

Natural Resource Rents and Human Capital Accumulation in Brunei Darussalam: A Tale of Resource Blessing?

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Abstract: This paper examines the short- and long-run effects of natural resource rents, including oil and gas rents, on human capital accumulation in Brunei Darussalam, using the autoregressive distributed lag (ARDL) bound test, augmented-ARDL cointegration tests, and the Gregory-Hansen structural break testing approach for nondegenerate cointegration over the pre-COVID-19 period from 1975 to 2019. The evidence shows that resource rents (both aggregate and disaggregate oil and gas rents) crowd in human capital accumulation in both the short and long run, consistent with a ‘resource blessing’ view. The findings also reveal that past physical capital accumulation has a complementary effect on current human capital accumulation, but only in the short run. At the same time, aggregate government expenditure promotes the development of human capital only in the long run.

Keywords: Brunei Darussalam, human capital, natural resource rents, oil- and gas-dependent economy, resource blessing

JEL classification: I25, O53, Q32

1. Introduction

Education lies at the heart of the first pillar of Wawasan Brunei 2035, which aims to produce ‘educated, highly skilled and accomplished people’. This long-term vision seeks to achieve three related national outcomes: first-class education, equal educational opportunities and human resource development. As an oil and gas-abundant country, Brunei Darussalam naturally relies on these hydrocarbon resources to finance its socio-economic development, including significant investments in education and human capital development, healthcare, and welfare for its small population. Endogenous growth theories emphasise the crucial role of human capital in driving long-term economic growth. Human capital development is expected to contribute to Brunei’s long-term economic development goals, including a diversified economy, a skilled workforce and higher rates of long-term economic growth.

Various measures of Brunei’s human capital and health development show significant improvements over the years. Figure 1 shows persistent improvement in the stock of human capital as measured by the human capital index (capturing average

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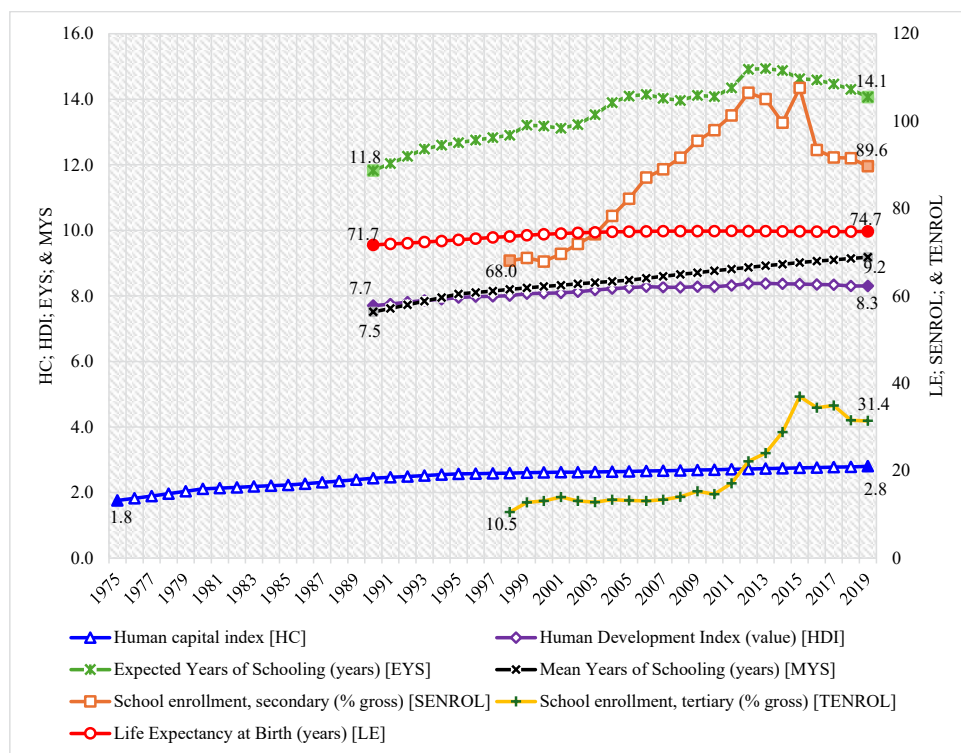


Figure 1. Measures of human capital development, Brunei Darussalam

Sources: Penn World Table version 10.0 (see Feenstra et al., 2015); UNESCO Institute for Statistics (UIS); UNDP (2020).

years of schooling and the returns to education, see Feenstra et al. (2015)), the United Nations Development Programme (UNDP, 2020) mean years of schooling, expected years of schooling, and overall human development (human development index). Other educational outcomes of human capital, such as secondary and tertiary school enrollment, also show significant improvement, peaking in 2015, declining in 2016, and remaining relatively stable thereafter. Health measure (life expectancy) also shows progress over time. Figure 2 time-plots measures of natural resource dependency, including total natural resource rents and the oil and gas rents. It depicts the trend moving from a period of high rents (approximately 50–60% of GDP) in the 1970s to a relatively lower figure, hovering around 20–30% of GDP. These fluctuations in resource rents, particularly oil rent, primarily reflect volatility in global oil prices and a declining trend in Brunei's oil production.

For a long time, development economics literature has debated whether countries endowed with abundant natural resources that rely on them for development would achieve better socioeconomic outcomes than countries with comparatively scarce natural resources. Accumulated empirical evidence supports both sides of the debate, suggesting that resource-dependent countries may experience poorer socioeconomic

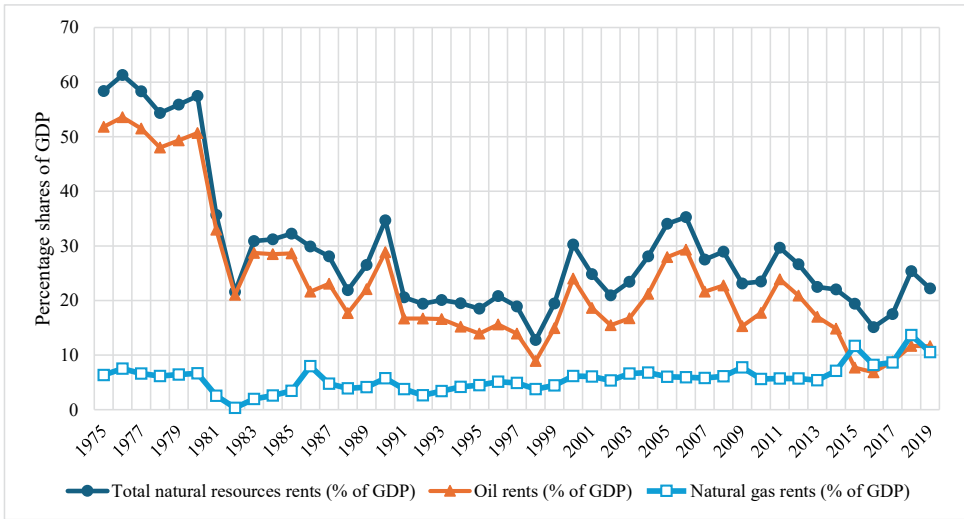


Figure 2. Measures of natural resource dependency, Brunei Darussalam
 Source: World Bank's World Development Indicators.

and developmental outcomes (the well-known ‘resource curse’ view). At the same time, others also found evidence to the contrary (the ‘resource blessing’ view) (Badeeb et al., 2017).

One specific line of this literature examines the effects of natural resources on human capital accumulation (Mousavi & Clark, 2021). In theory, resource rents can have either a net negative or a net positive impact on human capital accumulation, reflecting ‘resource curse’ versus ‘resource blessing’ views. This is a result of the counteracting interplays of the resource windfall induced increase in the fiscal resources for government expenditure on education and health; distorting domestic wage signals in the resource sector causing a contraction in the supply of skilled workers in the non-resource sector; the forming of ‘myopic sloth’ by individuals (students and parents) and the government; brain drain; and because of oil prices volatilities induced volatile fiscal positions. Like the broader literature examining the socioeconomic development implications of resource dependency, the accumulated empirical evidence for this nexus records adverse effects (Araji & Mohtadi, 2018; Gylfason, 2001; Mosquera, 2022; Zhan et al., 2015), positive effects (Acuna et al., 2024; Agüero et al., 2021; Hilmawan & Clark, 2021; Le Clech et al., 2023; Stijns, 2006), nonsignificant effects (Carpenter et al., 2019), and mixed effects (James, 2017).

In the context of Brunei Darussalam, although past studies have investigated the macroeconomic performance involving oil price volatility and the transmission channels (Koh, 2011, 2017, 2019), determinants of economic growth (Anaman, 2004) including oil and gas rents (Slesman, 2025; Slesman & Baha, 2023; Tahir et al., 2023), there is no systematic time-series empirical study that examine the dynamic contributions of natural resource rents on the human capital accumulation in the short and long run. Both variables are critical components of Brunei’s long-term socioeconomic

development vision, *Wawasan Brunei 2035*. It is imperative to fill this important, policy-relevant research gap by quantifying the contributions of natural resources to human capital accumulation over time. This study contributes to the scholarship on the oil-and-gas-dependent Brunei economy and the broader literature on the debate between the resource curse and resource blessing views. Specifically, we aim to contribute to this debate by providing a first empirical examination of the nexus between natural resource dependence and human capital accumulation in Brunei Darussalam during the pre-COVID-19 period (1975–2019), using a time-series analysis framework based on a robust ARDL bound tests for cointegration (long-run relationship and short-run dynamics).

To provide an overview of our empirical insights, we found evidence consistent with the resource blessing view. Our findings reveal that oil and gas (and total resource) rents promote the accumulation of human capital in both the short and long run in Brunei Darussalam. Furthermore, our empirical findings also showed that government expenditure promotes human capital accumulation only in the long run, while physical capital investment complements it only in the short run. This study confirms that oil and gas rents have been translated into a higher stock of human capital in Brunei Darussalam, both in the short and long run.

The rest of this paper is structured as follows. Section 2 reviews relevant theoretical and empirical literature. Section 3 explains the empirical model, data and method used in the empirical analysis. This is followed by Section 4, which presents and discusses empirical findings in detail. Lastly, Section 5 concludes and discusses policy implications.

2. Literature Review on Natural Resource Rents and Human Capital Accumulation

2.1 Relevant Theoretical Review

Theoretically, natural resources influence human capital development in complex, multifaceted ways, as discussed by Mousavi and Clark (2021). The overall effects can be positive or negative, reflecting the ongoing debating positions: ‘resource curse’ versus ‘resource blessing’ hypothesis. In this brief theoretical review, we focus on channels most relevant to the Brunei context. First, the most obvious positive effect is the resource windfall, which would ease government budget constraints, increase expenditure (e.g., on education, health and development), and spur private investment in education and skills development. As endogenous growth theory suggests, a larger and increasing stock of human capital can enhance labour productivity, stimulate technological progress, and foster innovation (Birdsall et al., 2001), thereby supporting long-term economic growth.

Second, a related theoretical explanation is based on relative wage signals between the resource sector and the non-resource traded sector (e.g., the manufacturing sector). The former is assumed to require relatively lower levels of education and skills than the latter, which consequently has a higher equilibrium wage (Gylfason, 2001). Mousavi and Clark (2021) summarised the mechanism by which shifts in labour-market demand and supply curves determine the equilibrium wage in each sector. An oil boom would increase labour demand in the resource sector (raising wages there),

thereby reducing the wage premium for those still in school,¹ leading to a contraction in demand for higher education and a decrease in the future supply of skilled labour in the non-resource sector. However, such an oil boom would also lower government budget constraints, allowing it to expand public education supply (shifting the supply curve to the right), thereby decreasing the time or opportunity cost of attending school or pursuing further study (Mousavi & Clark, 2021). Conversely, a reduction in the supply of education (shifting the supply curve leftward) can occur if the government's spending priorities are elsewhere. Furthermore, due to free resource rent distribution, there may also be a behavioural response to this oil boom by students (and their parents) when they form a 'myopic temptation'² that they would be able to receive income regardless of their educational achievements; and if this is the case, it would lower the pressure on the government to supply more education, resulting in a contraction of the education supply, as Zhan et al. (2015) demonstrated for the case of resource-rich villages in China.

The net effect of resource rents on human capital accumulation is therefore uncertain, as it depends on how the government and private individuals respond. Additionally, another potential theoretical consequence of rent-distorted domestic wage signals is a brain drain in resource-dependent countries: educated individuals may choose to migrate abroad, for example, to developed countries, to seek higher returns to their education (higher wages), which can diminish the domestic human capital stock (Mousavi & Clark, 2021; Ngoma & Ismail, 2013).

Finally, significant fluctuations in global natural resource prices, such as volatile oil and gas prices, would induce volatility in export earnings, negatively affecting government fiscal health and sustainability and, hence, the accumulation of both physical and human capital. For example, volatile oil and gas prices can lead to fluctuations in public education spending, especially if fiscal policy is procyclical, as is typically observed in many oil- and gas-exporting countries with limited tax capacity. This will have negative repercussions on human capital development because, unlike physical capital investment, as Flug et al. (1998, p. 466) noted, human capital investment is irreversible (cannot be sold), cannot serve as collateral (impossible to expropriate), involves moral hazard (since individual efforts in studying are hard to observe by third parties), and yields long-term returns. These inherent characteristics, tied to human capital investment (i.e., upfront costs), reduce private incentives to fund education, a situation exacerbated by private credit constraints stemming from income volatility and underdeveloped financial institutions. Consequently, government financing of education through public spending and resource rents becomes essential to promote education and skills development.

All in all, the contrasting effects across these theoretical channels suggest that the overall net effect of resource rents on human capital is highly mixed.

¹ The increase in wages of the relatively lower-skilled jobs in the resource sector due to the resource boom also increase the opportunity cost of education (James, 2017; Mosquera, 2022), especially for those who were still in school as education must be taken at a critical age and once taken cannot be postponed (Flug et al., 1998).

² This short-sighted temptation is formed to avoid the upfront costs of higher education required to upgrade their skills to increase their future employability, especially during downturns (Mousavi & Clark, 2021; Zhan et al., 2015).

2.2 Relevant Empirical Review

Indeed, the debate over whether natural resource wealth is a ‘blessing’ or a ‘curse’ for socioeconomic development and welfare outcomes has long been ongoing, with mixed empirical evidence (Badeeb et al., 2017; Slesman, 2022, 2024). Reflecting the theoretical ambiguities regarding the net effects of resource rents on human capital accumulation, the empirical evidence has yielded highly mixed findings across both cross-sectional and within-country case studies (Mousavi & Clark, 2021).

For instance, in line with the resource curse view, a body of this literature started with an earlier cross-sectional study by Gylfason (2001), who showed negative correlations between resource dependence and three measures of human capital accumulation: public expenditure on education, expected years of schooling for females, and gross secondary school enrolment rates for a panel of 52 to 91 countries during the 1980–1997 period. A similar investigation was conducted by Araji and Mohtadi (2018), who, in their overlapping-generations model, argued that lump-sum transfers to individuals could distort incentives to invest in tertiary education. They empirically confirmed this by documenting an adverse interaction effect between resource rents and government transfers on tertiary education in a panel of 46 countries, including those in the Middle East and North Africa (MENA) countries, during 1980–2009. This adverse effect was also observed in within-country studies. For example, Zhan et al. (2015) examined a panel of 31 Chinese provinces during 1999–2009. They found that Chinese localities dependent on natural resources tend to spend less on human capital-enhancing public goods, such as education and health, due to resource abundance-induced ‘myopic sloth’ among residents and officials. In a more recent study, Mosquera (2022) utilised proprietary individual-level data from individuals born in the 1950s and 1960s who were exposed to the 1970s oil boom in Ecuador to analyse the long-term impacts of resource booms on human capital accumulation in 2014. He showed that exposure to the boom decreased college completion rates, increased low-skill employment, and had limited long-term effects on wealth accumulation.

However, James (2017) demonstrated both positive and negative effects. For a panel of US states during 1970–2008, he showed that public educational expenditure is higher in oil-rich states (8% higher) compared to oil-scarce states. However, additional public-school funding was shown to attract students away from private schools (for example, due to improved public-school quality). However, this crowding out of private educational services was found to be partial (incomplete). A similar study by Carpenter et al. (2019) on the shale oil boom in Texas found, however, that it had an insignificant effect on local communities’ secondary school enrolment rates. In Saudi Arabia, Almansour (2023) showed that oil downturns increase parents’ preferences for public schools, leading to higher public-school enrolment and lower private-school enrolment rates. This implies that an oil boom would increase private school services in Saudi Arabia (crowd in) and that public funding for schools acts as a buffer during prolonged economic downturns, supporting human capital accumulation in Saudi Arabia.

The contrary evidence presented by Almansour (2023) against the ‘curse’ view – that countries rich in natural resources lack the foresight to optimise investment in human capital – has also been reported by other studies documenting positive effects. For example, an earlier study by Stijns (2006) found that resource rents were positively

correlated with various measures of human capital accumulation across countries, using both cross-sectional and panel-data estimation for the period 1975–2000. Supporting this, Le Clech et al. (2023) recently demonstrated a positive long-term effect of resource rents on human capital accumulation in Latin America and the Caribbean. Additionally, within-country studies (Agüero et al., 2021; Hilmawan & Clark, 2021) provided further support for this positive evidence. Hilmawan & Clark (2021) used a panel of 390 Indonesian districts from 2006 to 2015 to demonstrate that resource rents increase high school enrolment rates, size of the manufacturing sector, institutional quality, and regional income growth rates. In a similar case involving Peru’s mining sector, Agüero et al. (2021) showed that a mining boom in Peru has non-monotonic effects on education and health outcomes: sufficient rents boost students’ math scores and reduce health complications and sickness. Comprehensive evidence of a ‘resource blessing’ is provided by Acuna et al. (2024), who demonstrated the positive causal impacts of oil royalties on human capital accumulation. In a quasi-experimental setting in Ecuador, where a law prescribes an algorithm to assign oil royalties to municipalities regardless of their oil-producing status, among other positive effects, it is shown that royalties increase the likelihood that students complete primary and secondary education and pass and excel in high school exams.

All in all, empirical evidence on whether natural resource rents promote or hinder human capital accumulation is highly mixed, supporting both sides of the debate. For Asian resource-abundant countries (e.g., Brunei, Indonesia and Malaysia), although empirical studies have examined Indonesia at the district level (e.g., Hilmawan & Clark, 2021), there are no systematic time-series country case studies on Brunei that examine the dynamic short- and long-run relationships between oil and gas dependence and human capital accumulation. A recent, though small, body of empirical research using time-series data examines the short- and long-term impacts of natural resources on macroeconomic performance in Brunei.³ For example, a recent series of studies (Slesman, 2025; Slesman & Baha, 2023; Tahir et al., 2023) using a time-series ARDL modelling framework shows that oil and gas rents have a consistent positive contribution to Brunei’s economic growth in both the short and long run. There is no comparable systematic time-series case study of the relationship between resource rents and human capital accumulation for this small, oil- and gas-dependent Southeast Asian country. We fill this critical research gap and contribute to this emerging scholarship on the Brunei economy by offering the first insights into the dynamic relationships between resource dependence and human capital development.

3. Empirical Model, Data and Method

This paper examines the long- and short-run dynamic effects of resource rents on human capital accumulation in Brunei Darussalam, using time-series data and the

³ Koh (2011) conducted a sectoral macroeconometric analysis of Brunei’s oil and gas (O&G) dependent economy. He showed that economic performance (economic growth) is highly sensitive to swings in the O&G sector, which are closely tied to fluctuations in O&G production and oil price shocks. Furthermore, over the past decades, more than 80% of government revenue has come from O&G, and Koh (2017) empirically confirmed that Brunei’s fiscal policy is procyclical. See Koh (2019) for an excellent review of the Brunei economy’s dependence on the O&G sector.

autoregressive distributed lag (ARDL) model for the period from 1975 to 2019, prior to the COVID-19 pandemic. We consider the following parsimonious model of human capital development, which posits that human capital is a function of natural resource dependency, government expenditure and physical capital accumulation (Le Clech et al., 2023).

$$HC_t = \alpha_0 + \alpha_1 NRESOURCE_t + \alpha_2 GOV_t + \alpha_3 GFCF_t + \mu_t \tag{1}$$

where HC_t is the human capital index – that is built from the measures of average years of schooling and the returns to education (Feenstra et al., 2015),⁴ $NRESOURCE_t$ is

Table 1. Variables and measurement

Variables	Details	Unit of Measurement	Sources of Data
HC_t	Human capital index	Index	Penn World Table 10.01
$RENT_t$	Total natural resource rent	Percentage share of GDP	WDI, World Bank
$OGRENT_t$	Oil and gas rents	Percentage share of GDP	WDI, World Bank
$GFCF_t$	Gross fixed capital formation	Percentage share of GDP	UNCTAD, United Nations
GOV_t	Government expenditure	Percentage share of GDP	UNCTAD, United Nations

Notes: WDI = World Bank’s *World Development Indicators*; UNCTAD = United Nations Conference on Trade and Development.

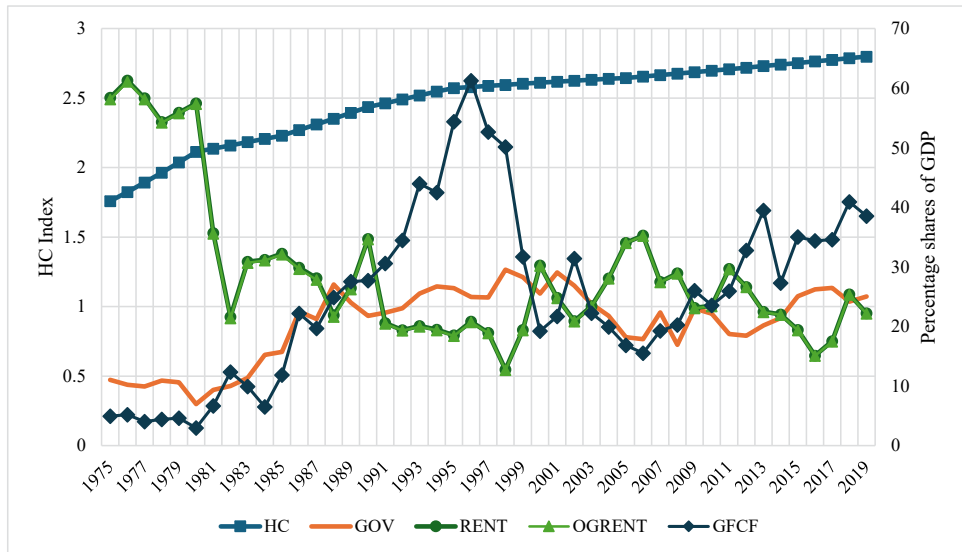


Figure 3. Human capital (HC), natural resource rents (RENT), oil and gas rents (OGRENT), government expenditure (GOV), and gross fixed capital formation (GFCF).

Sources: Author’s calculations based on data from Penn World Table version 10.0, World Bank’s *World Development Indicators*, and United Nations Conference on Trade and Development.

⁴ Penn World Table 10.01 is the only source of human capital data that provides long and uninterrupted time-series data for Brunei Darussalam.

natural resource rent, GOV_t is government expenditure as a percentage share of GDP, and $GFCF_t$ is the gross fixed capital formation as a percentage share of GDP, used to measure the physical capital accumulation.

Theoretically, as briefly reviewed in the preceding section, the net effects of $NRESOURCE_t$ can be positive or negative. This ambiguity stems from resource rents' links to human capital development through counteracting forces, including oil-and-gas-dependent government revenue and spending (positive), the government's supply of public education (positive), exogenous fluctuations in oil and gas prices (negative), resource boom-induced distorted wage signals that lower the skilled labour supply (negative), and the potential myopic behavioural responses of economic agents to the booming resource sector (negative). Hence, *a priori*, the short- and long-run net effects of $NRESOURCE_t$ on HC_t can be positive, negative or nil. We further provide the theoretical rationales for the controlling variables as follows.

We control for GOV_t in Equation (1) because there is a strong consensus that it positively influences human capital accumulation (Dissou et al., 2016).⁵ *A priori*, we therefore expect a positive effect of GOV_t on HC_t . Furthermore, we control physical capital accumulation because recent studies examining the drivers of human capital accumulation find that physical capital accumulation, rather than real GDP, is a better proxy for economic development and labour productivity (Le Clech et al., 2023). Therefore, we control $GFCF_t$ instead of real GDP.

Theoretically, physical capital accumulation can both crowd in and crowd out human capital accumulation, as an increase in physical capital may affect the time devoted to (or the opportunity cost of) education (Caballé & Santos, 1993). Caballé and Santos' endogenous growth model features the dynamic interaction between physical and human capital in the growth process, illustrating how human capital accumulation responds to variations in physical capital through two countervailing forces. First, an increase in physical capital raises labour productivity (and real wages), which in turn increases the opportunity cost of attending school, thereby reducing human capital accumulation. Second, an increase in physical capital may lower the growth rates of both consumption and physical capital. Such lower growth rates in consumption would lead to greater human capital accumulation when the educational sector is intensive in physical capital, as individuals would be incentivised to increase their education to augment their labour productivity and raise their real wage.

In a similar endogenous growth model, Graca et al. (1995) demonstrated that private incentives to accumulate human capital increase with the levels of physical and human capital. These incentives are low or stagnant in the early stages of economic development but rise once a sufficient level of physical capital is attained. This suggests a positive complementary effect of physical capital on the accumulation of human capital. Overall, theoretical models suggest a mixed effect of physical capital, but a net positive effect is most likely, as empirical studies have shown that physical capital crowds in human capital accumulation in Latin America and sub-Saharan Africa (Grier, 2002, 2005) and in low- and lower-middle-income countries (Amir-ud-Din et al., 2019).

⁵ Ideally, educational expenditure as a percentage of GDP is a better proxy than the GOV. Unfortunately, long-time series data is not available for this variable.

Table 2. Unit root tests

	Augmented Dickey-Fuller (ADF) test			Phillips and Perron (PP) test		
	Level	First Differenced	Result	Level	First Differenced	Result
HC_t	-3.0443	-3.6911**	I(1)	-3.0850	-3.2352*	I(1)
$RENT_t$	-3.2673*	-4.9841***	I(0)	-3.2673*	-5.4453***	I(0)
$OGRENT_t$	-3.2681*	-4.9782***	I(0)	-3.2681*	-5.4565***	I(0)
$GFCF_t$	-1.7371	-6.0709***	I(1)	-1.8548	-6.0725***	I(1)
GOV_t	-2.0762	-8.4965***	I(1)	-2.0582	-8.4359***	I(1)

Note: *** $p < 0.01$, ** $p < 0.05$ and * $p < 0.10$.

Next, we assess the stationarity of each variable using standard augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests. Table 2 shows the outcomes of these tests. We found that all variables are stationary at the first differencing, I(1), except the two measures of the $NRESOURCE_t$ namely $RENT_t$ and $OGRENT_t$ which are stationary at the level, I(0). This mixture of I(1) and I(0) variables allows for the use of ARDL-based bound test approach to test for cointegration (Pesaran et al., 2001; Pesaran & Shin, 1998).⁶

Equation (1) can be expressed into the ARDL framework to examine the existence of the long-run relationship between HC_t and $NRESOURCE_t$ (including other controlled drivers of HC_t accounted for in Eq. (1) in the following ARDL (p, q, r, s) model.

$$\begin{aligned} \Delta HC_t = & \beta_0 + \beta_1 HC_{t-1} + \beta_2 NRESOURCE_{t-1} + \beta_3 GOV_{t-1} + \beta_4 GFCF_{t-1} + \\ & \sum_{i=1}^p \gamma_i \Delta HC_{t-i} + \sum_{j=0}^q \lambda_j \Delta NRESOURCE_{t-j} + \sum_{k=0}^r \pi_k \Delta GOV_{t-k} + \\ & \sum_{l=0}^s \delta_l \Delta GFCF_{t-l} + \sigma_1 OILCRISIS + \sigma_2 AFC + \sigma_3 GFC + \varepsilon_t \end{aligned} \quad (2)$$

The Δ is the first-difference operator; ε_t is the residual term; OILCRISIS is a dummy variable accounting for oil crisis periods that include: 1979–1980 (the Iranian Revolution, during which oil prices almost doubled), 1990–1991 (the Gulf War oil price shock with a sharp spike in oil prices), and 2014–2016 (the oil price collapse due to OPEC's oil output cut and the US shale oil boom); AFC is a dummy variable for the 1997–1998 Asian financial crisis; and GFC is the dummy variable capturing the 2007–2008 global financial crisis. The long-run elasticities can be obtained by dividing the coefficient on the one-lagged explanatory variable (multiplied by a negative sign) by the coefficient on the one-lagged dependent variable (Slesman, 2023, 2026). The coefficients on the first-differenced variables (terms with the summation sign) capture the dynamic short-run effects.

⁶ An advantage of the ARDL cointegration approach via the bound test is its ability to test for the existence of a cointegrating/long-run relationship between variables in levels with the mixture of I(0) and I(1) variables (Pesaran et al., 2001). Not only does it have better finite-sample properties than other traditional cointegration methods, which are suited to our small sample; other advantages are explained in Slesman (2023, 2026).

Our estimation proceeds as follows. We select the optimal lag structures for p , q , r and s using the Akaike information criterion (AIC). Second, we conduct standard model specification tests on the ARDL (p , q , r , s) model, including normality of residuals (Jarque-Bera normality test), residual serial correlation (Breusch-Godfrey LM test), autoregressive conditional heteroscedastic (ARCH) effects, heteroscedastic residuals (White test), model misspecification (Ramsey RESET test), and model stability (CUSUM and CUSUM of squares, CUSUMSQ) tests. Third, we conduct the bound test on the well-specified model, with the null hypothesis of no cointegrating or long-run relationship among the level variables, $H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, against the alternative hypothesis of the existence of a cointegrating or long-run relationship, $H_a: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$. This bound test is distributed as an F statistic (F_{overall}), and the lower and upper critical bounds' values for small samples are provided by Narayan (2005).⁷

However, rejecting H_0 of the bound test (F_{overall}) does not guarantee that a non-degenerated cointegrating relationship exists because such rejection may also be possible due to either a significant lagged level dependent variable or joint significant lagged levels of the independent variables. Hence, a degenerated cointegrating relationship occurs when further statistical tests on either the lagged level of the dependent variable (HC_{t-1}) or lagged levels of independent variables ($NRESOURCE_{t-1}$, GOV_{t-1} and $GFCF_{t-1}$) in the error correction term ECT_{t-1} (as in Equation 3) are found to be statistically insignificant despite significant F_{overall} (Goh et al., 2017; McNown et al., 2018; Pesaran et al., 2001; Sam et al., 2019). Recent studies augmented two additional cointegration tests, within the augmented ARDL framework, to complement the bound test to robustly and reliably confirm the existence of a *nondegenerated* long-run cointegrating relationship between the dependent variable (human capital accumulation) and its drivers, including resource rent (Goh et al., 2017; McNown et al., 2018; Saffarudin et al., 2025; Sam et al., 2019). That includes, first, the t test (t_{DV}) on the significance of the coefficient β_1 on HC_{t-1} ($H_{0,t_{\text{DV}}}: \beta_1 = 0$); and second, the F test (F_{IDV}) on the joint significance of the coefficients on the lagged levels of all independent variables ($H_{0,F_{\text{IDV}}}: \beta_2 = \beta_3 = \beta_4 = 0$). Non-degenerated cointegrating relationship is confirmed when all three tests – F_{overall} , t_{DV} , and F_{IDV} – are statistically significant at the conventional levels.⁸

Once the nondegenerate cointegration is confirmed, we would estimate the long-run coefficients and proceed to investigate the short-run dynamics and the adjustment towards the equilibrium path through the error-correction model (ECM) as follows.

⁷ For the computed F-statistics > upper bound critical values (UBCV), the null hypothesis is rejected. For F-statistics < upper bound critical values (LBCV) we fail to reject H_0 . However, for LBCV < computed F-statistic < UBCV, the findings will be inconclusive (see Pesaran et al., 2001).

⁸ There are two possible cases of degenerate cointegration (see Goh et al., 2017; McNown et al., 2018; Pesaran et al., 2001; Sam et al., 2019). First, the *degenerate lagged independent variable case* occurs when F_{overall} and t_{DV} are significant, but F_{IDV} is not. In this case, the cointegrating relationship is degenerated because ΔHC_t depends solely on its own lagged level HC_{t-1} (autoregressive structure of HC), while the lagged levels of explanatory (or forcing) variables play no role. Hence, there is no meaningful long-run relationship embedded in the error-correction term, as in Equation (3). Second, the *degenerate lagged dependent variable case* occurs when F_{overall} and F_{IDV} are significant but t_{DV} is not. In this case, there is no long-run adjustment in the dependent variable, i.e., no error-correction mechanism, even when F_{overall} suggests the existence of a long-run relationship.

$$\Delta HC_t = \beta_0 + \sum_{i=1}^p \gamma_i \Delta HC_{t-i} + \sum_{j=0}^p \lambda_j \Delta NRESOURCE_{t-j} + \sum_{k=0}^r \pi_k \Delta GOV_{t-k} + \sum_{l=0}^s \delta_l \Delta GFCE_{t-l} + \sigma_1 OILCRISIS + \sigma_2 AFC + \sigma_3 GFC + \rho ECT_{t-1} + \varepsilon_t \quad (3)$$

where coefficient ρ on ECT_{t-1} (error correction term) captures the speed of adjustment from short-run shocks/disequilibrium towards long-run equilibrium.⁹

4. Empirical Findings and Discussion

Table 3 summarises our empirical findings. Panel A of Table 3 reports the findings of the diagnostic and cointegration tests. The diagnostics tests – normality, serial correlation, ARCH, and Ramsey RESET tests; and CUSUM and CUSUMSQ stability tests (reported in Appendix 1) – for Model 1, ARDL (2, 2, 0, 3) for total natural resource rents, and Model 2, ARDL (2, 2, 0, 3) for oil and gas rents, fail to reject their respective null hypotheses at the 5% significance level. The findings of the ARDL bound test ($F_{overall}$) and the additional tests of t_{DV} and F_{IDV} conducted on both well-specified models (Model 1 and 2) are all statistically significant at the 5% level or better. This provides strong evidence of *nondegenerate* cointegration between the level variables, suggesting that natural resource rents, government expenditure and physical capital accumulation are the main combined driving forces of long-run human capital accumulation in Brunei Darussalam.

Nevertheless, the bound test does not account for possible structural breaks in the cointegrating relationship, for example, due to the breaks in the time series of oil and gas rent and human capital accumulation (Farooq et al., 2013). We further apply the cointegration test proposed by Gregory and Hansen (1996), which accounts for an endogenous structural break in the cointegrating relationship with unknown timing, to complement the ARDL bound test in validating the existence of a long-run relationship. This Gregory-Hansen cointegration test tests the null hypothesis of no cointegration versus the alternative hypothesis of cointegration with an unknown one-time regime shift. This test is based on ADF test statistics, with critical values of -5.13 , -4.61 and -4.34 corresponding to significance levels of 1%, 5% and 10%, respectively.¹⁰ The Gregory-Hansen cointegration test reported in Panel A of Table 3 confirms the bound test and additional augmented tests for the existence of a cointegrating relationship between human capital accumulation and its drivers. This suggests that a long-run relationship between human capital and natural resource rents, particularly oil and gas rent, exists even in the presence of a structural break in the cointegrating relationship

⁹ To have convergent (stability) in the adjustment, the negative-signed ρ must be statistically significant at conventional levels and belong to $-2 < \rho < 0$, with $-1 < \rho < 0$ indicating convergent without oscillatory trajectories (see Slesman, 2023, 2026).

¹⁰ Gregory and Hansen (1996) considered three types of structural change with an unknown timing within the sample: (i) *level shift* in the cointegrating relationship via intercept while the slope of the cointegrating vector is held constant; (ii) *level shift with trend* where level shift via intercept with time trend incorporated; and (iii) *regime shift*, in which, in addition to level shift via intercept, the slope of the cointegrating vector is also allowed to change. Although we opted for case (ii), we also tested both Models (1) and (2) using alternative cases (i) and (iii) and found that the Gregory-Hansen cointegration test statistics remain highly significant at 5% (case (i)) and 1% (case (iii)).

Table 3. Natural resource rents and human capital accumulation in Brunei Darussalam

	Model 1	Model 2
	$NRESOURCE_t =$ Total natural resource rent ($RENT_t$)	$NRESOURCE_t =$ Oil and gas rent ($OGRENT_t$)
A. Diagnostic and cointegration tests		
<i>ARDL Model diagnostic tests</i>		
χ^2 NORMAL [<i>p</i> -value]	3.3679 [0.1856]	3.4098 [0.1856]
χ^2 SERIAL [<i>p</i> -value]	2.1302 [0.3447]	2.1361 [0.3437]
χ^2 ARCH [<i>p</i> -value]	0.5954 [0.4403]	0.6024 [0.4376]
χ^2 WHITE [<i>p</i> -value]	21.8647 [0.0575]*	21.6849 [0.0604]*
<i>F</i> -statistics RAMSEY [<i>p</i> -value]	0.9405 [0.3399]	0.9130 [0.3469]
CUSUM	Stable	Stable
CUSUMSQ	Stable	Stable
<i>F</i> -statistics [<i>p</i> -value]	7151.439 [0.0000]***	7161.473 [0.0000]***
Adjusted R^2	0.9995	0.9996
Period (<i>T</i>)	1975–2019	1975–2019
<i>ARDL cointegration tests</i>		
Optimal lag length (AIC)	ARDL (2, 2, 0, 3)	ARDL (2, 2, 0, 3)
ARDL bounds test (<i>F</i> -statistics) ($F_{overall}$)	13.0547***	13.0937***
<i>t</i> test (t_{DV}) (for lagged level dependent variable)	-2.7860***	-2.8228***
<i>F</i> test (F_{IDV}) (for lagged level independent variables)	3.8227**	3.7949**
<i>Gregory-Hansen cointegration test</i>		
ADF test	-5.1180**	-5.1180**
Break year	1980	1980
B. Long run effects (Dependent variable: HC_t)		
$NRESOURCE_t$	0.0649 (0.0490)**	0.0631 (0.0446)**
GOV_t	0.0969 (0.0345)**	0.0950 (0.0310)**
$GFCF_t$	-0.0085 (0.4239)	-0.0085 (0.4142)
Constant	-0.5554 (0.7006)	-0.4750 (0.7299)
C. Short run effects (Dependent variable: ΔHC_t)		
ECT_{t-1}	-0.0193 (0.0000)***	-0.0197 (0.0000)***
ΔHC_{t-1}	0.3744 (0.0000)***	0.3747 (0.0000)***
$\Delta NRESOURCE_t$	0.0013 (0.0000)***	0.0013 (0.0000)***
$\Delta NRESOURCE_{t-1}$	-0.0007 (0.0000)***	-0.0007 (0.0000)***
ΔGOV_t	—	—
$\Delta GFCF_t$	0.0002 (0.1203)	0.0002 (0.1203)
$\Delta GFCF_{t-1}$	0.0004 (0.0210)**	0.0004 (0.0210)**
$\Delta GFCF_{t-2}$	0.0003 (0.0360)**	0.0003 (0.0360)**
Oil crisis	0.0075 (0.0067)***	0.0075 (0.0000)***
Asian financial crisis	0.0031 (0.5018)	0.0031 (0.5018)
Global financial crisis	-0.0030 (0.4672)	-0.0030 (0.4672)

Note: Numbers in parentheses are *p* values. Finite-sample bounds *F* critical values are based on Narayan (2005) methods. ARDL models are estimated with a restricted constant. Optimal lag length is determined by Akaike information criteria (AIC). *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$. Gregory-Hansen test of cointegration with an endogenous structural break in the intercept with trend is based on ADF test statistics. The critical values for this ADF test at 1%, 5% and 10% significant levels are -5.13, -4.61 and -4.34 respectively.

Source: Author's calculations.

between human capital accumulation and its drivers – the total natural resource or oil and gas rents, physical capital accumulation, and government expenditure over the 1975–2019 period. Interestingly, the Gregory-Hansen cointegration test suggests the same break date for Models 1 and 2 to be 1980, coinciding with the shift from high rents, for example, high oil and gas rents (around 57% of GDP in 1980, and averaged at 57.6% during 1975–1980) to relatively lower rates (around 35.7% in 1981, and averaged at 24.7% during 1981–2019); while HC, after a significant increase from 1975 (HC score = 1.758) to 1980 (2.114), has since gradually increased over time.

The existence of an equilibrium/long-run relationship (as specified in Equation 3) implies that there would be short-run dynamics between HC and its drivers, whereby any short-run disequilibrium in the values of HC will be corrected over time until the equilibrium value of HC is completely restored. Panel C of Table 3 summarises the findings on short-run dynamics. It shows a stable dynamic adjustment path as indicated by a statistically significant negative-signed coefficient $\hat{\rho} = -0.019$ ($\epsilon -1 < \rho < 0$) on the ECT_{t-1} (Models 1 and 2), suggesting that about 1.9% of the adjustments occur within a year. This implies a slow speed of adjustment towards a complete restoration of the equilibrium value of HC_t after short-run shocks – perhaps due to oil price-induced changes in oil and gas rents and government fiscal positions. This slow adjustment reflects the long-term nature of human capital accumulation (Flug et al., 1998) and, therefore, its response to short-term shocks. Furthermore, the isolated oil crisis dummy variable has a statistically significant positive effect on human capital in the short run, whereas AFC and GFC do not. This suggests that oil price shocks, especially price spikes, have positive effects on short-run changes in human capital development.

We further assess the coefficients on the first-differenced variables, reported in part C of Table 3, to evaluate short-run effects. Notably, the positive coefficients on ΔHC_{t-1} are statistically significant, indicating that HC improvement exhibits past dependence, as prior improvement influences current improvement. Among the control variables, only physical capital accumulation has a significant short-run effect on ΔHC_t . At the same time, changes in government expenditure does not influence short-run variations in ΔHC_t . We observe that past (but not current) increases in the rate of physical capital accumulation, $\Delta GFCF_t$, promote the present accumulation of human capital, suggesting a positive lagged effect. This finding generally aligns with the complementarity between physical capital accumulation and human capital accumulation observed in recent studies (Amir-ud-Din et al., 2019; Le Clech et al., 2023). This finding has important policy implications. The Brunei government's policy strategies and directions (e.g., as enshrined in the recent Ministry of Finance and Economy's (2020) blueprint to achieve a dynamic and sustainable economy for the *Wawasan Brunei 2035*) that aims to promote non-resource private sector growth through strategic and prioritised domestic investment (and attracting FDI) in its economic diversification efforts can have a short-run positive spillover into human capital accumulation.

For our focal variables – the total resource rents, and oil and gas rents – the results from both Models show that past increases in $\Delta NRESOURCE_t$ crowded out ΔHC_t , but a present increase crowd in ΔHC_t . Due to a relatively larger current positive effect of $\Delta NRESOURCE_t$, the net effect is positive, implying a net crowding in effect of

$\Delta NRESOURCE_t$ on ΔHC_t . Such short-run dynamics may reflect the theoretical postulations on the counteracting effects discussed earlier. For example, adverse effects in the past years may be due to two opposing dynamics: (1) the ‘reduced demand for education’ induced by the booming resource sector (as labour demand in the sector increases, lowering the wage premium and raising the opportunity cost of pursuing education) outweighs (2) the oil-boom-induced ‘increase in government supply of education’ that lowers the opportunity cost of education. However, past fluctuations in rents (for example, coupled with the current high youth unemployment rate in Brunei) may also prompt more individuals (including those now graduating) to remain in school or pursue further studies to increase their future employability in the current period. The net effect is the positive effects observed in the present period. Such dynamics, which produce a net positive effect, imply a ‘resource blessing’ in human capital accumulation for Brunei Darussalam in the short run.

We now turn to the coefficients on the level variables reported in Panel B of Table 3 to assess the long-run effects. It shows that only the coefficients on total rents (and the specific disaggregate measure of oil and gas rents) and government expenditure are positive and statistically significant at the 5% level. At the same time, physical capital accumulation is not statistically significant. This implies that, in the long run, a one-percent increase in total resource rent (or oil and gas rent) as a percentage share of GDP would be associated with a 0.065 (or 0.063) unit increase in the index of human capital accumulation. Our finding of this ‘resource blessing’ is in line with recent studies such as Hilmawan and Clark (2021) who found positive spillover effects of resource dependency on Indonesian districts’ high school enrollment rates; Agüero et al. (2021) who recorded a positive redistribution effects of mining boom on Peru’s district human capital accumulation even in the context of Peru’s weak institutions; Le Clech et al. (2023) who record similar positive effects for Latin America and the Caribbean countries; and Acuna et al. (2024) who showed a positive causal effect of oil royalties on school performances in Ecuador. Furthermore, our positive findings for the government expenditure – which also include education and health expenditure – suggests that a one percent increase in government expenditure (as a percentage share of GDP) would lead to about 0.13 unit increase in the index of human capital accumulation over the long run, also in accord with this line of ‘resource blessing’ literature (e.g., Dissou et al., 2016). It is noteworthy that the partial effect of government expenditure (0.097) is higher than that of resource rent (0.065), all else equal. This implies that higher, directly targeted government educational spending – financed by resource rents and other sources – can be significantly more effective in promoting human capital accumulation than the long-run positive spillover effects of resource rents on human capital formation.

Overall, our findings suggest that resource rents (both aggregate and disaggregate oil and gas rents) foster human capital accumulation in both the short and long run, providing strong support for the ‘resource blessing’ view. Further findings on our key control drivers of HC indicate that government expenditure promotes HC only in the long run. At the same time, physical capital investment complements HC only in the short run. Thus, natural resources, including oil and gas rents, have been translated into a higher stock of human capital in Brunei Darussalam in both the short and long run.

5. Conclusion and Policy Implications

A widely debated issue in development and resource economics is the contrast between the resource curse and the resource blessing hypotheses regarding development outcomes. This also includes the stocks of human capital in countries endowed with abundant natural resources. Theoretical and empirical evidence are mixed, supporting both perspectives. This study contributes to the debate by examining a time-series, country-specific case of Brunei Darussalam, a small net oil-exporting economy in Southeast Asia, over the period 1975–2019, using the dynamic time-series econometric framework of the ARDL bound tests and additional cointegration tests suggested by the augmented-ARDL modeling framework, complemented by the Gregory-Hansen cointegration test, to assess the existence of a robust and reliable long-run relationship. Our findings indicate that resource rents, both in aggregate and disaggregated form (i.e., oil and gas rents), promote human capital accumulation in the short and long term, thereby supporting the ‘resource blessing’ view. Further findings on key controlled variables reveal that government expenditure promotes human capital only in the long run, whereas investment in physical capital complements it only in the short run.

Over the past five decades, resource rents (and government expenditure) have remained critical in promoting human capital accumulation in Brunei Darussalam. Changes in resource rents – generated from oil and gas production and prices – can influence government revenue and fiscal positions in the education sector, and the supply of skilled labour, thereby impacting human capital development in Brunei. A key implication is that consistent, long-term public investment and government support for education, during both economic booms (high oil and gas prices) and downturns (low oil and gas prices), will promote the accumulation of human capital in the short and long term.

Resource rents can be crucial in supporting the government’s goals of making its workforce ‘future ready’ by ensuring that Bruneians are ‘skilled, adoptive & innovative people’ – the second of the six aspirations proposed to achieve the Brunei *Wawasan* 2035 Goal of ‘Dynamic and Sustainable Economy’ – (MoFE, 2020) through various policy actions to improve the quality of its education.¹¹ Overall, resource rents (and government expenditure) play a crucial role in the human capital development pathway, thereby supporting long-term economic growth in Brunei Darussalam. They provide essential fiscal resources for sustained public investment in quality education, thereby helping to build human capital and realise Brunei’s national vision, *Wawasan* Brunei 2035.

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¹¹ At least five out of six policy actions outlined under this second aspiration aim to provide and promote a high-quality education system; digital inclusive education and training; lifelong learning; research, development and innovation; and entrepreneurship-focused programs (see MoFE, 2020).

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Appendix 1. CUSUM and CUSUMSQ

