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Rising Population and Economic Growth: The Role of Human Capital Development

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Abstract: This study investigates the mediating role of human capital development in the relationship between rising population and economic growth in South Africa. Understanding this nexus is vital for policy formulation aimed at harnessing population growth as a driver of sustainable development. The research builds on demographic-economic transition theories and human capital-led growth literature. It extends the discourse by integrating the interaction between population dynamics and capital accumulation in the South African context. Using annual data from 1960 to 2023, the study employs the AutoRegressive Distributed Lag (ARDL) technique to analyse both short- and long-run relationships among variables. The findings reveal that physical capital formation significantly boosts economic growth in the short run. Population growth contributes positively to economic performance only when matched with human capital development. However, unchecked population growth without adequate investment in human capital negatively impacts growth. Inflation poses a consistent threat to growth, while trade openness exhibits both growth-enhancing and distortionary effects through labour market disruptions. The study offers valuable insights for policymakers, particularly in designing strategies for balanced capital investment, inflation control, and education reform to align with global market needs. The study uniquely demonstrates the conditional effect of population on growth via human capital, highlighting the importance of coordinated macroeconomic and educational policies in a developing economy.

Keywords: physical capital; trade openness; inflation; labour mismatch; education reform

JEL Classification: E52, E62, E63, P24.

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1. Introduction

The relationship between population growth and economic growth has been a long-time debate among economists. This debate could be traced back to Malthus (1803) who posited that "*population growth would lower the standard of living of the people*" in the long run. Malthus based his argument on a fixed supply of land and that growth in the human population will eventually reduce the number of available resources, leading to starvation. Harrod (1939) also supported this view, however, in the late '60s and early '80s, some economists such as Kuznets (1967) and Simon (1981) could not establish a significant relationship between per-capita income and population growth meanwhile Meier (1984) noted that the effect or impact of population growth on economic growth can be either negative or positive depending on the existence of certain factors and conditions, which, when studied and understood, can be managed or controlled to ensure continuous and sustainable economic growth and development. This notion is supported by Marsiglio and La Torre (2012) who asserted that population growth affects technical progress by providing a higher number of professionals.

In the developing countries context, it is of the view that high birth rates and rapid population growth rates would divert scarce capital away from savings and investments, thereby causing a development drag (Coale & Hoover, 1958). It was argued further that parents would have to spend more on children's education and healthcare rather than on savings and investments. For instance, Tartiyus et al. (2015) noted that as the global fertility rates continue to outweigh the mortality rate, the world's natural resources are being placed under a huge strain which in turn gives rise to negative consequences through the different aspects of human lives that are being hampered, especially in developing nations. Empirically, recent studies revealed that no consensus has been reached on the matter of the relationship between population growth and economic growth. For instance, studies such as Stungwa and Daw (2021), Akinola (2021), and Befikadu and Tafa (2022) found that population increase significantly contributes to GDP growth while Omolola et al. (2023) claim another way round. All things being equal, it should be noted that an increasing population would bring about an increase in the potential labour force (EAPD, 2023), however, the productivity and efficiency of such an army in the economy are a function of the quality of the labour force, determined by education, healthcare, and skill development (Isham et al., 2021). This implies that when the population is growing, but with investments in education, vocational training, and healthcare, the burden on the increasing population can be balanced with a skilled workforce, and increased productivity helps economic growth (Sairmaly, 2023; Umair et al., 2024). On the other hand, if population growth is not associated with investments in human capital, the advantages of an increased number of workforces may be overshadowed due to the competition of the limited resources which could explain the contrary and mixed results prevalent in literature. In this regard,

examining the potential role human capital development could play in the relationship becomes important.

In the context of South Africa, studying the relationship between population growth, human capital development and economic growth is worthy of empirical analysis. South Africa like most developing countries has experienced high population growth rates (SSA, 2024; Statista, 2024; CCC, 2024) and has equally faced a lot of challenges in human capital development such as education quality, health, and skill development which could limit the positive impact of the population on economic performance (Etim & Daramola, 2020; Ogujiuba et al., 2024). This gives room for empirically studying the growth effect of population growth and human capital development and the interactive effect of the two in South Africa to identify the necessary policy measures for the improvement of human capital and ensure that population growth translates into sustainable economic progress in the economy.

2. Empirical Literature

In literature, the moderating role of human capital on the population has not been receiving much empirical examination, however, some of the studies relevant to the study are reviewed below. In Singapore, Suluk (2021) investigated the relationship between population and economic growth. Using data from 1970 to 2020 and employing the Granger causality test as a tool of data analysis, he found a unidirectional causality relationship running from population growth to economic growth. Also, Stungwa and Daw (2021) investigated the relationship between population growth and infrastructure development on South Africa's economic growth. The study used data from nine provinces covering 2006 to 2019 and employed a seemingly unrelated regression model technique as a tool for data analysis. They found in their study that population growth and government expenditure are significant economic growth drivers in South Africa whereas the infrastructure effect is insignificant. The study also found a significant inverse relationship between economic growth and unemployment and a unidirectional causal relationship running from population growth towards infrastructure.

Likewise, in Nigeria, Akinola (2021) examined the impact of population growth on economic growth. The study used data on GDP per capita, population growth, food production index, human development index, and fossil fuel energy consumption from 1985 to 2014 and employed error correction as a tool of data analysis. The study showed that the rise in population growth and food production has a significant positive impact on economic growth in the short and long run. However, the result showed that human development insignificantly impacts economic growth while fossil fuel energy consumption has a negative impact on economic growth in the long run. In a more recent, Grace (2022) investigated whether the rising population

is a curse or blessing to the South African economy. The study used data on GDP, population growth, fertility rate, life expectancy at birth, death rate, and exports from 1990 to 2019. Estimating a VECM, the study showed that population growth rate stimulates economic growth thus concluding it to be a blessing. Also, fertility rate and exports have a significant long-run impact on GDP while none of the variables has a significant short-run impact. In Ethiopia, Befikadu and Tafa (2022) analysed the effect of the risen population on economic growth from 1980 to 2020. The study employed an ARDL regression model as a tool of data analysis and found that an increase in population significantly contributes to Ethiopian economic growth in the short and long run. Using the case of China, India, the United States of America and Nigeria Omolola et al. (2023) analysed the effect of population growth on economic growth in the world's populous countries. The study estimated ARDL regression models and the result showed that population growth significantly caused degrowth in all the economies in the short and long run. In a country like Nigeria, the working-age population and trade openness are found to have a significant positive impact on economic growth in the short and long run.

On the human capital-growth relationship, using a panel of 269 municipalities, Ngepah et al. (2021) examined the relationship between human capital and economic growth in South Africa, covering 1993 to 2016. Employing a GMM-based panel dynamic regression model, the result from the aggregate analysis showed that human capital significantly raised GDP and GDP growth. In the disaggregated analysis, the study revealed that higher levels of skilled employment of human capital have a significant positive impact on GDP and economic growth. Furthermore, the result from the panel causality showed that there is a bidirectional causal relationship between human capital and GDP, and between GDP and total employment. Also, Djamal et al. (2023) examined the human capital effect on South African economic growth from 2000 to 2021. The study used data on per capita GDP, gross fixed capital per GDP, government educational spending as a proxy for human capital, and labour force participation rate. Employing the ARDL model regression technique, the study found that physical and human capital has insignificant short and long-run impacts on GDP per capita growth while the labour force has only a short-run significant impact on GDP per capita growth.

Similarly, Hlapi et al. (2023) examined some factors driving economic growth in South Africa using data covering 1990 to 2021. Data on real GDP, human capital, capital, labour, technological progress, and power supply were utilized in estimating an ARDL regression model and the result showed that human capital has a negative insignificant impact on economic GDP growth in the long run. Except for the power supply, other variables including physical capital were shown to be significant economic growth drivers in the long run except for power supply which has a negative effect. Also in South Africa, Dhobha and Madondo (2024) examined the role of human capital on economic growth from 2000 to 2023. In the study, data on

GDP and FDI were employed and human capital was proxy with government expenditure on health and education and secondary school enrolment rate. Employing the cointegration technique, they conclude in their study that government expenditure on health has a significant positive effect on South Africa's economic growth while the secondary school enrolment rate has a significant negative effect in the long run. However, the other variables' impacts were found insignificant in the long run.

3. Methodology and Data

3.1. Model Specification

The model for this study is considered as a modification of the model of Umar et al. (2020). In their study, real GDP is expressed as a function of population, poverty, unemployment, and foreign direct investment. Their model is shown in equation 3.1 below:

$$GDP_t = f(Pop_t, Pov_t, Unem_t, FDI_t) \quad (3.1)$$

In this study, however, poverty, unemployment, and foreign direct investment are replaced with capital, trade openness, consumer price index, and human capital. This is expressed as Equation 3.2 below:

$$Y_t = f(K_t, N_t, HC_t, CPI_t, Open_t) \quad (3.2)$$

Where *Y* is the real GDP, K is the capital, *N* is the population, *HC* is the human capital, *CPI* is the consumer price index, and *Open* is the trade openness. The consumer price index is included as a control variable to capture the inflationary pressure in the economy which could distort the relationship between population, human capital, and economic growth. Also, trade openness is included to capture the external shock effect on the endogenous variables in the model.

In parameterising the model, four different ARDL models are formulated for robust analysis. The first model is a baseline endogenous growth model equation and the control variables are sequentially added in the other models. The generalized unrestricted form ARDL models are given below:

Model 1:

$$\Delta\ln(Y_t) = \phi_0 + \sum_{i=1}^{p} \phi_{1i}\,\Delta\ln(Y_{t-i}) + \sum_{i=0}^{q} \phi_{2i}\,\Delta\ln(K_{t-i}) + \sum_{i=0}^{q} \phi_{3i}\,\Delta\ln(N_{t-i}) + \sum_{i=0}^{q} \phi_{4i}\,\Delta HC_{t-i} + \eta_1\ln(K_{t-1}) + \eta_2\ln(N_{t-1}) + \eta_3 HC_{t-1} + v_t \quad (3.3)$$

Model 2:

$$\Delta\ln(Y_t) = \phi_0 + \sum_{i=1}^{p} \phi_{1i}\,\Delta\ln(Y_{t-i}) + \sum_{i=0}^{q} \phi_{2i}\,\Delta\ln(K_{t-i}) + \sum_{i=0}^{q} \phi_{3i}\,\Delta\ln(N_{t-i}) + \sum_{i=0}^{q} \phi_{4i}\,\Delta HC_{t-i} + \sum_{i=0}^{q} \phi_{5i}\,\Delta(HC_t * \ln(N_t))_{t-i} + \eta_1\ln(K_{t-1}) + \eta_2\ln(N_{t-1}) + \eta_3 HC_{t-1} + \eta_4(HC_t * \ln(N_t))_{t-1} + v_t \quad (3.4)$$

Model 3:

$$\Delta\ln(Y_t) = \phi_0 + \sum_{i=1}^{p} \phi_{1i}\,\Delta\ln(Y_{t-i}) + \sum_{i=0}^{q} \phi_{2i}\,\Delta\ln(K_{t-i}) + \sum_{i=0}^{q} \phi_{3i}\,\Delta\ln(N_{t-i}) + \sum_{i=0}^{q} \phi_{4i}\,\Delta HC_{t-i} + \sum_{i=0}^{q} \phi_{5i}\,\Delta(HC_t * \ln(N_t))_{t-i} + \sum_{i=0}^{q} \phi_{6i}\,\Delta\mathrm{n}(CPI_{t-i}) + \eta_1\ln(K_{t-1}) + \eta_2\ln(N_{t-1}) + \eta_3 HC_{t-1} + \eta_4(HC_t * \ln(N_t))_{t-1} + \eta_5\ln(CPI_{t-1}) + v_t \quad (3.5)$$

Model 4:

$$\begin{aligned}
&\Delta\ln(Y_t) \\
&= \phi_0 + \sum_{i=1}^{p} \phi_{1i}\,\Delta\ln(Y_{t-i}) + \sum_{i=0}^{q} \phi_{2i}\,\Delta\ln(K_{t-i}) + \sum_{i=0}^{q} \phi_{3i}\,\Delta\ln(N_{t-i}) \\
&+ \sum_{i=0}^{q} \phi_{4i}\,\Delta HC_{t-i} + \sum_{i=0}^{q} \phi_{5i}\,\Delta(HC_t * \ln(N_t))_{t-i} + \sum_{i=0}^{q} \phi_{6i}\,\Delta\mathrm{n}(CPI_{t-i}) \\
&+ \sum_{i=0}^{q} \phi_{7i}\,\Delta Open_{t-i} + \eta_1\ln(K_{t-1}) + \eta_2\ln(N_{t-1}) + \eta_3 HC_{t-1} \\
&+ \eta_4(HC_t * \ln(N_t))_{t-1} + \eta_5\ln(CPI_{t-1}) + \eta_6 Open_{t-1} \\
&+ v_t
\end{aligned} \tag{3.6}$$

In the equations, the terms with the summation signs represent the short-run dynamics with their respective short-run coefficients ϕ. The coefficients η are the long-run coefficients corresponding to the long-run impact. The variable v_t is the white noise error term, Δ is the first difference operator and p and q are the lag length for the conditional ARDL model. To test the existence of a long-run relationship for the above model, an F-test for a joint significance of the coefficient of the lagged levels is conducted by using ordinary least squares (OLS). This simply shows the mechanics behind the Bound test. Thus, using an F-test, the null hypothesis of no cointegration implies that η1 = η2 = η3 = … = ηi = 0 against the alternative hypothesis of the existence of cointegration.

3.2. Data

This study covers the periods of 1960-2023 and the data used are sourced from the World Bank Development Indicator (WDI) online database and the Penn World Table version 10.1. The variables that are sourced from the WDI are real GDP, population, gross fixed capital formation, degree of trade openness, and consumer price index, while the human capital index is sourced from the Penn World Table. The real GDP and the gross fixed capital formation are measured in billion-dollar units, and the population is measured in millions. Trade openness is derived from the ratio of trade to real GDP. The human capital index captures the education and health factors. The data on the human capital index is available from 1950 until 2019 and the data from the remaining years are supplied through ARIMA forecast to preserve the structure of the data.

3.3. Method of Analysis

Before any econometric analysis is carried out, a pre-estimation test of unit root needs to be carried out to avoid spurious results which is pertinent to time series data. The first step is to conduct a unit root test to know if the variables are stationary or integrated. There are different types of tests to achieve this, however, the Augmented Dickey-Fuller (1979) is adopted in this study. After the unit root test follows the cointegration test to test for a possible long-run relationship between the dependent and the independent variables. In literature, there are many versions of the single-equation cointegration tests such as the Engle-Granger (1987) and the Phillip-Oulairis (1990). However, these tests are conducted on a two-stage basis and are liable to be biased. Moreover, they are suitable for a bivariate study or perhaps when the independent variables are strictly exogenous. Other problems such as serial correlation and heteroscedasticity render these approaches powerless. The ARDL model addresses all these issues by using lags that are optimally selected and hence is adopted in this study. Apart from its usability in testing for cointegration (Pesaran et al., 2001), it can estimate both the short and long-run parameters simultaneously. Also, unlike Engle-Granger (1987) and Phillip-Oulairis (1990), the ARDL model can accommodate the mix of stationary and first-order integrated regressors. Moreover, it can also be used in modelling stationary variables.

4. Data Analysis and Discussion

Table 1. Descriptive statistics of variables in South Africa

Variable	Live statistics				
	Mean	S.D.	C.V.	Max	Min
Real GDP ($ Billion)	207.9	91.78	0.441	363.3	65.65
Capital ($ Billion)	29.69	23.76	0.800	81.60	1.529
Population (Million)	39.50	14.17	0.359	63.21	16.44
Human Capital Index	2.132	0.402	0.189	3.118	1.739
Consumer Price Index	52.45	56.28	1.073	194.8	1.772
Trade Openness	47.83	7.325	0.153	65.97	34.32

Source: Author's computation

The descriptive statistics of the variables are presented in Table 1 to give an insight into the state of economic and demography of South Africa. From the statistics, it can be deduced that the real GDP, with an average of $207.9 billion and a high standard deviation of 91.78, shows that there are fluctuations in the levels of economic performance over time. The same applies to capital investment which has a mean of $29.69 billion and C.V. of 0.800, meaning that there is a lot of variation in investment across the country. The population figures are relatively stable with the average population of 39.50 million and the lower C.V of 0.359, which shows that the population of the region is growing at a steady rate. As for human capital,

the HCI is relatively constant with an average of 2.132 and a low C.V of 0.189 indicating slow but progressive enhancement of human capital. CPI also has the highest coefficient of variation of 1.073 and an average of 52.45, which shows that the index of inflation and price level has a lot of variation. However, trade openness is the most stable variable with an average of 47.83 and a C.V of 0.153 indicating that countries have been relatively stable in their participation in international trade.

Table 2. Unit root test result

Variable	ADF		Phillips-Perron		Remark
	Level	Diff.	Level	Diff.	
$\ln(Y_t)$	-2.667	-5.773***	-4.972	-5.785***	$I(1)$
$\ln(K_t)$	-2.274	-5.314***	-4.990	-5.286***	$I(1)$
$\ln(N_t)$	-2.100	-3.887**	-0.970	-3.943**	$I(1)$
HC_t	-0.188	-3.236**	-0.092	-3.171**	$I(1)$
$\ln(CPI_t)$	-3.564**	-3.186**	-2.103	-3.006**	$I(1)$
$Open_t$	-2.527	-7.570***	-8.343	-8.799***	$I(1)$

*Note: *** p < 1%, ** p < 5%, * p < 10%*

Source: Author's computation

Table 2 shows the Augmented Dickey-Fuller and the Phillips-Perron unit root test results for the variables. Some of the variables are log-transformed to reduce the variation in them and also aid the interpretation of their coefficients as elasticities. It can be observed from the unit test results that all the variables are first-order integrated variables. The cointegration test is thus applied to avoid spuriosity. Table 3 depicts the bound test results for the models employed. Akaike information criteria are employed in the optimal lag selection for each model (ARDL (1,1,1,0); ARDL (1,1,0,0,0); ARDL (1,1,0,0,0,0); ARDL (1,1,1,1,1,1,1)). It can be observed from the result that all the computed f-statistics are significant at the conventional level; the first and the last models have f-stat significance at 5% level while the second and the third models have F-statistics significant at 1% level. It can be inferred that there is a long-run relationship between the dependent variable and the regressors in the models.

Table 3. ARDL bound test result

No	F-stat	Critical values					
		10%		5%		1%	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
1	4.676**	2.492	3.350	2.976	3.896	4.056	5.158
2	17.36***	2.335	3.252	2.750	3.755	3.725	4.940
3	16.37***	2.209	3.201	2.596	3.677	3.430	4.721
4	3.584**	2.120	3.145	2.473	3.583	3.225	4.571

*Note: *** p < 1%, ** p < 5%, * p < 10%*

Source: Author's computation

Table 4 depicts the ARDL regression model estimates for the population and economic growth relationship in South Africa. Contrary to the study of Djamal et al. (2023), it can be observed from the result that there is a consistency among the models that physical capital formation significantly contributes to South Africa's economic growth, particularly in the short run. The result shows that a percent rise in the capital may bring about between 0.06%-0.08% increase in GDP growth in the short run. However, the long-run evidence is weak; only the baseline model estimates show that a percent rise in capital formation brings about a 0.179% increase in GDP growth in the long run.

Table 4. Regressions estimates of population and growth models in South Africa

IV	DV: $\Delta \ln(Y_t)$			
	Model 1	Model 2	Model 3	Model 4
$\ln(K_t)$	0.179*	0.029	0.007	0.007
	(0.102)	(0.057)	(0.030)	(0.042)
$\ln(N_t)$	-0.120	4.958***	5.552***	4.611***
	(0.514)	(1.305)	(0.705)	(1.090)
HC_t	0.352**	47.09***	46.00***	32.47***
	(0.141)	(13.38)	(6.400)	(11.27)
$HC_t * \ln(N_t)$		-2.595***	-2.531***	-1.776***
		(0.742)	(0.355)	(0.625)
$\ln(CPI_t)$			-0.156***	-0.144**
			(0.044)	(0.066)
$Open_t$				0.008**
				(0.003)
Constant	23.62***	-64.70***	-74.17***	-57.43***
	(8.181)	(22.52)	(12.04)	(18.83)
$\Delta \ln(K_t)$	0.082***	0.074***	0.060***	0.061***
	(0.018)	(0.0016)	(0.016)	(0.012)
$\Delta \ln(N_t)$	-1.114***	0.956***	2.143***	9.358***
	(0.415)	(0.248)	(0.622)	(1.085)
ΔHC_t	0.028	9.078***	17.76***	65.42***
	(0.019)	(2.401)	(4.797)	(8.675)
$\Delta(HC_t * \ln(N_t))$		-0.500***	-0.977***	-3.706***
		(0.133)	(0.264)	(0.494)
$\Delta \ln(CPI_t)$			-0.060**	-0.457***
			(0.029)	(0.059)
$\Delta Open_t$				0.004***
				(0.000)
Ect_{t-1}	-0.080***	-0.193***	-0.386***	-0.258***
	(0.0016)	(0.018)	(0.034)	(0.045)
Adj. R^2	0.480	0.544	0.577	0.764
LM Test	0.061	0.000	2.025	6.742
White Test	7.990	6.142	7.620	19.70

*Note: *** p < 1%, ** p < 5%, * p < 10%*

Source: Author's computation.

The population parameter shows a mixed result. In line with the result of Omolola et al. (2023), the baseline model shows that an increase in population is detrimental to economic growth with a reduction value of about 1.11% in the short run and with insignificant reduction of about 0.12% in the long run. However, after controlling for some factors, there is consistency in the results of the other models, supporting the findings of Stungwa and Daw (2021) and Grace (2022). For instance, the result of models 2-4 shows that population is a blessing rather than a curse to economic progress. In model 2-3, before the inclusion of openness, it can be observed that a rise in population by a percent could yield between 0.96%-2.14% increase in GDP growth in the short run and between 4.96%-5.55% increase in the long run respectively. However, with the inclusion of openness, it is observed that the positive short-run impact of population on economic performance is more than in the long run; the impact reduces over time. Looking at the Model 4 estimates, the short-run impact of an increase in population on GDP growth is about 9.36% and reduced to 4.61% in the long run. The explanation for this divergence could be a reflection that in the short run, an increase in population creates a more immediate rise in aggregate demand; domestic consumption and production, while openness facilitates access to foreign markets, amplifying economic activity and GDP growth. However, sustaining these gains in the long run would require strategic investments in infrastructure, human capital, and economic diversification to mitigate diminishing returns and external vulnerabilities pertinent to trade openness. Another justifiable reason for such a countercyclical result is that in the short run, population growth and trade openness may boost labour-intensive sectors like agriculture or manufacturing; however, over time, structural shifts toward capital- or knowledge-intensive industries may lower the direct correlation between population growth and GDP growth.

Regarding human capital, there is evidence from the result that human capital development has a significant positive impact on economic progress in line with the study of Ngepah et al. (2021) but contrary to Hlapi et al. (2023). The Model 1 estimates have a lower coefficient for human capital than the others; insignificant short-run estimates of 0.028 and significant long-run coefficient value of 0.352. From models 2 and 3, an increase in human capital from the previous level could result in GDP growth of about 9.08%-17.8% in the short run and 46%-47.1% in the long run. Careful observation would show that a similar phenomenon noted in the population estimates with the inclusion of trade openness is also observed in the case of human capital; the impact of human capital is reduced by almost half in the long run. Specifically, model 4 reveals that an increase in the human capital level results in GDP growth of about 64.4% in the short run and 32.5% in the long run. This result could be an indication of the initial increase in productivity that human capital

investments bring in the short run. An increase in education, skills, and training will contemporaneously raise labour productivity and thus many economic returns and GDP growth. However, the marginal utility of human capital would decline over time, especially if other complementary factors like physical capital or technology are not increasing correspondingly. Furthermore, this may point to the role played by trade openness through which the short-run advantages of human capital are boosted by the integration of skilled labour into international markets. In the long run, though, the economy may shift to sectors where the marginal returns to human capital accumulation reduce the effects on GDP growth. The result could also be due to a skills-technology mismatch that occurs over time. Whereas human capital complements economic demand in the short run, technological advancement and changing patterns of trade may cause a divergence between workforce skills and demand for it, reducing the impact of human capital on economic growth in the long run.

The interaction between human capital and population is shown to have a negative impact on GDP growth in the short and long run. The result shows that the coefficient of the interaction is approximately between -0.5 and -3.71 in the short run and between -1.78 and -2.6 in the long run respectively. This result may be attributed to the resource scarcity and capacity challenges that are associated with population increase and human capital in an economy. For instance, in the short run, the negative coefficient which ranges from -0.5 to -3.71 may suggest that rapid population growth reduces the impact of human capital as resources, infrastructure and public utilities are overstretched. This strain diminishes the general output and productivity of the workforce and thus slows down the GDP. In the long run, the more negative effect (coefficients ranging from -1.78 to -2.6) may indicate the failure of the country to invest in human capital development to correspond with population increase. It also becomes a challenge to be able to educate, train and offer health care to all the people in the population resulting in a less productive population. This divergence between population size and the ability to improve the quality of human capital restrains economic growth in the long run. The result could also reveal the cost/benefit of managing the population growth to the need to invest in human capital. As a result, governments and policymakers may focus more on the current requirements like shelter and necessities over the future requirements of education and human capital. This shift has a dampening effect on the GDP in the short run as well as in the long run.

The models' estimates consistently show that an increase in the general price level has a significant negative effect on economic growth. For instance, in model 3, a percent rise in the consumer price index is shown to result in a decline in GDP growth of about 0.06% in the short run and 0.56% in the long run. However, in the model with trade openness, the effect of inflation (price increase) declines in the long run; a percent rise in price level reduces GDP growth by 0.46% in the short run indicating

that inflation initially disrupts economic activity by eroding purchasing power, increasing production costs, and creating uncertainty for investors, and reduces GDP growth by 0.14% in the long run, suggesting the economy adjustment to inflationary pressures over time. The inclusion of trade openness likely plays a role in this declining long impact because trade openness facilitates access to global markets and more competitive pricing, which helps offset the adverse effects of inflation by providing cheaper imports, diversifying supply chains, and stabilizing domestic price levels. Over time, these mechanisms reduce the long-term drag of inflation on GDP growth. Trade openness itself is shown to significantly impact GDP growth in the short and long run; an increase in trade openness increases GDP growth by 0.4% in the short run, suggesting that greater global market integration enhances South Africa's economic performance by facilitating access to international markets, resources, technology, and the inflow of foreign investment. Likewise, in the long run, the impact of trade openness on GDP growth rises to 0.8% suggesting that, over time, South Africa's economy becomes better positioned to take advantage of global supply chains, creating opportunities for more specialized production, improved labour markets, and stronger economic linkages with other countries.

Lastly, all the models show that there is an adjustment tendency for the economy towards equilibrium but at a different speed if the economy is hit by a one-time shock. Given all the variables in the model, the speed of adjustment for the first model suggests that it would take about 12.5 years (i.e., 1/0.08) for the economy to recover from such a shock. Meanwhile, the other model with a larger error correction term predicts that it would take about 2.6 years (i.e., 1/0.386) to 5.1 years (i.e., 1/0.193) for the economy to recover if a one-time shock hit the economy, given all the variables in the model. The post-estimation diagnostics tests (Breusch-Godfrey LM test and White's general heteroscedasticity test) results portion of Table 4 showed that none of the tests are significant, hence, the models are free of autocorrelation and heteroscedasticity.

5. Conclusions and Recommendations

This study examined the impact of population on economic growth, which has been a subject of debate for decades, and the role played by human capital in the relationship. Using the South African macroeconomic indicator data, and after meticulous empirical analyses have been carried out, several conclusions can be arrived at. First, physical capital formation is a significant short-run growth determinant for the South African economy. The rising population is considered a virtue and a significant economic growth driver of the South African economy and human capital is an essential pillar in the South African economic growth dynamic in the short and long run. However, it was noted that a rising population without a corresponding human capital development effort would jeopardise the economy in

the short and long run. Furthermore, it can be concluded that immediate and persistent rise in the general price significantly degrowth the South African economy's aggregate output. Trade openness has a significant direct and indirect positive and negative effect on the South African economy. The direct effect of trade openness positively and significantly aids South African economic growth in the immediate and over time. Indirectly, on the negative side, trade openness significantly accounts for labour shift and skill-tech mismatch; however, on the positive side, trade openness encourages global supply chains and domestic price stabilization in the South African economy. This study thus recommends that the South African government should prioritize balanced and sustainable investments in both physical and human capital to ensure that population growth translates into productive economic growth. Additionally, the government should aim for controlled inflation and address the negative impacts of rising general prices, which have been found to significantly depress economic growth. To mitigate the negative indirect effects of trade openness, the South African government must focus on enhancing technological innovation and skills development to match the evolving demands of the global market.

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