Investment in Human Capital and Manufacturing Enterprise Productivity: Evidence from Pakistan

Riaz Ahmed[1], Muhammad Ayyoub[2], Muhammad Iqbal[3] and Waseem Barkat[4]

Abstract

This study examines the complex relationship between human capital investments and enterprise productivity within Pakistan's manufacturing sector, examining firm and district levels. Leveraging firm-level data from the census of manufacturing enterprises (2005-06) and district-level human capital indicators from social and living measurement surveys (2004-05 and 2006-07), this research informs evidence-based policy decisions. Employing OLS regressions and robustness checks, the study delves into the impact of human capital investment on enterprise productivity, accounting for district-level nuances, rural-urban differentials, and variations among enterprises of diverse sizes and capital intensities. Results unveil a subtle yet significant positive correlation between district-level human capital indicators and manufacturing enterprise productivity. Detailed analyses highlight the influential role of improvements in healthcare indicators in urban areas within districts on the productivity of large-scale manufacturing enterprises. Conversely, the impact of healthcare infrastructure in rural regions on overall productivity remains uncertain, particularly in the short term. The study emphasizes the necessity for tailored policies, recommending heightened investments in healthcare infrastructure in urban areas and a concentration on education capital in rural regions to bolster small manufacturing businesses. Policymakers are urged to differentiate interventions based on enterprise characteristics and the urban-rural divide to optimize human capital benefits across diverse manufacturing entities.

Keywords: Manufacturing Enterprises; Enterprise Productivity; Human Capital; Health and Education Indicators; Pakistan.

Introduction

The concept of human capital has long been a central focus in economic discourse, tracing its roots back to the ideas of Adam Smith and gaining prominence through the work of Chicago School economists in the late 1950s. This notion gained a reputation in the early 1970s, with a specific focus on the importance of health as a crucial component (Stein & Sridhar, 2019). Over the years, human capital has emerged as a pivotal lens to analyze various labor-related issues, including income disparities, economic growth, and public health. It is a multidimensional construct encompassing elements such as education, training, skills, and healthcare, collectively shaping the development, adoption, and utilization of technologies that enhance productivity (Lim et al., 2018). In the context of humans, education and health stand out as fundamental pillars that drive economic growth. The quality of education and the fulfillment of primary healthcare needs are recognized as critical determinants of a society's prosperity (Mulia & Saputra, 2021). Empirical studies have consistently shown that factors such as life expectancy, education spending, and internet literacy have a profound impact on growth and employment in developing nations (Khan & Chaudhry, 2019; Widarni et al., 2022).

[1]*Assistant Professor, Department of Management Sciences, University of Turbat, Turbat-Pakistan.*
[2]*Assistant Professor, Department of Economics, University of Sahiwal, Sahiwal-Pakistan.*
Email: m.ayyoub@uosahiwal.edu.pk
[3]*Assistant Professor, Department of Economics, University of Mianwali, Mianwali-Pakistan.*
[4]*Assistant Professor, Department of Management Sciences, University of Turbat, Turbat-Pakistan.*

Human capital, encompassing skills, expertise, and well-being, is instrumental in sustainable industrial productivity and economic growth. Cognitive skills and educational attainment significantly influence long-term economic development (Hanushek & Woessmann, 2023). Health, a critical component of human capital, is directly linked to life expectancy, with higher education positively correlated with increased life expectancy (Railaite & Ciutiene, 2020). The variation in worker productivity among countries can be attributed to factors such as education, cognitive skills, and health, with health playing a significant role (Campbell & Üngör, 2020). Moreover, the inverse relationship between adult mortality and economic growth highlights the pivotal role of health indicators, particularly life expectancy, in understanding economic development dynamics (Lorentzen et al., 2008). Alnoor (2020) emphasized the importance of diverse aspects of human capital, such as education, experience, health, personal traits, skills, and training, in improving a company's chances of survival. Prior studies, such as the work by Amjad et al. (2012), emphasized the obstacles confronted by Pakistani businesses due to a lack of proficient workforce linked to insufficient training facilities and below-par educational standards. Additionally, Mubarik et al. (2020) highlighted the crucial role of human capital, particularly in education and training, in shaping the export outcomes of medium-sized manufacturing enterprises, especially those engaged in moderate to high export activities.

Building on this foundational understanding, recent research has examined the nuanced interplay between human capital and economic growth within the context of specific countries, including Pakistan. These studies have underscored the direct and indirect positive impact of human capital, including education and health, on production, economic efficiency, and GDP growth (Afzal et al., 2013; Afzal et al., 2010; Ali & Ramay, 2014). In particular, Ezoji et al. (2019) investigated the relationship between human capital indicators such as secondary school enrollment, infant mortality rate, and life expectancy, and the expansion of Pakistan's manufacturing sector, revealing a beneficial impact of human capital on the sector's growth.

However, while these country-level analyses have provided valuable insights, a critical gap must be addressed. More comprehensive, disaggregated research at the enterprise and district levels needs to be conducted, mainly focusing on Pakistan's manufacturing sector, represents a significant portion of the country's economy. Furthermore, the existing research needs to adequately address distinctions between urban and rural regions and has explored the differential impact on big versus small enterprises and high-capital-enterprises versus low-capital enterprises.

This study seeks to bridge this evident void in the literature by examining the relationship between human capital investments and economic growth at the enterprise level, explicitly focusing on Pakistan's manufacturing sector. By utilizing district-level data from the census of manufacturing enterprises and human capital indicators from surveys of social and living measurement in Pakistan, this research aims to provide concrete, granular findings contributing to informed policy-making decisions.

The study addresses critical research questions, including the impact of investing in human capital on enterprise productivity, potential differences between rural and urban locations, and variations between big and small enterprises and high-capital and low-capital enterprises. Ultimately, the findings are expected to shed light on the challenges and opportunities facing Pakistan's manufacturing sector in the context of human capital development and offer valuable insights for policymakers and stakeholders.

Objectives of the Study

This study investigates the relationship between human capital investments in health and education and enterprise productivity in Pakistan's manufacturing sector. The specific objectives include:

- Examine the impact of investing in human capital on the productivity of manufacturing enterprises at the district level.
- Analyze potential differences in the relationship between human capital and productivity in rural and urban locations.
- Investigate variations in the impact of human capital on productivity between big and small enterprises within the manufacturing sector.
- Explore the differential effects of human capital investments on productivity in high-capital and low-capital manufacturing enterprises.

Significance of the Study

This research holds significant implications for advancing our understanding of the challenges and opportunities within Pakistan's manufacturing sector, addressing a critical void in the existing literature. By conducting a comprehensive, disaggregated analysis at both the enterprise and district levels, this study provides nuanced insights into the human capital dynamics of the sector. The findings offer valuable guidance for policymakers and stakeholders, shedding light on the challenges and opportunities related to human capital development. The emphasis on tailoring interventions to address the unique needs of diverse enterprises and regions underscores the practical relevance of this research. Furthermore, the study contributes to the broader discourse on the connection between district-level human capital indicators and firm-level productivity, focusing on the urban-rural divide. The implications extend beyond academia, informing strategic decision-making for policymakers and contributing to the broader goal of fostering economic development through targeted investments in healthcare and education. Additionally, by identifying avenues for further research and policy initiatives, this study paves the way for future investigations that consider enterprise size, capital intensity, and regional disparities, thereby offering a comprehensive framework for maximizing the benefits of human capital for diverse enterprises across different district regions.

This article is structured to provide a comprehensive exploration of the research topic. The subsequent sections delve into the existing literature, detail the chosen methodology, present the model estimation, discuss the obtained results, and offer concluding remarks along with relevant recommendations.

Literature Review

The persistent concern regarding the uneven distribution of welfare among regions and cities has long captured the attention of policymakers and researchers, particularly in disciplines such as economic geography, regional economics, regional science, and economic growth theory (Faggian et al., 2019). This concern has prompted a shift in urban and regional economic research from a traditional focus on firms and industries to a growing recognition of the pivotal role of skills in economic growth (Mellander & Florida, 2021).

Human capital, encompassing educational attainment, absenteeism factors, and strategic investments such as R&D and bonus systems, emerges as a crucial determinant in enhancing firms' productivity and competitiveness, with varying impacts across industries and organizational characteristics (Jibir et al., 2023). The classic human capital theory, originating from the seminal work "Human Capital," underscores the importance of education as a critical component, viewing expenditures on education, training, and healthcare as investments with calculable valuable returns (Alnachef & Alhajjar, 2017). The literature on human capital measurement involves three primary methods—indicator, cost, and income (Abraham & Mallatt, 2022) —wherein, in this study, the indicator approach is favored for assessing human capital in health and education infrastructure due to concerns such as corruption affecting the accuracy of monetary values.

Global policymakers are increasingly emphasizing the pivotal role of human capital, defining it as knowledge, skills, and experiences, with recent research highlighting the significance of both education and health in driving innovation and economic growth (Sultana et al., 2022). Studies in Indonesia (Sulisnaningrum et al., 2022) and beyond (Harnani et al., 2022) underline the interdependence of human capital, technological advancement, and economic growth, emphasizing the need for sustained investment in both. Urbanization significantly contributes to human capital accumulation, fostering economic growth by stimulating infrastructural development, investment in human capital, institutional arrangements, entrepreneurship activities, and improving living standards (Mehmood & Lal, 2021). Agglomeration economies, offering advantages such as improved infrastructure efficiency, cost savings, specialized labor pools, and knowledge spillovers, play a crucial role in promoting human capital investment, which is particularly beneficial for knowledge-based industries (Bolter & Robey, 2020).

Macro-level literature spanning specific countries or cross-country analyses contributes valuable insights. For instance, in Nigeria, a study advocates increased investment in education and health budgets to enhance skills across educational levels (Keji, 2021). Another study across 100 countries finds a positive relationship between human capital and economic growth, with evidence of nonlinear dynamics (Matousek & Tzeremes, 2021). In BRICS countries, outward foreign direct investment is associated with positive short-term impacts on human capital and economic growth (Mohanty & Sethi, 2019). Studies in Africa emphasize the varying effects of external money flows on growth moderated by human capital levels (Dinh et al., 2022).

At the micro level, studies focusing on firms or industries within a country reveal nuanced relationships. Technically skilled human capital in IT-related fields positively correlates with higher firm valuations but negatively predicts future financial and operational performance (Fedyk & Hodson, 2022). In Vietnam, human capital and larger firm size positively contribute to implementing construction firms (Nguyen, 2020). Human capital indicators significantly influence Chinese manufacturing firms' innovation, with some variables showing a more significant impact in mid-sized cities (Sun et al., 2020). The global job market's rising significance of human capital is highlighted, linking it to firm performance (Marimuthu et al., 2009).

Despite the wealth of literature at the macro and micro levels, a critical gap exists at the mezzo level, where district-level human capital indicators are merged with firm-level productivity. Existing studies often separate models for local human capital and agglomeration, neglecting their interconnected impact on firm-level productivity (Peng et al., 2023). Our study aims to bridge this gap by exploring the mezzo level, providing a more comprehensive understanding of how district-level human capital indicators influence firm-level productivity. Furthermore, our study takes a bold step by integrating human capital and agglomeration factors within the same production function model, enabling a more holistic analysis of their collective impact on firm-level productivity. Through these contributions, we aim to fill existing gaps and offer a nuanced understanding of the intricate relationship between investment in human capital and manufacturing enterprise productivity.

Methodology

Measurement of Human Capital

The assessment of human capital involves two main methods, focusing on investments in health and education infrastructure. One approach, the monetary investment approach, quantifies government spending on health and education, sometimes including private investments. However, this method has limitations, such as corruption and delays between spending and positive outcomes. For instance, spending on healthcare or education might not yield immediate returns for businesses, as demonstrated by Pritchett's (1996) research, which

found that in developing countries, investing one dollar in human capital results in a capital stock valued at less than half a dollar.

The second method, the output indicator approach, estimates human capital using outcome measures. These measures include health-related indicators like waterborne diseases and education metrics such as enrollment percentages and literacy rates. Researchers like Sumarto and De Silva (2014) and McDonald and Roberts (2002) have employed this approach to assess healthcare and education systems. In this study, we adopt the second approach, focusing on health and education outcomes, similar to Ogundari and Awokuse's (2018) study. We use specific metrics for health, including the satisfaction of the population with healthcare amenities and the percentage of married women receiving TT-Injection during pregnancy, and for education, net enrollment in primary schools and literacy rates among individuals aged 10 and above. When selecting these indicators, data availability, reliability, and comparability are crucial considerations.

Table 1 Data, Definition and Sources of Variables

	Variables	Measurements	Sources
P	Production	The overall production output priced in PKR	Pakistan Census of Manufacturing Industries PCMI (2005-06)
W	Worker	Average number of staff members (including both productive and non-productive personnel) throughout the year.	PCMI (2005-06)
C	Capital	The net book value of capital, which encompasses assets such as land, buildings, machines, automobiles, etc. is expressed in Pakistani Rupees (PKR).	PCMI (2005-06)
M	Material Inputs	The expenditure on materials in PKR utilized throughout the fiscal year encompasses a wide range of items whether acquired locally or imported.	PCMI (2005-06)
SO	State Ownership	State ownership indicator. Takes on a value of 1 when the enterprise is under the ownership of the Pakistani government..	PCMI (2005-06)
FO	Foreign Ownership	Foreign Ownership is represented as a binary variable indicating whether the enterprise is under foreign ownership, either fully or partially. It takes a value of 1 when the enterprise is under foreign ownership to some extent.	PCMI (2005-06)
IE	Importing Enterprise	Enterprise engaged in the importation of materials from foreign sources are represented by a binary variable that takes on a value of 1 when the enterprise has imported materials with a value greater than zero, and 0 if they haven't imported any materials.	PCMI (2005-06)
EI	EG Index	It is determined using information from the Census of Manufacturing Industries, and the specific formula for its computation can be found in the accompanying text.	PCMI (2005-06)

Pop	Population	The population of districts for the fiscal year 2005-06 has been approximated using the population growth rate from the Pakistan's population censuses.	Development Statistics of the Provinces
UR	Urban Residents	It represents the proportion of the population residing in urban areas	Population Census 1998
KVR	Kilometre-Vehicle Ratio	It represents the relationship between the district's overall well maintained roads (in km) and the count of officially recorded vehicles.	Development Statistics of the Provinces
HDI	Human Development Index	The Human Development Index (HDI) is determined using the UNDP's standards, which include three fundamental factors: health, education, and income. Health is measured by considering life expectancy at birth, while education is evaluated by examining enrolment and literacy rates. Regarding income, due to the absence of district-level data, a technique was used to estimate district-level income using provincial-level data.	Jamal and Khan (2007)
DKD	Districts-to-Karachi Distance	We obtained longitude and latitude information for the primary cities in each district from the provided link. To calculate the distance in kilometres between these districts and Karachi, we employed the Haversine distance formula.	http://www.distancesfrom.com
HR	Healthcare Services	Proportion of residents in the district content with healthcare services	PSLM-Surveys (2004-05 & 2006-07)
TTI	TT-Injection	The proportion of women aged 15-49 who are currently married and gave birth in the past three years, and also received a tetanus toxoid injection during their most recent pregnancy.	PSLM-Surveys (2004-05 & 2006-07)
PNE	Primary Net Enrolment	This represents the overall enrolments of primary school students within the sector, calculated as the count of children aged 5-9 years who are currently attending primary schools, divided by the total population of children in the same age group.	PSLM-Surveys (2004-05 & 2006-07)
LR	Literacy Rate	Individuals aged 10 and above with the ability to both read a newspaper and compose a basic letter.	PSLM-Surveys (2004-05 & 2006-07)

Sources of Data and Summary Statistics

In this study, we aim to investigate the correlation between investment in human capital and the productivity of manufacturing enterprises in Pakistan. To accomplish this, it is imperative to acquire comprehensive data on both enterprise productivity and the key factors influencing productivity, as well as district-level data regarding the measures of human capital and other control variable at the districts level. We draw upon enterprise-level data derived from the Pakistan's census of manufacturing industries (P-CMI 2005-06) — which stands as the sole survey accessible to researchers that provides representative firm-level data for the manufacturing sector—conducted Pakistan Bureau of Statistics (PBS). This dataset comprises information from 6,417 manufacturing enterprises. To assess the investment in human capital

aspect, we refer to the Pakistan's social and living standard measurement (PSLM) surveys. Since our enterprise data is available for year 2005-06, we use district-level health and education indicators from the surveys 2004-05 and 2006-07. The human capital indicators are then averaged to provide data aligned with enterprise level data. The district and enterprise-level variables, along with concise descriptions, are presented in Table 1. Missing observations for variables such as capital and Kilometer-Vehicle Ratio (KVR) were addressed using dummy variables, and although regional data was available for all 120 districts in Pakistan, the P-CMI, detailed in Table 2, was conducted in only 73 districts.

Table 2 Summary Statistics

Variable	Number of Enterprises/Districts	Mean	Standard Deviation	Min.	Max.
Enterprise-Level					
Production (P)[a]	6413	10.91	2.08	4.83	18.39
Capital (C)[a]	6213	9.46	2.15	3.22	17.69
Worker (W)[a]	6413	3.69	1.32	0.70	9.73
Materials (M)[a]	6413	10.41	2.23	1.95	18.02
State Ownership (SO)	6413	0.09	0.28	0	1
Foreign Ownership (FO)	6413	0.04	0.21	0	1
Importing Enterprise (IE)	6413	0.14	0.34	0	1
EI	6413	0.06	0.12	-0.82	3.68
EI Square	6413	0.02	0.25	0	13.52
District-Level					
Pop[a]	73	7.47	1.06	5.73	14.37
UR	73	24.06	17.82	0	94.75
KVR	69	0.38	2.43	0.00	20.22
HDI	73	0.65	0.07	0.31	0.89
PNE-District	73	75.97	14.20	31	97.5
PNE-Urban	73	57.17	19.66	0	88.5
PNE-Rural	73	82.25	11.92	44	99.5
LR- District	73	46.55	11.88	26.5	83.5
LR-Urban	73	60.84	14.44	0	90.5
LR-Rural	73	40.85	11.17	21.5	71.5
HR- District	73	39.35	13.89	7.4	76.02
HR-Urban	73	37.84	18.46	0	84.29
HR-Rural	73	40.11	13.18	16.3	73.55
ITI- District	73	52.73	17.07	19.5	84
ITI-Urban	73	65.34	16.89	0	93.5
ITI-Rural	73	47.15	17.90	14.5	82.5

Note: Authors' own calculations. Please refer to Table 1 for a more detailed definition and the sources of data. [a] values in log.

Model Estimation

In this study, we adopt a similar approach as the recent work by Sumarto and De Silva (2014), who incorporated healthcare and education indicators as additional input in an augmented growth model. Healthcare facilities and education outcomes, through various means and positive impacts on society, contribute to the formation of human capital, a crucial factor for

economic growth, alleviating poverty, and enhancing overall human well-being and development. However, our approach differs slightly because we possess cross-sectional enterprise-level data. We employ an enterprise-level production function, where enterprises utilize their private capital (C), workforce (W), and material supplies (M) to production output (P). Furthermore, an enterprise's output may be influenced by the accessibility of public human capital (H), which can enhance productivity through a better-educated and healthier workforce. Using the well-known Cobb-Douglas production function, the fundamental model is expressed as follows:

$$P = \alpha W^{\beta 1} C^{\beta 2} M^{\beta 3} H^{\lambda} e^{u}.$$

In the above equation, α symbolizes total factor productivity, while β_1, β_2, β_3, and λ correspond to the production elasticities of worker, enterprise private capital, material supplies, and public human capital, respectively, with u representing the typical error term. When we take the natural logarithm of the equation, we obtain the following:

$$p = \alpha + \beta_1 w + \beta_2 c + \beta_3 m + \lambda h + u.$$

Additional modifications are necessary to calculate the model mentioned above. While it's feasible to directly assess p, w, c, and m using accounting data, evaluating h presents a greater challenge. Instead, public human capital will be assessed through various indicators ($Z \in$ n=1,...,N) that capture different facets of government and private sector investments in education and healthcare facilities. These indicators are assessed at the district level where enterprise i is situated and encompass district-specific control variables. Given that the decision regarding the location of a business enterprise could have been affected by the presence and caliber of the workforce, we adopt the approach of Ellison and Glaeser (1997) by including the index (EI) to assess the regional clustering of industries (see below for its calculation). By including EI, we address the potential for selection bias stemming from enterprise location decisions. This index helps us account for the geographic concentration of business enterprises, assuming that enterprises strategically choose their locations based on the benefits derived from external economies of scale resulting from industrial agglomeration.

When enterprises operating in the same industry are clustered in close physical proximity (localization) or in proximity to companies in associated industries (urbanization) within the same geographic area, they enjoy advantages such as reduced transaction costs, knowledge sharing, access to skilled labor and cost-effective inputs, and improved access to customer markets. Nevertheless, it's crucial to recognize that too much clustering can lead to difficulties such as elevated property prices, rising transportation and operational costs, and heightened rivalry in product markets. To account for these potential negative effects of agglomeration, we incorporate the EI-squared in our analysis. This squared term allows us to capture adverse agglomeration effects that may emerge when industrial concentrations exceed a certain threshold. The evaluation of this index occurs at the industry sector level (j) corresponding to the enterprise i's affiliation. Furthermore, it is necessary to incorporate additional control variables (denoted as $X \in$ v=1,...,V) that consider factors related to an enterprise's ownership and market orientation.

$$p_{ijk} = \alpha + \beta_1 w_{ijk} + \beta_2 c_{ijk} + \beta_3 m_{ijk} + \sum_n \delta_n Z_{nk} + \varphi EI_j + \sum_v \gamma_v X_{vijk} + ID_j + PD_p + \varepsilon_{ijkp},$$

In the above model, Z denotes variables specific to each district, while ε_{ijkp} represents an idiosyncratic error term. Industry-fixed effects (ID_j) and province-fixed effects (PD_p) dummies are included in the estimation. We derive parameter estimates for this model using the ordinary least squares (OLS) estimation techniques. It is also crucial to account for and address any potential selection bias that could arise from the enterprises' location choices, as it is possible that more productive enterprises intentionally opt to establish themselves in regions offering a higher supply of skilled human capital.

This may especially apply to businesses in need of highly skilled personnel, a common requirement for more efficient enterprises. To address this potential bias, we can incorporate a metric for industry concentration. The EI utilized for this specific objective is defined as follows:

$$EI_j = \frac{\sum_{i=1}^{M}(DW_{jk} - TW_k)^2 - (1-\sum_k TW_k^2)\, HI_j}{(1-\sum_k TW_k^2)\,(1-HI_j)},$$

where DW_{jk} denotes the jth proportion of workers in district k, while TW_k shows the overall manufacturing workers within district k. HI_j represents the Herfindahl index, a metric used to gauge the concentration of workers at the ith enterprise within industry j. This index is characterized by the following definition:

$$HI_j = \sum_{i=1}^{M} EW_{ij}^2 ,$$

where EW_{ij} represents the proportion of workers from the ith enterprise within the overall workforce of industry j.

Estimation Results and Discussion

The OLS regression results for different model specifications are presented in Table 3, with a log-log production function employed in the cross-sectional analysis in the econometric approach. The study incorporates enterprise and district-level control variables to account for specific variations. Dummy variables for manufacturing sectors and Pakistani provinces are included to capture fixed effects. Errors are clustered at the district level. The baseline model (column 1) reveals estimated elasticities for worker, capital, and material inputs falling within anticipated ranges (0.15, 0.053, and 0.81, respectively) at a 99% confidence level. These results were consistent with a prior study by Kneller and Misch (2014). The foreign enterprise indicator is a crucial factor in assessing business performance in Pakistan, indicating that foreign manufacturing companies outperform their local counterparts. Other enterprise-level controls like import-focused enterprises and EI have minimal impact, with negative coefficients, whereas state-owned enterprises have a positive effect. The study found a significant positive impact of district population on the outcome variable, while the kilometer-vehicle ratio did not have a considerable impact.

In this study, we are examining the connection between human capital and the overall efficiency of manufacturing enterprises, with a specific focus on the influence of health and education indicators. Our examination has revealed a weak positive relationship between human capital at the district level and the productivity of manufacturing businesses, although this correlation needs more statistical significance. To gain a deeper understanding of these connections, we investigate how health and education indicators impact the productivity of manufacturing enterprises at the district level in rural and urban areas.

Nevertheless, when we conducted detailed analyses at a more specific level, distinguishing between rural areas (column 1, Case II) and the urban regions (column 1, Case III), our analyses indicated that enhancing healthcare indicators in metropolitan areas within districts has a noteworthy and favorable impact on the productivity of large-scale manufacturing enterprises only. In all other instances, the coefficients lack statistical significance. To be more precise, allocating resources to improve healthcare facilities in the urban region of a district and subsequently increasing the satisfaction level of the population by ten percentage points (for instance, from 50% to 60%) is positively associated with higher output in large-scale manufacturing enterprises. Holding other variables constant, this increase is associated with a significant 4.1% boost in enterprise production, a finding that has statistical significance at the 10% level. This is likely because manufacturing entities are primarily concentrated in urban regions, and improvements in healthcare facilities directly benefit their employees. The results regarding healthcare facilities align with a study by De Silva, 2014) in Indonesia, which investigated how healthcare indicators at the district level influenced regional development and

poverty. A recent study (Turganbayev 2023) explored Kazakh regions between 1994 and 2019, finding that although human capital didn't directly affect production, it significantly influenced the growth of total factor productivity (TFP).

While the benefits of healthcare facilities in cities are apparent, the influence of healthcare infrastructure in rural regions on the overall productivity of large-scale manufacturing at the district level is only sometimes evident, especially in the short term. This ambiguity could be because rural residents primarily engage in tax-free agricultural production, while significant manufacturing industries are centered in Pakistan's urban areas. However, over time, improved healthcare services in rural regions could encourage migration to cities, potentially increasing involvement in industrial production. These findings enhance our comprehension of the complex connection between human capital investment and the productivity of large-scale manufacturing sectors across various contexts in Pakistan.

Table 3 Relationship Between Human Capital and Manufacturing Enterprises Productivity: Regression Results

	Total Enterprises	Big Enterprises	Small Enterprises	High Capital Enterprise	Low Capital Enterprise
	(1)	(2)	(3)	(4)	(5)
Case-I: District Human Capital					
HR	0.0012	0.0020	0.0008	-0.0019	0.0038
	(0.0019)	(0.0023)	(0.0015)	(0.0013)	(0.0024)
PNE	0.0005	-0.0037	0.0030**	0.0038**	-0.0016
	(0.0019)	(0.0030)	(0.0013)	(0.0015)	(0.0021)
No of Enterprises	6,413	3,205	3,208	3,104	3,105
District	73	65	69	70	66
Case-II: Urban Human Capital					
HR	0.0041*	0.0041**	0.0028*	0.0009	0.0069***
	(0.0021)	(0.020)	(0.0016)	(0.0014)	(0.0021)
PNE	-0.0013	-0.0040	0.0008	0.0018	-0.0045**
	(0.0018)	(0.0024)	(0.0014)	(0.0014)	(0.0017)
No of Enterprises	6,413	3,205	3,208	3,104	3,105
District	73	65	69	70	66
Case-III: Rural Human Capital					
HR	-0.0002	-0.0003	0.0001	-0.0011	0.0005
	(0.0010)	(0.0012)	(0.0013)	(0.0012)	(0.0016)
PNE	0.0030	-0.0025	0.0053*	0.0014	0.0060*
	(0.0028)	(0.0019)	(0.0054)	(0.0027)	(0.0035)
No of Enterprises	6,413	3,205	3,208	3,104	3,105
District	73	65	69	70	66

Note: The main variable of interest is the Total Production Output in PKR, which serves as the dependent variable in the analysis. Several control variables are considered at the enterprise level, including capital, workforce, material inputs, state-ownership, foreign-ownership, presence of importing enterprise, and EG Index. Additionally, district-level factors such as population (in Case-I) and urban residents (in Cases-II and III) are taken into account, along with Kilometer-Vehicle Ratio in all regression models. Dummy variables are introduced to handle missing data related to capital and Kilometer-Vehicle Ratio, except in (5) and (6). The analysis also incorporates industry and province indicator variables. The Ordinary Least Squares (OLS) estimation technique is applied, with standard errors clustered at the district level. ***p<0.01; **p<0.05; *p<0.1.

In the previous regression analyses, the impact of larger and more capital-intensive companies on the findings should have been considered. These companies might react differently to the available human capital stock at the district level. To test this hypothesis, the data was divided into two categories: small and big enterprises. The criteria for categorization were based on the median number of workers per enterprise in the industry. The results of this additional analysis are presented in columns (2) and (3) of Table 3. The production output of small and big manufacturing companies at the district level demonstrates a positive relationship with healthcare human capital in urban areas.

In contrast, the production output of small companies at the district level positively correlates with the education of human capital in rural regions of a district. This implies that substantial public investments in urban health capital could benefit large manufacturing enterprises. In contrast, investments in rural education capital could support small manufacturing businesses. In all other situations, the observed connections are not statistically meaningful.

We further investigated the relationship between human capital at the district level and the productivity of manufacturing enterprises, considering their capital intensity. We split our sample into high and low-capital-intensive groups using the median capital intensity value. The regression results in columns (4) and (5) indicate no significant correlation between district-level human capital and productivity for enterprises with low capital intensity. However, a positive relationship was found between education investment at the district level and productivity in high-capital-intensive enterprises. When we further analyzed urban and rural areas, we discovered that health capital investment in urban areas and education capital investment in rural areas significantly influenced productivity in low-capital-intensive manufacturing enterprises at the district level. Intriguingly, there was a negative correlation between urban primary net enrolment and output in low-capital-intensive enterprises, highlighting the complexity of factors at play. These findings stress the importance of considering enterprise size, capital intensity, and regional differences when assessing the impact of human capital on manufacturing productivity. Tailored policies and investments are crucial to maximize the benefits of human capital for diverse enterprises in different district regions.

Robustness/Sensitivity Tests and Further Extensions

We conducted a series of tests and further investigations to ensure the reliability of our research findings (see Table 4). Initially, we discovered that manufacturing enterprises in Balochistan showed higher productivity than those in other parts of the country. To validate this unusual outcome, we conducted an analysis excluding Balochistan-based enterprises, and our results remained consistent, confirming the robustness of our findings (column 1).

We altered our approach in column 2 to address potential biases in our human capital proxies. Instead of relying solely on the initial brokers, we incorporated alternative indicators for

healthcare and education: the proportion of women who got tetanus toxoid injections during their most recent pregnancy for healthcare capital and the adult literacy rate for education capital. While the coefficient on health capital slightly decreased, it remained statistically significant at the 10% level, reinforcing the credibility of our findings. When we excluded missing observations in column 3, our findings showed negligible variations, ensuring the stability of our results.

In regression (4), we examined the influence of district-level human capital on enterprise-level productivity by incorporating the district's human development index (HDI). The strong correlation between HDI and manufacturing industries' output confirmed our initial findings. Our variables of interest retained their significance, reaffirming the robustness of our model. Considering the challenges associated with industrial concentration, traffic jams, and elevated transportation expenses, we explored the non-linearity of the EI by including EI-square in the analysis (column 5) to account for diminishing returns to scale, showing a positive impact up to a specific point. However, beyond this threshold, diminishing returns began to outweigh the benefits. While the coefficients of EI and EI-square were insignificant, our main estimates of interest remained robust, aligning with the findings of previous studies.

In column 6, we analyzed the impact of district-level human capital on productivity while accounting for proximity to export markets, particularly Karachi. The negative coefficient for the distance factor emphasized the importance of proximity to local and international markets. Despite variations in some coefficients, our variables of interest maintained their original signs, indicating the stability of our results. Our rigorous tests and additional explorations consistently support our initial findings. These analyses enhance the validity of our conclusions and provide a solid basis for the implications drawn from this study.

Table 4 Robustness/Sensitivity Checks and Further Extensions

	Analysis without enterprises from Balochistan	Substitute Metrics for Human Capital	Analysis limited to available Observation	Account for Human Development	Analysis with EI-Square	Districts-to-Karachi Distance
	(1)	(2)	(3)	(4)	(5)	(6)
Case-I: Urban Human Capital						
HR	0.0041**	0.0037*	0.0043**	0.0037**	0.0041*	0.0028
	(0.0017)	(0.0021)	(0.0021)	(0.0017)	(0.0021)	(0.0018)
PNE	-0.0010	-0.0003	-0.0023	-0.0004	-0.0012	-0.0003
	(0.0013)	(0.0023)	(0.0021)	(0.0014)	(0.0019)	(0.0017)
Observations	6201	6413	6059	6413	6413	6413
District	70	73	69	73	73	73
Case-II: Rural Human Capital						
HR	0.0008	0.0016	-0.0004	0.0009	-0.0002	0.0007
	(0.0014)	(0.0020)	(0.0011)	(0.0014)	(0.0010)	(0.0009)
PNE	0.0012	-0.0027	0.0032	0.0017	0.0031	-0.062**
	(0.0025)	(0.0022)	(0.0029)	(0.0026)	(0.0028)	(0.0030)
No of Enterprises	6201	6413	6059	6413	6413	6413
District	70	73	69	73	73	73

Note: The main variable of interest is the Total Production Output in PKR, which serves as the dependent variable in the analysis. Several control variables are considered at the enterprise level, including capital, workforce, material inputs, state-ownership, foreign-

ownership, presence of importing enterprise, and EG Index. Additionally, district-level factors such as urban residents, Kilometre-Vehicle Ratio in all regression models. Dummy variables are introduced to handle missing data related to capital and Kilometre-Vehicle Ratio, except in (4). The analysis also incorporates industry and province indicator variables. In regression analysis (2), human capital indicators are substituted with TT Injection for health capital and the adult literacy rate of the population for education capital. The Ordinary Least Squares (OLS) estimation technique is applied, with standard errors clustered at the district level. ***p<0.01; **p<0.05; *p<0.1.

Conclusion and Recommendations

This study has delved into the intricate connection between human capital investment and enterprise productivity in Pakistan, concentrating specifically on the country's manufacturing sector. By addressing critical gaps in existing literature, the research has offered a comprehensive, disaggregated analysis at both the enterprise and district levels, illuminating the challenges and opportunities within Pakistan's manufacturing industries. The findings of this study reveal a subtle positive correlation between district-level human capital indicators and the productivity of manufacturing enterprises. Although this correlation lacks statistical significance, detailed analyses at more granular levels uncover nuanced insights. Notably, improvements in healthcare indicators in urban areas within districts exhibit a significant and favorable impact on the productivity of large-scale manufacturing enterprises. Conversely, the influence of healthcare infrastructure in rural regions on overall productivity, particularly in the short term, remains to be seen.

Moreover, the study has explored variations based on enterprise size and capital intensity, suggesting that substantial public investments in urban health capital could benefit large manufacturing enterprises. In contrast, investments in rural education capital could support small manufacturing businesses. These findings underscore the importance of considering enterprise size, capital intensity, and regional differences in assessing the impact of human capital on manufacturing productivity.

Recommendations stemming from the study's outcomes include the need for tailored policies to address the unique needs of diverse enterprises and regions. Policymakers are advised to differentiate interventions based on enterprise size, capital intensity, and the urban-rural divide to maximize the benefits of human capital for various manufacturing entities. Specific recommendations include increasing investments in healthcare infrastructure in urban areas and focusing on education capital in rural regions to support small manufacturing businesses. The study advocates for acknowledging the differential effects of human capital investments on enterprises based on size and capital intensity. Policies are encouraged to consider the specific characteristics of different enterprises to foster productivity and growth. Additionally, establishing a system for continuous monitoring and evaluation of human capital indicators is recommended, providing policymakers with real-time insights for agile adjustments to policies and interventions.

Finally, the study suggests encouraging further research to explore additional factors influencing the relationship between human capital and manufacturing enterprise productivity. Variables such as technological advancements, innovation, and external market dynamics should be considered to deepen the understanding of these complex relationships. In summary, the study's findings and recommendations offer a valuable foundation for informed decision-making, providing insights that can contribute to the development and sustainability of Pakistan's manufacturing sector through strategic investments in healthcare and education.

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