capital to achieve sustainable growth and improved welfare. Structural stability of the model is evidenced by Figure 3.

*5.3.2 Mediating effect analysis.* In this study, we examine the mediating role of WE in the relationship between human HCD and TFP within a dynamic ARDL framework. To examine the indirect effect of HCD on TFP through WE, we adopt a two-step causal path estimation approach within the ARDL cointegration framework (Hatemi-j, 2012; Pesaran *et al.*, 2001). This approach enables the identification of both the direct effect of HCD on TFP and the indirect effect operating through WE. The specific long-run models are presented as follows:

$$ln\,(TFP)_t = \partial_0 + \partial_1 \sum_{i=0}^{m} ln\,(TFP)_{t-1} + \partial_2 \sum_{i=0}^{m} (X)_{t-1} + \partial_3 \sum_{i=0}^{m} (HCD)_{t-1} + \upsilon_t \quad (7)$$

$$(HCD)_t = \delta_0 + \delta_1 \sum_{i=0}^{m} ln\,(HCD)_{t-1} + \delta_2 \sum_{i=0}^{m} (\mathrm{X})_{t-1} + \delta_3 \sum_{i=0}^{m} (WE)_{t-1} + \upsilon_t \quad (8)$$

$$ln\,(TFP)_t = \alpha_0 + \delta_1 \sum_{i=0}^{m} ln\,(TFP)_{t-1} + \alpha_2 \sum_{i=0}^{m} (X)_{t-1} + \alpha_3 \sum_{i=0}^{m} (WE)_{t-1} + \upsilon_t \quad (9)$$

Short-run models are:

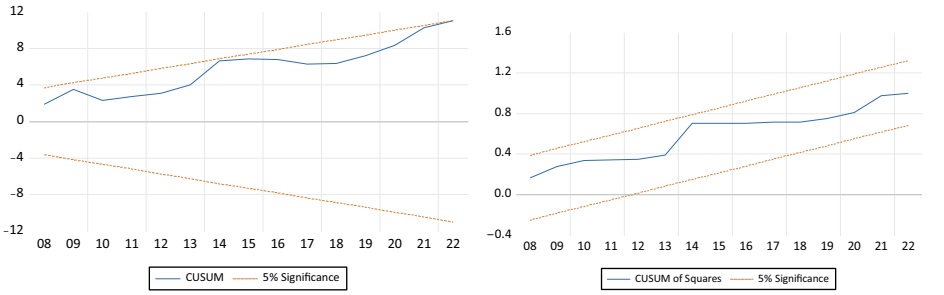


**Figure 3.** CUSUM and CUSUM square of the moderating model

$$ln\,(TFP)_t = \partial_0 + \partial_1 \sum_{i=0}^{m} ln\Delta\,(TFP)_{t-1} + \partial_2 \sum_{i=0}^{m} \Delta(X)_{t-1} + \partial_3 \sum_{i=0}^{m} \Delta(HCD)_{t-1} + \psi(ecm)_{t-1} + \vartheta_t \quad (10)$$

$$(HCD)_t = \delta_0 + \delta_1 \sum_{i=0}^{m} \Delta(HCD)_{t-1} + \delta_2 \sum_{i=0}^{m} \Delta(X)_{t-1} + \delta_3 \sum_{i=0}^{m} \Delta(WE)_{t-1} + \psi(ecm)_{t-1} + \vartheta_t \quad (11)$$

$$ln\,(TFP)_t = \alpha_0 + \delta_1 \sum_{i=0}^{m} ln\Delta\,(TFP)_{t-1} + \alpha_2 \sum_{i=0}^{m} \Delta(X)_{t-1} + \alpha_3 \sum_{i=0}^{m} \Delta(WE)_{t-1} + \psi(ecm)_{t-1} + \vartheta_t \quad (12)$$

where X represents all control variables of the models. If the coefficients $\partial 3$, $\delta_3$ *and* $\alpha_3$ are significant, then there is a mediating effect. The long-run equations (7)–(9) capture the equilibrium relationships among TFP, HCD and WE, while the short-run models (10)–(12) incorporate the adjustment dynamics through the error-correction term. If the coefficients on HCD → WE ($\delta_3$) and WE → TFP ($\alpha_3$) are significant and the total effect of HCD on TFP decreases after including WE, then this indicates a mediating (indirect) relationship in the dynamic system.

The regression results in Columns (1)–(3) of Table 8 indicate that WE has a significant promotional influence on TFP and HCD, and in turn, HCD has a significant positive effect on TFP. Therefore, we can conclude that WE serve as a mediator in the model. Its mediating effect or

**Table 8.** Results of mediating long-run models

| Models<br>Variables | Model 1<br>lnTFP | Model 2<br>HCD | Model 3<br>lnTFP |
|---|---|---|---|
| FR | 0.100*** (0.050017) | 0.025** (0.007608) | −0.125*** (0.059598) |
| K | 0.097 (0.057156) | 0.004 (0.004159) | 0.157** (0.073864) |
| REE | −1.32E-05 (0.000470) | 0.0002* (7.39E-05) | −0.0017*** (0.000980) |
| T | −0.0017 (0.002371) | 0.0002 (0.000171) | −0.0015 (0.001576) |
| EDU | −0.053* (0.016379) | 0.0008 (0.002336) | −0.033*** (0.016605) |
| WE | 2.734* (0.910295) | 0.345** (0.121875) | |
| HCD | | | 3.516*** (1.992956) |
| C | −1.554 (1.093028) | 0.031 (0.120328) | −1.488 (1.498863) |
| Adjusted $R^2$ | 0.99 | 0.99 | 0.98 |
| F-Bound test | 389.37*** | 2817.127*** | 185.3806*** |

**Note(s):** Significance levels are indicated by *, ** and ***, at 10, 5 and 1% levels, respectively. Standard errors are shown in parentheses

estimated indirect effect (0.345 × 3.516/2.734 = 44%) represents the proportion of HCD's long-run influence on TFP transmitted through WE (For short-run estimation results of the mediation models, see Table A2 in the Appendix). This dynamic mediation interpretation consists of causal inference in cointegrated systems, where long-run coefficients represent steady-state relationships among variables (Hacker and Hatemi-J, 2006).

Public investments in female human capital development positively impact food security, quality of life and economic development can be supported by the positive and significant mediating effect of HCD on TFP through WE. This is because of the intensified and interrelated benefits that female human capital provides (Houston and Huguley, 2014). Men and women are two separate types of human capital that have different biological and cognitive specifications. In countries with substantial gender inequality, like Pakistan, investments in female human capital have a stronger positive impact on a nation's long-term development than equivalent investments in men. WE alter society's choices and priorities in important ways (Duflo, 2012). WE is a source to improve the productivity of current and future generations by eradicating malnutrition and stunting (Nafukho *et al.*, 2004).

According to the Sobel test, the mediating effect accounts for 13.42% of the overall effect with a value of 1.49 at the 10% significance level. In other words, HCD demonstrates a favourable relationship between WE and TFP. Furthermore, the significant value of the Bound test in Figures 4–6 shows the long-run cointegration among all determinants of the models.

### *5.4 Causality analysis*

We conducted a Pairwise Granger causality test to determine the direction of causality between our main independent variables and TFP. Table 9 illustrates a unidirectional relationship between WE to TFP and between HCD and TFP. Moreover, we observed a unidirectional relationship between the combined effects of WE and HCD on TFP. Therefore, to enhance productivity in Pakistan, it is essential to invest in empowering women and aligning human capital with the dynamic demands of the economy.

## 6. Conclusion and policy recommendations

This study examines the role of WE in the promotion of HCD and TFP in Pakistan from 1990 to 2022. This study aimed to test two hypotheses related to the impact of WE on TFP in Pakistan. The first hypothesis examined the moderating effect of WE on TFP, while the second hypothesis explored the mediating effect of WE on TFP. This study used the ARDL Bounds testing approach of cointegration for econometric analysis. The results showed that WE and HCD have a positive and significant effect on TFP in both the short and long run. The Granger

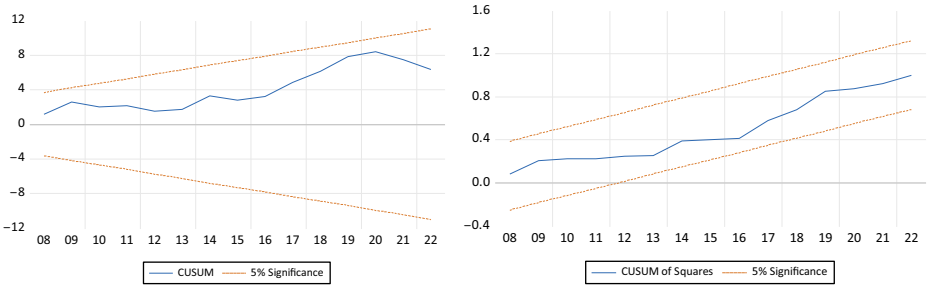


**Figure 4.** CUSUM and CUSUM Square of the Mediation Analysis Model 1

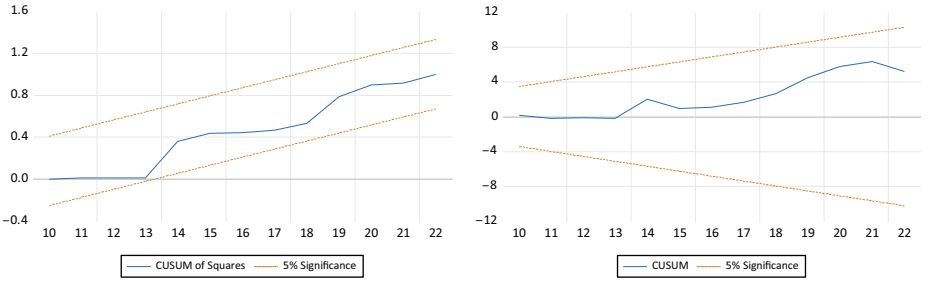


**Figure 5.** CUSUM and CUSUM Square of the Mediation Analysis Model 2

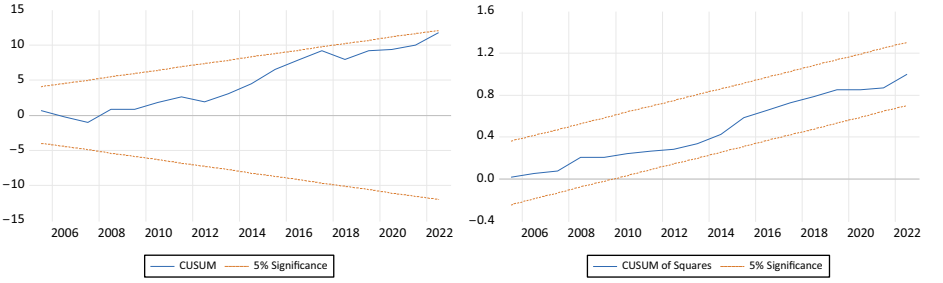


**Figure 6.** CUSUM and CUSUM Square of the Mediation Analysis Model 3

**Table 9.** Pair-wise Granger Causality test

| Null hypothesis | Observations | F-statistics | Prob. |
|---|---|---|---|
| HDI does not Granger-cause TFP/TFP does not | 31 | 4.472** | 0.021 |
| Granger-cause HDI | 31 | 3.286 | 0.053 |
| EDU does not Granger-cause TFP/TFP does not | 31 | 4.224** | 0.026 |
| Granger-cause EDU | 31 | 0.744 | 0.485 |
| WE does not Granger cause LNTFP/TFP does | 31 | 4.224** | 0.025 |
| not Granger-cause WE | 31 | 0.390 | 0.680 |
| WE_HDI does not Granger-cause TFP/TFP does | 31 | 4.912** | 0.015 |
| not Granger-cause WE_HDI | 31 | 0.342 | 0.713 |

**Note(s):** *, ** and *** indicate significance at 10, 5 and 1% levels, respectively

Causality Test was used to analyse causality between WE, HCD and TFP. Results showed unidirectional causality from WE and HCD, individually and in combination, with TFP.

Pakistan has relatively slow economic growth relative to other countries in the Asian region. The primary root cause of this problem is, among other causes, inadequate productivity growth and ineffective human resources. The demographic division of the population in Pakistan shows that half of its population is women who suffer from sub-optimal protection of freedoms. Its existing levels of gender inequality are undermining the transition to inclusive economic growth, competitive human capital development, poverty alleviation and sustainable

development. Ensuring the protection of women's rights is crucial for economic growth and resilience. Reforms aimed at stimulating the economy cannot succeed when almost half of the population's human capital is not safeguarded. Neglecting WE as a growth channel for HCD in policy discussions makes the growth less inclusive. The inclusion or exclusion of women in policy-making and public debates has a substantial impact on society and the economy. This study argues that four sub-components of WE independently determine the introduction of new ideas into society and the selection of effective economic policies. The limitations of this study stem from the lack of available data on women's economic participation in Pakistan.

Based on the findings, several context-specific policy directions are proposed to strengthen Pakistan's demographic and economic transition through WE. First, to harness the demographic dividend effectively, policymakers should recognise women's empowerment as a core driver of HCD and TFP. This requires mainstreaming women's well-being into the Pakistan Vision 2025 and National Human Development Policy, ensuring that gender equity indicators are integral to national planning and budgeting processes. Second, women's participation in economic activities should be enhanced through targeted fiscal incentives and institutional reforms – for instance, expanding access to microfinance under the Kamyab Jawan and Ehsaas programmes and strengthening women entrepreneurship schemes in collaboration with the State Bank of Pakistan and SMEDA. Third, at the policy design level, gender diversity in leadership positions should be improved by implementing the 33% quota for women's representation in parliament and provincial administrations. Such inclusion is vital for developing adaptive, gender-sensitive policies that align with the Sustainable Development Goals (SDG 5 and SDG 8). Fourth, investment in female education should be scaled up through a dedicated increase in the education sector budget, with transparent accountability and performance-based monitoring systems. Priority should be given to improving girls' secondary and tertiary education through public–private partnerships and digital learning initiatives under the Education Sector Reform Program. Fifth, the government should expand parenting programs and early childhood education facilities – especially in rural and low-income areas – to address gender stereotypes from an early age. This could build on initiatives such as the National Early Childhood Care and Education Policy to promote equality of opportunity. Finally, ensuring social and constitutional protection for women's civil liberties is essential. Strengthening enforcement mechanisms under the Protection against Harassment of Women at Workplace Act (2010) and integrating gender justice measures into the National Commission on the Status of Women framework will enhance women's agency, allowing them to transform their potential into human capital and contribute to sustainable economic growth.

Future research could expand the scope of this study in the following directions: first, by exploring the role of WE in specific sectors such as technology, health care or education. This would provide a more detailed understanding of its contributions to HCD and TFP. Second, the relationship between WE and technological advancement could be evaluated to see how women's digital literacy and technology adoption enhance their roles in HCD and TFP. Third, examining the intergenerational effects of WE on HCD and TFP could also shed light on how empowering women impacts productivity and quality of life for future generations. These approaches aim to deepen understanding of the complex effects of women's empowerment and to inform policies that foster equitable economic growth.

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## Appendix

**Table A1.** Description, measurement of variables and data sources

| Variables (symbol) | Variable description | Measurements | Source |
|---|---|---|---|
| Total factor productivity (TFP) | TFP quantifies the efficiency of production by measuring the output generated from given inputs | Index = 1 denotes maximum productivity, 0 denotes no productivity | Growth accounting framework method (Author's calculation) |
| Human development index (HCD) | HDI encompasses a long, healthy life, education and good living standards | Index = 1 denotes maximum development, 0 denotes no development | Human Development Reports (2018) |
| Women's empowerment index (WE) | WE is the process of increasing the abilities, agency, participation in social decision-making and economic participation of women | Index = 1 denotes fully empowered, 0 denotes no empowerment | Entropy method (author's calculation) |
| Government expenditure on education (EDU) | Total governments' expenditure on education, health, social services, etc | % of government expenditure | World development indicators |
| Gross fixed capital formation (K) | It includes land improvements, plant and equipment purchases, construction of buildings, railways and roads | Data are in constant 2015 prices, expressed in US dollars | World development indicators |
| Fertility rate (FR) | Total number of kids a woman would have if she followed age-specific fertility rates until the end of her childbearing years | Total (births per woman) | World development indicators |
| Real effective exchange rate index (REER) | The real effective exchange rate is obtained by dividing the nominal effective exchange rate by an index of prices or costs | (2010 = 100) | World development indicators |
| Trade openness (T) | It refers to the total value of both exports and imports of goods and services | Trade (% of GDP) | World development indicators |

**Table A2.** Short-run results of mediation models

| Models | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Dependent variables | lnTFP | HCD | lnTFP |
| FR | 0.100131* (0.050017) | 0.025043*** (0.007608) | −0.125109* (0.059598) |
| K | 0.097400* (0.057156) | 0.004746 (0.004159) | 0.157752* (0.073864) |
| REE | −0.000013 (0.000470) | 0.000275*** (0.000074) | −0.001734* (0.000980) |
| T | −0.001704 (0.001064) | 0.000203(0.000171) | −0.001593(0.001576) |
| WE | 2.734228*** (0.910295) | 0.345175** (0.121875) | |
| EDU | −0.053528*** (0.016379) | 0.000802 (0.002336) | −0.033944* (0.016605) |
| HCD | | | 3.516770* (1.992956) |
| ECM | −0.261483** (0.120694) | −0.348545*** (0.083374) | −0.398474** (0.167004) |

**Note(s):** *, **, and *** indicate significance at 10, 5 and 1% levels, respectively