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Natural resource rent's effect on Ethiopian inequality and manufacturing's moderating role: evidence from dynamic simulated ARDL model

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Abstract

Purpose – The purpose of this study is to empirically examine the impact of natural resource rents on income inequality in Ethiopia from 1981 to 2022 and investigate whether investments in manufacturing moderate this relationship.

Design/methodology/approach – Dynamic autoregressive distributed lag simulation and Kernel-based regularized least squares (KRLS) models are used to analyses short- and long-run relationships, as well as the potential moderating role of manufacturing.

Findings – The bounds test indicates natural resource rents have a long-run positive effect on inequality but a short-run negative impact. The KRLS model finds manufacturing conditions for this linkage in the short run. In the long run, economic growth decreases inequality following an inverted Kuznets pattern, while government expenditures reduce disparities when directed at priority social services.

Research limitations/implications – The findings provide mixed support for theories while highlighting nuances not fully captured without local analyses. Strategic sectoral investments may help optimize outcomes from resource dependence.

Practical implications – The results imply Ethiopia should prudently govern resources, productively invest revenues and prioritize social spending to equitably manage industrialization and uphold stability.

Social implications – Reducing disparities through inclusive development aligned with empirical evidence could help Ethiopia sustain peace amid transformation and realize its goals of shared prosperity.

Originality/value – This study applies innovative econometrics to provide novel insights into Ethiopia's experience, resolving inconsistencies in the literature on relationships between key determinants and inequality.

Keywords Natural resource rents, Income inequality, Ethiopia, ARDL bounds testing, Dynamic simulations, Kernel-based regularized least squares

Paper type Research paper

1. Introduction

The linkages between natural resource wealth, economic growth and social welfare outcomes have long been debated in development economics. As the previous research has

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shown, while resource endowments can potentially power structural change and generate more broad-based prosperity, they also tend to enable rent-seeking behaviors which distort incentives and skew the distribution of gains towards extractive elites if not carefully managed (Gemicioğlu *et al.*, 2024). Opening up to global markets additionally renders resource-rich nations' development trajectories more exposed to external shocks if undiversified industrial structures fail to take root (Noumba *et al.*, 2022). It is also well established from both theoretical and empirical work that human and physical capital deepening plays key moderating roles in determining whether a given resource blessing or curse prevails over the long run (Amoaning *et al.*, 2024).

Technological dynamism and shifts in productive capabilities across economic space further mediate the effects of resource abundances on labor market outcomes and distributional impacts. Meanwhile, sustainable resource management proves elusive without capable institutions capable of reining in rent-seeking and crafting equitable environmental policies (Wang *et al.*, 2023). Taking Ethiopia as a *locus* of study, this project aims to advance understanding of resource curse transmission channels and mitigation strategies. In particular, leveraging a panel data set spanning multiple countries over recent decades, we investigate the potential conditioning influence of industrial development on the resource rent-inequality relationship. By modeling investment flows into priority manufacturing and technology sectors explicitly, we hope to disentangle direct and indirect effects in theoretically robust yet policy-relevant ways.

There are different kinds of empirical results on how natural resource dependence affects income inequality. These results depend on things like the level of development, the quality of government and the institutions in a country (Chekouri, 2023; Farzanegan and Habibpour, 2017). Some studies find that resource rents increase inequality, though the effects vary across income levels and regions (Avom *et al.*, 2022). Research also suggests that political and economic factors like democracy, institutions and economic complexity play moderating roles in determining whether resource dependence reduces or exacerbates inequalities(Canh *et al.*, 2020; Chekouri, 2023; Farzanegan and Habibpour, 2017). Much of the existing literature in this domain has adopted broad regional or continental lenses (Akpa, 2023; Avom *et al.*, 2022), with few investigations considering how potential transmission channels like structural economic change (Chekouri, 2023) may condition relationships between rents and equity outcomes. By honing in on Ethiopia's expanding minerals sector amid ambitions of manufacturing-led diversification, this study seeks to add nuanced context regarding heterogenous influences depending on strategic policy pathways pursued (Wolde *et al.*, 2022). Deeper exploration of context-specific experiences like Ethiopia's ongoing process of productive transformation (Assefa, 1985; Tadesse *et al.*, 2003) may illuminate dynamic effects and moderating factors that aggregate cross-country analyses often obscure.

The relationship between natural resource dependence and inequality is complex, with outcomes dependent on various economic and institutional factors (Mdingi and Ho, 2021). While resource rents sometimes increase inequality, evidence also shows they can lessen it under certain conditions. For example, in less developed nations natural resources tend to yield more equalizing revenue distributions in democratic versus non-democratic settings (Farzanegan and Habibpour, 2017). Previous Ethiopian studies on this topic found mixed associations. Gatiso and Wossen (2014) reported forest incomes lowered rural inequality, though reliance on cross-sectional data limits broader inferences. Geda *et al.* (2009) documented rising national inequality potentially linked to commodity booms mainly benefiting wealthier groups, but did not consider policy moderators. Babulo *et al.* (2009) highlighted uneven market effects but treated resource dependence as exogenous. By exploring diverse contextual factors that can facilitate more equalizing distributions of resource wealth, Ethiopia can gain insights for policy design supporting inclusive growth from its expanding mineral sector.

The current study aims to advance scholarship on the complex nexus between natural resource dependence and societal welfare distributions in the Ethiopian context. Drawing upon theoretical frameworks that postulate structural transformation moderates resource curse transmission (Chekouri, 2023; Farzanegan and Habibpour, 2017), this research utilizes dynamic ARDL econometric techniques to empirically analyze rental income impacts with specific consideration of the manufacturing sector's potential conditioning influence. By leveraging an autoregressive distributed lag modeling approach on longitudinal data, this investigation facilitates the disaggregation of direct and indirect pathway effects in a nuanced yet policy-relevant manner. Emergent insights offer timely empirical guidance to inform Ethiopian policymakers navigating strategic mineral sector stewardship aimed at maximizing commodity revenues' distributional outcomes concurrent with manufacturing-driven diversification (Wolde *et al.*, 2022). Prior Ethiopia-focused inquiries into this relationship yielded mixed findings. Gatiso and Wossen (2014) detected forestry incomes decreased rural inequities, yet the cross-sectional design constrained generalization (Farzanegan and Habibpour, 2017). Meanwhile, Geda *et al.* (2009) documented ascending national disparities potentially associated to booms benefiting wealthier segments absent consideration of policy dimensions.

By endogenizing investment dynamics across economic activities, this research aims to build upon and address limitations in past Ethiopia-centric analyses. Outcomes carry salience for advocates of industrialization-led growth promoted in tandem with expanding resource extraction (Tadesse *et al.*, 2003; Yihdego *et al.*, 2018). Insights also promise to enhance cross-country understanding of diversification moderating dependence–distribution linkages – issues vital to development on the continent (Akpa, 2023).

This investigation continues as follows: Section 2 discusses natural resource rents and income inequality theory and literature. The empirical model, data sources and econometric methods will be presented in Section 3. Section 4 analyzes and discusses major findings. Finally, the conclusion will synthesize key findings and explore policy implications. This structural structure conceptually grounds the study, methodologically guides the empirical inquiry and contextualizes the findings to advise Ethiopian natural resource-led development policy.

2. Literature review

2.1 Theoretical review

Within the 1950s and 1960s, Simon Kuznets, an American economist, produced groundbreaking research on the historical evolution of income disparity in connection to economic growth in both developing and established countries. Kuznets (1955), Anser *et al.* (2020) and Kuznets (2019) postulated a theory positing that income disparity exhibits an inverted U-shaped trajectory over the course of economic expansion. According to this idea, inequality first grows, then achieves a state of stability and then decreases as per capita income rises. This pattern is usually referred to as the Kuznets curve. Following Kuznets, more study was conducted to investigate the accuracy of this inverted U-shaped relationship between economic growth and income inequality.

However, the empirical evidence on this issue has shown contradictory findings, and the Kuznets curve failed to adequately portray the process of economic progress in all nations. In addition, the empirical evidence collected from the developmental experiences of many Latin American and Asian countries seems to provide little support for the Kuznets curve hypothesis, as asserted by Kuznets (2019). Kuznets (2019) argued that the absence of the Kuznets curve in several emerging and less developed countries may be attributed to the Kuznets theory's narrow focus on economic issues, neglecting the significant influence of political and institutional factors.

2.2 Empirical review

The association between resource rents and inequality has been examined in numerous contexts. To begin with, several cross-country analyses have sought to disentangle this connection. For example, Avom *et al.* (2022) employed panel quantile regression on 42 sub-Saharan African nations from 1998 to 2018, finding that resource rents decreased measured inequality overall but effects varied by resource type. Similarly, Davis (2020) leveraged a comprehensive global sample and uncovered that while oil correlated with lower gross and net inequality, mining tended to increase disparities. Moreover, region-specific empirical work has also provided insights. Specifically, examining Gulf Cooperation Council states, Teng *et al.* (2024) demonstrated oil and gas rents intensified top income concentration relative to bottom shares. Within sub-Saharan Africa, Acheampong *et al.* (2023) employed instrumental variables and uncovered resource impacts diverging between eastern, western and southern regions.

Several studies have examined this relationship across different contexts and levels of analysis. Sidek (2021) employed dynamic panel threshold regression across developing and developed countries, finding that while higher spending initially increased inequality in developed nations, it tended to reduce inequality overall, especially through education. Comparably, Wolde *et al.* (2022) uncovered that government expenditure is correlated with lower long-run inequality in Ethiopia specifically. However, results are mixed. Turnovsky and Erauskin (2022) incorporated theoretical growth models, revealing productive spending implications diverged as neoclassical theories predicted reductions but endogenous growth theories anticipated increases. Likewise, Maldonado and Ardanaz (2023) also detected a non-linear association, with natural resource transfers more efficiently addressing inequality only at moderate levels in Peruvian municipalities.

Notably, certain types of spending may impact inequality differentially. For example, Cammeraat (2020) distinguished spending categories in European Union nations, uncovering varying effects. Meanwhile, Yu and Li (2021) analyzed Chinese data, determining that social security outlays curbed rural poverty but did little to close urban–rural income gaps. Similarly, d'Agostino *et al.* (2020) established that social transfers decreased Organization for Economic Co-operation and Development country inequality, while Anser *et al.* (2020) found education and health outlays reduced poverty and crime in select developing nations. In summary, while some consensus emerges around an equalizing impact, the empirical evidence suggests the relationship is nuanced and contingent on contextual economic, political and social factors. Disentangling spending priorities and levels may offer clearer policy guidance on strategically deploying expenditures for inclusive development outcomes.

Numerous studies have examined the relationship between economic growth and income inequality across various contexts and levels of analysis. To begin with, a number of cross-country analyses have found mixed results, with some detecting a positive association between growth and top income shares (Rubin and Segal, 2015), while others encountered a negative, positive, inconclusive or no relationship depending on the countries studied (Mdingi and Ho, 2021). Country-specific research has revealed more nuanced, conditional relationships. For instance, Simon Kuznets originally hypothesized an inverted-U pattern for industrializing nations (Kuznets, 2019), and some empirical tests have supported this, with the connection between growth and inequality differing according to countries' developmental levels (Fawaz and Rahnama, 2022). Within-country analyses have also demonstrated heterogeneity, such as higher government quality simultaneously boosting Vietnamese growth and reducing disparities (Hung *et al.*, 2020).

Moreover, institutional and socioeconomic factors may moderate the link as well. Studies have found the inequality–growth nexus constrained by intergenerational mobility and equality of opportunity across societies (Aiyar and Ebeke, 2020). For example, information and communications technology expansion positively impacted African nations' growth up to certain inequality thresholds (Odhiambo, 2022). Overall, empirical evidence reflects the theoretical ambiguity regarding economic growth and income inequality (Mdingi and Ho, 2021). The relationship appears contingent on a range of contextual influences, from levels of development to political economy realities shaping income distributions during periods of change. Continued research unpacking conditional relationships can better inform inclusive development strategies.

2.3 Knowledge gap and importance of study

The linkages between natural resource wealth, economic development pathways and societal welfare distributions have long engaged scholars. While resource endowments can potentially enable structural transformation and generate prosperity if strategically leveraged (Farzanegan and Habibpour, 2017), they also tend to fuel rent-seeking behaviors that skew gains toward elites when not prudently governed (Davis, 2020). Undiversified economies further face external vulnerability upon trade integration (Noumba *et al.*, 2022).

Both theory and empirics indicate human and physical capital accumulation moderate resource impact trajectories (Chekouri, 2023; Teng *et al.*, 2024). Technological dynamism and shifts in economic structure also influence labor market outcomes and inequality from resource dependence (Langnel *et al.*, 2021). Sustainable stewardship remains elusive without robust governance curbing rent-seeking and crafting inclusive policies (Akpa, 2023; Wang *et al.*, 2023). Prior mixed findings highlight the need for nuanced case analyses empirically testing hypothesized mitigation strategies like industrial development (Canh *et al.*, 2020). Focusing on Ethiopia amid expanding minerals production and manufacturing ambitions (Tadesse *et al.*, 2003; Wolde *et al.*, 2022), this study leverages panel methods to investigate the potential equalizing role of strategic sectoral investments.

While prior scholarship provides useful insights into relationships between natural resource dependence, government spending, economic growth and income inequality(Avom *et al.*, 2022; Mdingi and Ho, 2021; Sidek, 2021), significant gaps remain around context-specific transmission dynamics and the prospects for policy-guided mitigation of potential resource curses (Chekouri, 2023; Farzanegan and Habibpour, 2017). The mixed and sometimes contradictory empirical findings highlight the need for more nuanced case study analyses that empirically test hypothesized moderators like industrial development trajectories (Canh *et al.*, 2020; Langnel *et al.*, 2021). By focusing on Ethiopia's experience of expanding minerals extraction amid goals of manufacturing-led structural transformation (Tadesse *et al.*, 2003; Wolde *et al.*, 2022), this study aims to contribute more finely grained evidence around heterogeneous influences depending on strategic policy priorities pursued (Davis, 2020).

3. Methods and materials

3.1 Model and data

Many regulatory factors affect income disparities and natural resource rent, according to studies. Academics can examine Ethiopia's resource richness and inequality with cross-country statistics for 43 years. Definitions of analytical variables are as follows: INEQ is income inequality, RENT is natural resource rent, GDPPC is gross domestic product (GDP) per capita, GEXP is government expenditures as a percentage of GDP, MNF is manufacture value added (%GDP) (Table 1). All variables use natural logs. According to empirical studies

(Akpa, 2023; Brown *et al.*, 2023; Chekouri, 2023; Davis, 2020), the top 10% income share predicts economic disparities. We study Ethiopia's natural resource rent, economic inequality and related issues using 1981–2022 time series data. All indicators except income inequality are World Bank World Development Indicator. Also used was Standardized World Income Inequality Database (SWIID) Gini-Index (9.2 and 8.2, Table 1). The "AUTOFILL: Stata module to fill missing values with existing values" by PS (2021) was used. This method allowed us to impute the missing values in a statistically rigorous manner, ensuring the continuity and robustness of the analysis. The top decile share index is available from 1981 to 2022; however, Ethiopia's Gini index, which measures income inequality, is only available for select years. The typical measure for assessing natural resource distribution discrepancies is natural resource rent as a percentage of GDP. Kuznets claims income inequality and GDP per capita are inverted U-shaped. Inequality and growth might be positive, negative or uncertain (Mdingi and Ho, 2021).

3.2 Model specification

This study examines the relationship between income inequality and natural resource rent, as well as other key control factors identified in previous resource-inequality research. We concentrate on Ethiopia using yearly time series data from 1981 to 2022. Based on empirical findings, given the topic, equation (1) specifies our empirical specification:

$$LINQ_t = \beta_0 + \beta_1 LNR_t + \beta_2 LGEX_t + \beta_3 LGDP_t + \beta_4 LMNF + \varepsilon_t \tag{1}$$

LINQ represents income inequality, *LNR* represents natural resource rent, *LGEX* represents government expenditures as a percentage of GDP, *LGDP* represents GDP per capita, *LMNF* represents manufacture value added and ε_t represents the error term. All variables are natural logarithms. Following past empirical studies (Avom *et al.*, 2022; Chekouri, 2023), we measure income inequality using the World Inequality Database's top 10% income share. Moreover, a second aim of this study is to examine the interactive influence of manufacturing investment and resource rent on income inequality. To empirically model this, the baseline specification can be expanded as shown below using equation (2):

$$LINQ_t = \beta_0 + \beta_1 LNR_t + \beta_2 LGEX_t + \beta_3 LGDP_t + \beta_4 LMNF_t + \beta_5 (LNR\ x\ LMNF)_t + \varepsilon_t \tag{2}$$

where:

$(LNR \times LMNF)_t$ = the interaction between investment in manufacture sector and resource rent.

Variable	Sign.	Log form	Description	Source
Government expenditure	GEX	LGEX	General government final consumption expenditure (% of GDP)	WDI
Income inequality	INQ	LINQ	The share of income held by the top 10% the population	SWIID
Natural resource	NR	LNR	Natural resource rent as a share of GDP	WDI
Economic growth	GDP	LGDP	GDP per capita (current LCU)	WDI
Manufacturing sector	MNF	LMNF	Manufacturing, value added (% of GDP)	WB, WDI

Notes: WDI = World development indicator; SWIID = Standardized world income inequality database
Source: Author's own calculations based on WDI and SWIID

Table 1. Description and sources of data for the study

3.3 Model estimation procedure

3.3.1 The ARDL bounds testing approach. The central aim of this study is to explore the influence of natural resource rent on Ethiopia's income inequality, employing the bounds testing methodology. The ARDL approach was chosen for this study due to its several advantages over other cointegration techniques. The ARDL bounds test does not require all variables to be integrated of the same order and can be applied even if some variables are I (0) while others are I(1). This is advantageous given the inconclusive results often obtained from unit root tests with small samples. Additionally, the ARDL approach estimates only a single equation rather than an entire system of equations, simplifying the model specification and interpretation of results. To examine the relationship between natural resource rent and income inequality with control variables, a dynamic ARDL model with three variables is employed; following the specified specifications for benchmark model [equation (1)] was explained in equation (3) as follows:

$$\begin{aligned}\mathrm{LINQ_t} = {} & \vartheta_1 + \beta_0\mathrm{LINQ_{t-1}} + \beta_1\mathrm{LNR_{t-1}} + \beta_2\mathrm{LGEX_{t-1}} + \beta_3\mathrm{LGDP_{t-1}} + \beta_4\mathrm{LMNF_{t-1}} \\ & + \tau_0\sum_{i=1}^{p}\Delta\mathrm{LINQ_{t-i}} + \tau_1\sum_{i=0}^{q1}\Delta\mathrm{LNR_{t-i}} + \tau_2\sum_{i=0}^{q2}\Delta\mathrm{LGEX_{t-i}} + \tau_3\sum_{i=0}^{q3}\Delta\mathrm{LGDP_{t-i}} \\ & + \tau_4\sum_{i=0}^{q4}\Delta\mathrm{LMNF_{t-i}} + \varepsilon_t \end{aligned} \tag{3}$$

Long-run vector error correction model (VECM) coefficients β_0–β_4 represent error corrections. Short-run coefficients $\tau_0 - \tau_4$ have lags by Schwarz–Bayesian criterion (SBC). Control variables align with inequality analyses. The extended ARDL specifies equations using methods from past works to test the cointegration null hypothesis between specified variables:

$$H0:\ \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0 \quad vs \quad H1: \beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$$

The null hypothesis is that lag-level variable coefficients are zero and the alternative hypothesis is non-zero. After the ARDL bounds test proves cointegration and a long-term link between these variables, the research defines the error correction model (ECM) representation in equation (4):

$$\begin{aligned}\mathrm{LINQ_t} = {} & \vartheta_1 + \beta_0\mathrm{LINQ_{t-1}} + \beta_1\mathrm{LNR_{t-1}} + \beta_2\mathrm{LGEX_{t-1}} + \beta_3\mathrm{LGDP_{t-1}} + \beta_4\mathrm{LMNF_{t-1}} \\ & + \tau_0\sum_{i=1}^{p}\Delta\mathrm{LINQ_{t-i}} + \tau_1\sum_{i=0}^{q1}\Delta\mathrm{LNR_{t-i}} + \tau_2\sum_{i=0}^{q2}\Delta\mathrm{LGEX_{t-i}} + \tau_3\sum_{i=0}^{q3}\Delta\mathrm{LGDP_{t-i}} \\ & + \tau_4\sum_{i=0}^{q4}\Delta\mathrm{LMNF_{t-i}} + \lambda\mathrm{ECT_{t-1}} + \varepsilon_t \end{aligned} \tag{4}$$

The coefficient of error correction terms (ECTs) (λ) should be negative and statistically significant to reflect the pace at which the system adapts to long-run equilibrium following a short-term shock.

3.3.2 Dynamic autoregressive distributed lag simulations model. Jordan and Philips (2018) note that ARDL models have complex specifications like lags and differences, making it challenging to comprehend variable effects. They introduced dynamic ARDL simulation as a simplified means to calculate and visualize positive and negative independent variable impacts on dependents. Our dynamic ARDL specification in equation (5) follows their approach (Jordan and Philips, 2018):

$$\mathrm{LINQ_t} = \vartheta_1 + \beta_0\mathrm{LINQ_{t-1}} + \beta_1\mathrm{LNR_{t-1}} + \tau_1\Delta LNR_t + \beta_2\mathrm{LGEX_{t-1}} + \tau_3\Delta LGEX_t + \beta_3\mathrm{LGDP_{t-1}} + \tau_3\Delta LGDP_t + \beta_4\mathrm{LMNF_{t-1}} + \tau_4\Delta LMNF_t \tag{5}$$

To address the second objective, a dynamic ARDL is used. Equations (6)–(8) show the specified ARDL, ECM and dynamic simulated ARDL forms testing interactive effects of rents, manufacturing and inequality:

$$\begin{aligned}\mathrm{LINQ_t} = {} & \vartheta_1 + \beta_0\mathrm{LINQ_{t-1}} + \beta_1\mathrm{LNR_{t-1}} + \beta_2\mathrm{LGEX_{t-1}} + \beta_3\mathrm{LGDP_{t-1}} + \beta_4\mathrm{LMNF_{t-1}} \\ & + \beta_5(LNR\ x\ LMNF)_{t-1} + \tau_0\sum_{\mathrm{i=1}}^{\mathrm{p}}\Delta\mathrm{LINQ_{t-i}} + \tau_1\sum_{\mathrm{i=0}}^{\mathrm{q1}}\Delta\mathrm{LNR_{t-i}} \\ & + \tau_2\sum_{\mathrm{i=0}}^{\mathrm{q2}}\Delta\mathrm{LGEX_{t-i}} + \tau_3\sum_{\mathrm{i=0}}^{\mathrm{q3}}\Delta\mathrm{LGDP_{t-i}} + \tau_4\sum_{\mathrm{i=0}}^{\mathrm{q4}}\Delta\mathrm{LMNF_{t-i}} \\ & + \tau_5\sum_{\mathrm{i=0}}^{\mathrm{q5}}\Delta(\mathrm{LNR} \times \mathrm{LMNF})_{\mathrm{t-i}} + \varepsilon_{\mathrm{t}}\end{aligned} \tag{6}$$

Long-run coefficients β_0–β_5 correspond to ECTs in the VECM model, whereas short-run coefficients τ_0–τ_5 have appropriate lag lengths based on SBC model specification requirements. Thus, to test the null hypothesis of no cointegration between variables specified as:

$$H0 : \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0\ vs\ H1 : \beta_0 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$$

The null hypothesis is that lag level variable coefficients are zero and the alternative hypothesis is non-zero:

$$\begin{aligned}\mathrm{LINQ_t} = {} & \vartheta_1 + \beta_0\mathrm{LINQ_{t-1}} + \beta_1\mathrm{LNR_{t-1}} + \beta_2\mathrm{LGEX_{t-1}} + \beta_3\mathrm{LGDP_{t-1}} + \beta_4\mathrm{LMNF_{t-1}} \\ & + \beta_5(LNR\ x\ LMNF)_{t-1} + \tau_0\sum_{\mathrm{i=1}}^{\mathrm{p}}\Delta\mathrm{LINQ_{t-i}} + \tau_1\sum_{\mathrm{i=0}}^{\mathrm{q1}}\Delta\mathrm{LNR_{t-i}} \\ & + \tau_2\sum_{\mathrm{i=0}}^{\mathrm{q2}}\Delta\mathrm{LGEX_{t-i}} + \tau_3\sum_{\mathrm{i=0}}^{\mathrm{q3}}\Delta\mathrm{LGDP_{t-i}} + \tau_4\sum_{\mathrm{i=0}}^{\mathrm{q4}}\Delta\mathrm{LMNF_{t-i}} \\ & + \tau_5\sum_{\mathrm{i=0}}^{\mathrm{q5}}\Delta(\mathrm{LNR} \times \mathrm{LMNF})_{\mathrm{t-i}} + \lambda\mathrm{ECT_{t-1}} + \varepsilon_{\mathrm{t}}\end{aligned} \tag{7}$$

The specification for dynamic ARDL simulations of our econometric model in equation (9) may be derived from Jordan and Philips (2018):

$$
\begin{aligned}
\mathrm{LINQ_t} = {} & \vartheta_1 + \beta_0 \mathrm{LINQ_{t-1}} + \beta_1 \mathrm{LNR_{t-1}} + \tau_1 \Delta LNR_t + \beta_2 \mathrm{LGEX_{t-1}} + \tau_3 \Delta LGEX_t \\
& + \beta_3 \mathrm{LGDP_{t-1}} + \tau_3 \Delta LGDP_t \quad + \beta_4 \mathrm{LMNF_{t-1}} + \tau_4 \Delta LMNF_t \\
& + \beta_5 (LNR\ x\ LMNF)_t + \tau_5 \Delta (LNR\ x\ LMNF)_t
\end{aligned} \tag{8}
$$

4. Empirical results and discussion

4.1 Descriptive statistics and correlation

Table 2 presents descriptive statistics and a correlation matrix for the main variables in the study. Panel A, shows, on average, income inequality in Ethiopia measured by the top 10% income share was 0.473, with a standard deviation of 0.045. Natural resource rent averaged approximately US$49.59bn annually but demonstrated high fluctuation represented by a standard deviation of $5.655tn. GDP per capita and government spending as a percentage of GDP grew progressively, ranging from $6,259 to $262,398 and 12.7%–27% respectively. Meanwhile, manufacturing investment averaged 4.743 with a variation of 0.86886.

Panel B introduces the pairwise correlation coefficients between the variables in log form. As anticipated, a negative correlation is observed between inequality and several hypothesized determinants. Natural resource rent correlated positively with GDP but negatively with inequality. This aligns with frameworks suggesting resource dependence can increase disparities without sufficient pro-equality policies. GDP per capita also correlated negatively with inequality, consistent with conditional convergence theories.

4.2 Unit root tests

Table 3 presents the results of unit root tests using the augmented Dickey–Fuller (ADF) test (Dickey and Fuller, 1981), Phillips–Perron (PP) test (Phillips and Perron, 1988) and Zivot–Andrews (ZA) test (Zivot and Andrews, 1992) for both the levels and first differences of each variable. For the variable LINQ (Income Inequality), the ADF and PP tests do not show significance at conventional levels, but the ZA test indicates significance at the 1% level, with a break year in 1996. When considering the first difference of LINQ (ΔLINQ), both ADF

Variable	Obs.	Mean	SD	Min.	Max.
Panel A: Descriptive statistics					
INQ	43	0.473	0.045	0.424	0.583
NR	43	4.959e + 09	5.655e + 09	7.156e + 08	2.136e + 10
GDP	43	44.987	57.325	6.259	262.398
GEX	43	18.889	3.626	12.696	27.041
MNF	43	4.7432	0.86886	3.14	7.3011

Panel B: pairwise correlations						
Variables	LINQ	LNR	LGDP	LGEX	LMNF	LNR_LMNF
LINQ	1.000					
LNR	−0.578* (0.000)	1.000				
LGDP	−0.381* (0.012)	0.933* (0.000)	1.000			
LGEX	−0.259 (0.093)	−0.133 (0.396)	−0.366* (0.016)	1.000		
LMNF	−0.249 (0.108)	0.205 (0.188)	0.055 (0.726)	0.391* (0.009)	1.000	
LNR_LMNF	−0.416* (0.005)	0.537* (0.000)	0.383* (0.011)	0.282 (0.067)	0.935* (0.000)	1.000

Notes: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$
Source: Author's calculations

Table 2. Descriptive statistics and correlation matrix

Variables	Dickey and Fuller (1981) t-stat.	Phillips and Perron (1988) Adj. t-stat.	Zivot and Andrews (1992) t-stat.	Break year
LINQ	−2.554	−1.278	−7.593***	1996
ΔLINQ	−2.646*	−3.126**	−3.724	1996
LNR	−1.065	−0.246	−3.583	1991
ΔLNR	−5.565***	−3.626***	−6.041***	1996
LGDP	2.381	3.008	−1.722	1996
ΔLGDP	−3.040**	−4.367***	−5.891***	1996
LMNF	−2.434.	−2.673	−2.986	2005
ΔLMNF	−6.375***	−6.379	−6.765***	1993
LGEX	−2.261	−2.072	−3.827	1998
ΔLGEX	−5.048***	−5.344***	−6.099***	1994
Confidence levels		Critical values		
1%	−3.648	−3.641		5.340
5%	−2.958	−2.955		4.800
10%	−2.612	−2.611		4.580

Note: ***, ** and *represents significance at the 1, 5 and 10% confidence intervals, respectively
Source: Table by author’s

Table 3.
Unit root tests result

and PP tests show significance at the 5% level, while the ZA test does not indicate significance. For LNR (natural resource rent), none of the tests show significance at conventional levels in their level form. However, the first difference of LNR (ΔLNR) shows significance across all three tests at the 1% level, indicating that the variable becomes stationary after differencing. In the case of LGDP (GDP per capita), the level form does not show significance in any of the tests, but the first difference (ΔLGDP) shows significance at the 5% level in the ADF test and at the 1% level in both the PP and ZA tests, with a break year in 1996.

For LMNF (manufacturing sector), none of the tests indicate significance in the level form. However, the first difference (ΔLMNF) shows significance at the 1% level in all tests, with the ZA test indicating a break year in 1993. Finally, for LGEX (government expenditure), none of the tests show significance at conventional levels in their level form. The first difference (ΔLGEX) indicates significance at the 1% level across all tests, with the ZA test showing a break year in 1994. In summary, the unit root tests yield different results across the various methodologies and variables. While some variables exhibit stationarity only after differencing, others show mixed results depending on the test applied. This nuanced understanding of stationarity is critical for appropriately modeling these variables using the ARDL approach.

These results indicate that order one I(1) processes integrate the variables, which are stationary after first differencing. The variables can be utilized in cointegration analysis and vector error correction modeling to study non-stationary series’ long-term equilibrium relationships and short-term dynamics.

4.3 ARDL-ECM model results

4.3.1 ARDL-ECM model results for benchmark model. Lag order selection in Table 4 determined the ARDL’s lag using Akaike information criterion (AIC), Hannan–Quinn (HQ) and Schwarz information criteria, with HQ and AIC suggesting four lags. The ARDL cointegration test in Table 5 shows that the *F*- and *t*-statistics exceed critical values independently of variables' integration status, supporting cointegration (Pesaran *et al.*, 2001). The p-values also indicate significance (Kripfganz and Schneider, 2018), rejecting no cointegration. The long-run and short-run ARDL coefficients are shown in Table 6, with Figure 1 plotting estimates. In the long-run, a 1% rise in natural resource rents increases inequality by 0.62% (Acheampong *et al.*, 2023). Both short-(0.094%, $p < 0.01$) and long-run estimates show GDP per capita greatly reduces inequality in line with Kuznets' theory (Fawaz and Rahnama, 2022; Kuznets, 2019).

In the long-run, government spending reduces inequality by 0.86% ($p < 0.01$), supporting equitable impacts (Sidek, 2021; Wolde *et al.*, 2022). The short-run is inconsistent with mixed predictions (Turnovsky and Erauskin, 2022). The 18.1% yearly error correction confirms cointegration (Banerjee *et al.*, 1998). Results give nuanced Ethiopian data consistent with prior work. Notably, manufacturing investment strongly decreases inequality by 0.055%–0.104%, with each 1% rise validating its equalizing role (Canh *et al.*, 2020).

This study informs policy goals through balanced, inclusive growth supported by strategic resource governance and priority social spending (Acheampong *et al.*, 2023). Confirming inverted Kuznets patterns (Fawaz and Rahnama, 2022; Kuznets, 2019) also informs equitable transition discussions. Diagnostic tests in Figures 2–5 and test statistics verify the model, demonstrating statistically correct, deterministic linkages rather than oddities (Brown *et al.*, 2023). Results thus support Ethiopia's inequality reduction goals.

Lag	AIC	HQIC	SBIC
0	−1.531	−1.4539	−1.317
1	−10.3896	−9.9305	−9.110
2	−11.8423	−11.001	−9.4963*
3	−12.1669	−10.943	−8.754
4	−12.890*	−11.283*	−8.411

Notes: **Indicates the optimal lag based on the information criteria. AIC = Akaike information criterion; SC = Schwarz information criterion; HQ = Hannan–Quinn information criterion
Source: Computed by author's

Table 4.
Criteria for lag length

Models	K	10% I(0)	I(1)	5% I(0)	I(1)	1% I(0)	I(1)	p-Value I(0)	I(1)
Model 1									
F-stat	11.424	2.45	3.52	2.86	4.01	3.74	5.06	0.001***	0.004***
t-stat	−3.901	−2.107	−3.18	−2.540	−3.126	−3.43	−4.60	0.011**	0.077*
Model 2									
F-stat	20.472	2.26	3.35	2.62	3.79	3.41	4.68	0.001***	0.004***
t-stat	−3.808	−2.51	−3.53	−2.81	−3.90	−3.43	−4.79	0.011**	0.077*

Notes: Model 1 is for ARDL model without joint effect of natural resource rent and manufacture sector on income inequality, while Model 2 included it. Where I(0) and I(1) denote the lower and upper band critical values, respectively, at 10, 5 and 1% significance levels of Pesaran *et al.* (2001) bounds test; p-value is as per Kripfganz and Schneider (2018) critical values and approximate p-values; ***, ** and *denote rejection of the null hypothesis of no level relationship at 1, 5 and 10% significance levels, respectively
Source: Table by author's

Table 5.
Bound test results

Variables	Long-run estimates	VARIABLES	Short-run estimates
LNR	0.620* (0.324)	D.LINQ	0.192 (0.150)
LGDP	−0.704** (0.329)	D.LINQ (−2)	0.262* (0.139)
LGEX	−0.866*** (0.286)	D.LINQ (−3)	0.183 (0.172)
LMNF	−0.292 (0.225)	D.LNR	−0.094*** (0.016)
		D.LNR (−1)	−0.0401 (0.0267)
		D.LNR (−2)	0.0303* (0.0173)
		D.LNR (−3)	−0.039** (0.0141)
		D.LGDP	0.0860** (0.0302)
		D.LGDP (−1)	0.0465 (0.0318)
		D.LGEX	0.0453 (0.0370)
		D.LGEX (−1)	0.0363 (0.0250)
		D.LGEX (−2)	−0.0585** (0.0237)
		D.LMNF	0.055** (0.0206)
		D.LMNF (−1)	0.104*** (0.0196)
		Constant	−1.005*** (0.242)
		ECM (−1)	−0.112** (0.0450)
N	39	R^2	0.939

Notes: Standard errors in parentheses; ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$
Source: Authors' own using STATA

Table 6.
ARDL Estimates: Model 1 (ARDL:4,4,2,3,2)

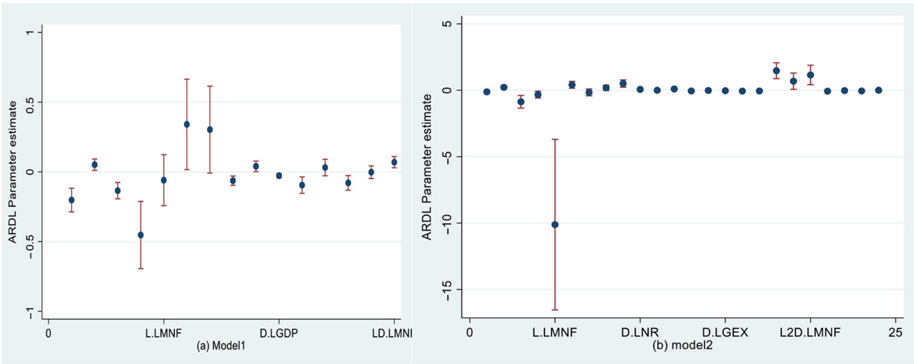
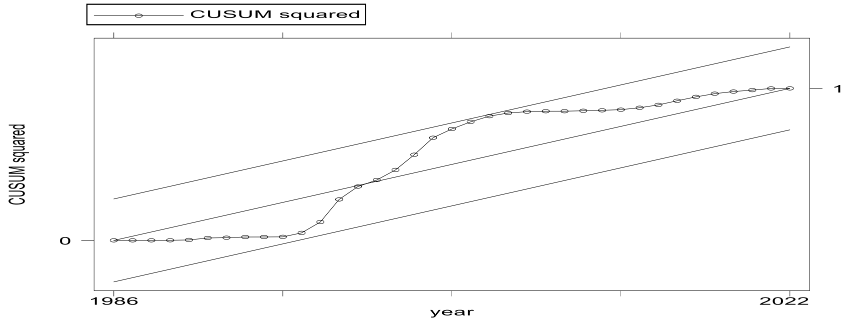


Figure 1.
The calculated ARDL model parameter estimations

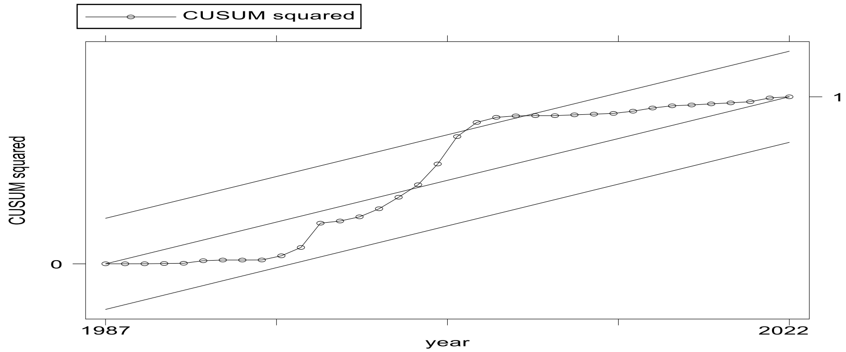
Notes: Black circles are log-log coefficient estimations, while the oliveteal long-dashed line is the reference line. Red spikes indicate 95% confidence interval lower and upper boundaries. LNR and LGEX are log variables for natural resource rent and government expenditure, respectively
Sources: Author's calculations

4.3.2 Dynamic ARDL modeling of the moderating influence of manufacturing investment on the relationship between natural resource rent and income inequality. Table 7 shows, in the long-run, GDP decreasing inequality significantly by 0.930% for every 1% rise aligns well with extensive studies supporting Kuznets' hypothesis (Fawaz and Rahnama, 2022). The positive interaction between natural resource rent and manufacturing investment contrasts some literature finding direct rent effects (Avom *et al.*, 2022; Davis, 2020), but validates hypotheses that moderators like investment condition relationships (Canh *et al.*, 2020). In the



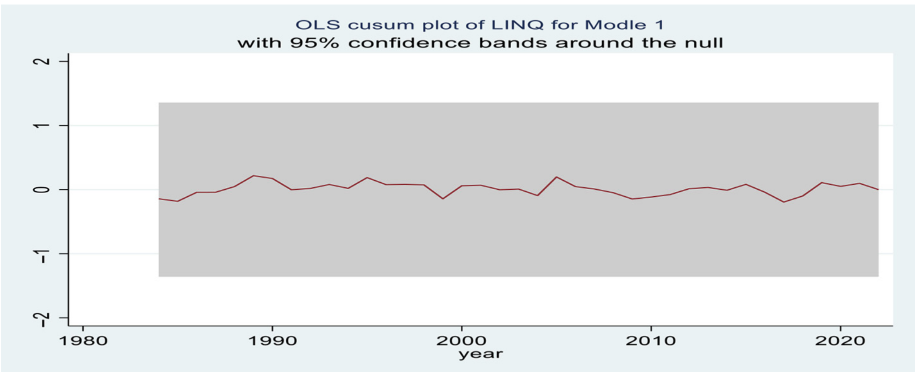
Source: Figures by authors

Figure 2.
CUSUM squared test for Model 1



Source: Figures by authors

Figure 3.
CUSUM squared test for Model 2



Source: Figure by author

Figure 4.
Cumulative sum test using OLS CUSUM plot for parameter stability for Model 1

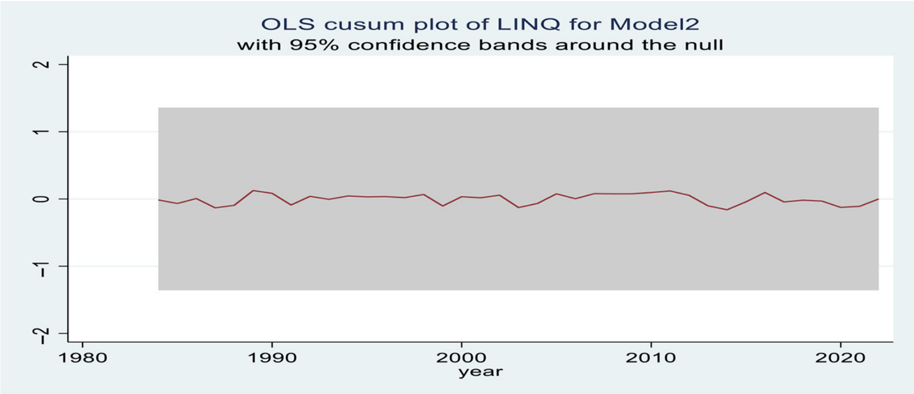


Figure 5. Cumulative sum test using OLS CUSUM plot for parameter stability for Model 2

Sources: Figure by author

Table 7. ARDL estimates: Model 2 (ARDL:4,4,2,3,4,3)

Variables	Long-run estimates	Variables	Short-run estimates
LNR	0.0613 (0.397)	D.LINQ (−1)	−0.174 (0.126)
LGDP	−0.930*** (0.268)	D.LINQ (−2)	0.193* (0.100)
LGEX	−0.245 (0.258)	D.LINQ (−3)	0.507*** (0.133)
LMNF	−13.51* (7.029)	D.LNR	0.057 (0.0401)
LNR_LMNF	0.560* (0.305)	D.LNR (−1)	0.015 (0.0437)
		D.LNR (−2)	0.106*** (0.029)
		D.LNR (−3)	−0.0441*** (0.011)
		D.LGDP	0.0905*** (0.022)
		D.LGDP (−1)	0.0189 (0.022)
		D.LGEX	−0.0014 (0.0374)
		D.LGEX (−1)	−0.0551* (0.0265)
		D.LGEX (−2)	−0.05** (0.0179)
		D.LMNF	2.808*** (0.553)
		D.LMNF (−1)	1.004* (0.530)
		D.LMNF (−2)	1.243** (0.516)
		D.LMNF (−3)	0.045** (0.015)
		D.LNR_LMNF	−0.122*** (0.024)
		D.LNR_LMNF (−1)	−0.038 (0.024)
		D.LNR_LMNF (−2)	−0.054** (0.024)
		Constant	0.416 (0.925)
		ECM (1)	−0.113*** (0.023)
N	39	R^2	0.984

Notes: Standard errors in parentheses; ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$
Source: Authors' own using STATA

short-run, GDP worsening inequality with lagged impacts agrees with evidence of country-specific dynamics (Fawaz and Rahnama, 2022). Meanwhile, government spending inducing non-monotonic inequality changes parallels Turnovsky and Erauskin's (2022) mixed theoretical predictions and empirical results. Crucially, manufacturing investment strongly reducing inequality both immediately and over time confirms expectations emerging from studies hypothesizing its strategic moderating role (Canh *et al.*, 2020; Chekouri, 2023). Most notably, the mitigating effect of the interaction term concurs with conceptual frameworks arguing conditioning factors mediate rent-inequality linkages (Langnel *et al.*, 2021).

Notably, the error correction term substantiates the model's predictive ability regarding equilibrium restoration, empirically supporting this key theoretical tenet. In conclusion, the findings provide robust evidence that manufacturing moderates resource rent's influence on inequality, empirically validating prior theories through this nuanced case analysis.

Table 8 shows both models pass diagnostic tests for serial correlation, heteroskedasticity, misspecification and normality. The Breusch–Godfrey and autoregressive conditional heteroscedasticity (ARCH) tests find no correlation or heteroskedasticity, while the Ramsey RESET and Skewness/Kurtosis tests confirm correct specification and normal residuals, demonstrating the models are robust and meet assumptions. Additionally, Figures 2 and 3 present the cumulative sum (CUSUM) squared tests for Model 1 and Model 2, respectively. Furthermore, Figures 4 and 5 (note the renumbering due to adding Figure 3) depict the cumulative sum tests using ordinary least squares (OLS) CUSUM plots for parameter stability in both models (Model 1 and Model 2).

4.4 Findings of dynamic ARDL simulations

This study uses dynamic ARDL modeling to analyze short- and long-term drivers of income disparity in Ethiopia. It examines inequality's response to hypothetical natural resource rent shocks through simulation-based counterfactual impacts (see Table 9 and Figure 6). The simulation shows a 1% resource rent increase lowers inequality by 0.0575% short-term ($p <$ 0.01), aligning with Nademi (2018)'s findings of initial equalization for Iran. However, greater rents increase inequality 0.003% long-term, supporting Acheampong *et al.*'s (2023) conclusion about concentrated wealth without management. Short-term economic growth is unaffected, but a 1% GDP/capita rise decreases inequality 0.041% long-term, backing Kuznets' (2019) conditional convergence theory and empirical support under conditions (Fawaz and Rahnama, 2022).

No short-term government spending relationship is found, contrary to Turnovsky and Erauskin's (2022) mixed prediction. A 1% spending boost lowers inequality 0.01% in the long term, as others identify strategic outlays benefiting citizens equally (Sidek, 2021; Wolde *et al.*, 2022). Manufacturing investment (LMNF) statistically significantly decreases inequality 0.002% and 0.038% in the short and long terms, respectively (Canh *et al.*, 2020). This aligns with arguments it drives equitable growth through jobs (Langnel *et al.*, 2021;

Diagnostic test	F (p-Value)	Results
Model 1		
Breusch–Godfrey LM	2.377 (0.1059)	Absence of serial correlations
Breusch–Pagan–Godfrey	0.0991	Absence of heteroscedasticity
ARCH lm	56.18 (0.506)	Absence of heteroscedasticity
Ramsey RESET test	0.7317	Model specified correctly
Skewness and kurtosis tests	0.4647	Normally distributed
Model 2		
Breusch–Godfrey LM	2.377(0.1059)	Absence of serial correlations
Breusch–Pagan–Godfrey	0.0991	Absence of heteroscedasticity
ARCH lm	56.18 (0.506)	Absence of heteroscedasticity
Ramsey RESET test	0.7317	Model specified correctly
Skewness and kurtosis tests	0.4647	Normally distributed

Source: Authors' using STATA program

Table 8.
Diagnostic analysis

Table 9.
Estimates of dynamic simulated ARDL model

Variables		Coeff. (SE)
Model 1		
ECM (−1)		−0.083** (0.8547)
ΔLNR		−0.0575*** (0.0192)
L1_LNR		0.003** (0.0155)
ΔLGDP		0.041*** (0.0514)
ΔLGEX		−0.0181 (0.0398)
ΔLMNF		0.002** (0.0357)
L1_LGDP		−0.01** (0.0153)
L1_LGEX		−0.023** (0.0293)
L1_LMNF		−0.038*** (0.0267)
Constant		0.0332 (0.238)
N		42
Model 2		
ECM (−1)		−0.0885*** (0.0564)
ΔLNR		−0.0300** (0.0461)
L1_LNR		−0.048** (0.0469)
ΔLGDP		0.031*** (0.0516)
ΔLGEX		0.0023* (0.0420)
ΔLMNF		0.240 (0.596)
ΔLNR_LMNF		−0.0121*** (0.0278)
L1_LGDP		−0.004** (0.0161)
L1_LGEX		−0.001*** (0.0340)
L1_LMNF		−0.730** (0.570)
L1_LNR_LMNF		0.031*** (0.0257)
Constant		1.088** (0.935)
N		42
Diagnostics		
R^2	0.532	0.565
p-Value of F-statistic	0.0016	0.0029
Simulations	5000	5000

Notes: Standard errors in parentheses; ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$
Source: Author using STATA

Chekouri, 2023). The significant error correction term (−0.083) and R^2 (0.527) show the model explains over half of inequality variation through connected long-run determinants (F = 0.0016, $p < 0.01$). Simulated shocks qualitatively confirm resource rents influence inequality as found in earlier Ethiopia studies. Figure 7 presents dynamic ARDL simulations analyzing the effects of a ±1% shock to natural resource rents (NR) on income inequality (INQ), with Panels (a) and (b) depicting base model predictions and (c) and (d) including a manufacturing.

4.5 Kernel-based regularized least squares results

The results in Table 10 provide insights into Ethiopia's income inequality determinants. In Model 1, natural resource rent has a marginal short-term negative impact on inequality (Nademi, 2018; Acheampong *et al.*, 2023), nuancing prior mixed evidence (Avom *et al.*, 2022) and demonstrating context-specificity (Avom *et al.*, 2022). GDP per capita emerges as moderately increasing disparities in the short-run, empirically validating Kuznets' theory of

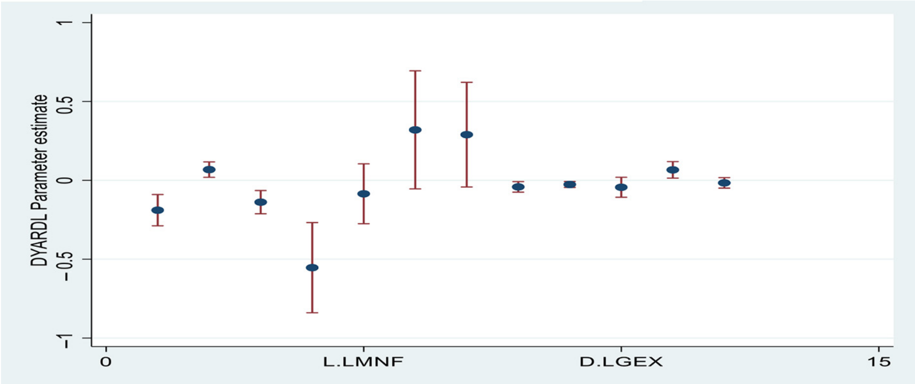


Figure 6. Parameter estimates of dynamic ARDL simulations

Notes: Black(•) is the estimate in a log-log model, olive teal long-dash three dots is the reference line; red-spike denotes lower 95% and upper 95% confidence limit
Sources: Figure by author

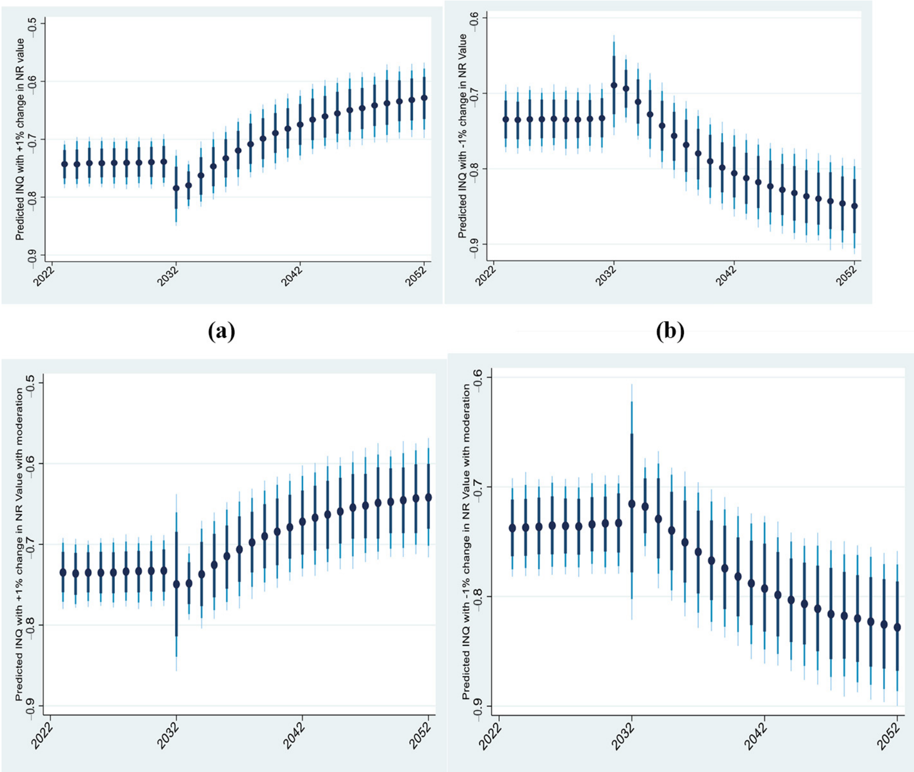
temporary imbalances (Kuznets, 2019; Fawaz and Rahnama, 2022). Most substantively, government expenditures exhibit strong average negative effects (Sidek, 2021; Wolde *et al.*, 2022), supporting frameworks positioning strategic spending as an influential policy lever for equalization over time (Turnovsky and Erauskin, 2022). Critically, in Model 2, the interaction term validates perspectives emphasizing manufacturing investment moderates resource rent fluctuations' impacts on inequality (Chekouri, 2023; Langnel *et al.*, 2021). Also, Figure 8 shows point-wise marginal effect of natural resource rent.

Diagnostic metrics confirm Kernel-based regularized least squares (KRLS) provides a coherent model with reasonable explanatory power, as predicted by econometric theory. It resolves prior studies' mixed evidence (Avom *et al.*, 2022) by considering nonlinear transmission pathways and contextual dynamics' differential shaping of inequality across settings and timeframes (Fawaz and Rahnama, 2022). The results emphasize inequality's context-specific determinants in Ethiopia while lending support for policies like strategic government spending, industry development and carefully managed natural resource sectors as potential equalizers over the short and long runs.

5. Discussions

This section discusses the key findings from the dynamic ARDL modeling and simulations regarding the determinants of income inequality in Ethiopia. The purpose of this study was to examine the impact of natural resource rents on inequality over time (Nademi, 2018; Acheampong *et al.*, 2023) and investigate whether manufacturing investment moderates this relationship (Chekouri, 2023; Canh *et al.*, 2020). The results suggest several notable trends. First, natural resource rents were found to have divergent short- and long-run impacts on inequality. In the short-run, rents decrease inequality (Nademi, 2018), but in the long-run, they increase it (Acheampong *et al.*, 2023). This nuances conflicting evidence from previous studies (Avom *et al.*, 2022) and highlights context dependencies (Fawaz and Rahnama, 2022). Notably, economic growth emerged as reducing inequality in the long run following an inverted-Kuznets pattern (Kuznets, 2019; Fawaz and Rahnama, 2022), empirically validating this classic theory.

Government expenditures also displayed a strong equalizing influence in the long run (Sidek, 2021; Wolde *et al.*, 2022), lending support to frameworks positioning strategic public



(a) (b)

(c) (d)

Figure 7.
Predicted Income inequality with ± 1% change in natural resource rent with moderate manufacture sector

Notes: Figure 7 shows the results of dynamic simulations using the ARDL model. Figure7 (a) depicts the predicted effect on income inequality (INQ) of a hypothetical +1% shock to natural resource rents (NR). Figure7(b) shows the predicted INQ response to a −1% NR shock. In both panels, the black dots (●) represent the predictions on the base log-log model, while the colored spikes denote the 75%, 90% and 95% confidence intervals. Figure7(c) predicts INQ response to +1% NR shock with manufacturing moderation, and Figure7 (d) shows INQ response to −1% NR shock, with black dots as base predictions and colored spikes as confidence intervals
Sources: Figure by author

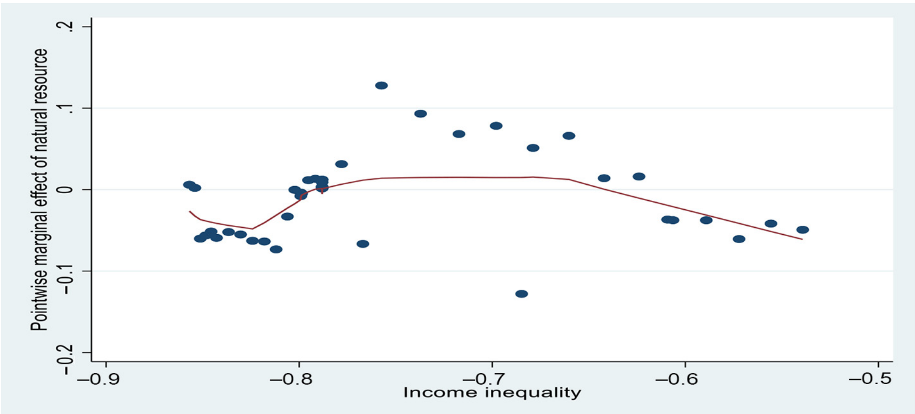
spending as impactful (Turnovsky and Erauskin, 2022). Most substantively, manufacturing investment modulated the rent-inequality linkage in both the short and long run (Canh *et al.*, 2020; Chekouri, 2023), validating hypotheses of its moderating role. The error correction term also substantiated the predictive capacity of the model regarding equilibrium dynamics, as econometric theory predicts.

These results provide mixed support for existing theories while resolving inconsistencies and emphasizing Ethiopia-specific nuances not fully captured previously (Avom *et al.*, 2022). The observed divergent short- and long-run impacts of resource reliance can optimize

LINQ	Avg.	SE	t	$p>t$	P25	P50	P75
Model 1							
LNR	−0.018	0.006	−2.87	0.007	−0.048	−0.004	0.016
LGDP	0.021	0.006	3.529	0.001	−0.087	0.009	0.111
LGEX	−0.078	0.03	−2.63	0.012	−0.286	−0.057	0.093
LMNF	−0.077	0.022	−3.44	0.001	−0.2	−0.087	0.021
Diagnostics							
N	43	Lamda	0.051	Tolerance	0.043		
Sigma	4	Eff.df	21.11	R^2	0.97		
Model 2							
LNR	−0.032	0.006	−5.13	0	−0.056	−0.022	−0.006
LGDP	0.024	0.007	3.714	0.001	−0.071	0.011	0.117
LGEX	−0.076	0.033	−2.3	0.027	−0.249	−0.07	0.094
LMNF	0.001	0.018	0.084	0.934	−0.06	−0.023	0.08
LNR_LMNF	−0.003	0.001	−4.22	0	−0.006	−0.003	0
Diagnostics							
N	43	Lamda	0.051	Tolerance	0.043		
Sigma	5	Eff.df	21.5	R^2	0.959		

Notes: Avg. is the average marginal effect; SE, is the standard error; P-25, P-50 and P-75 represent 25th, 50th and 75th percentile, respectively
Source: Tables by author using STATA

Table 10. Point-wise derivatives using KRLS



Sources: Figure by author

Figure 8. Representation of point-wise marginal effect of natural resource rent

policies balancing growth and equity if appropriately informed by these contextualized findings. Limitations include potential expansion of determinants and data analyzed, which presents opportunities for additional research. In conclusion, this study quantifies Ethiopia's experience and fills gaps in understanding heterogenous relationships, informing inclusive policy calibrated to realities (Akpa, 2023).

6. Conclusion

This study analyzed the relationship between natural resource dependence and income inequality in Ethiopia from 1981 to 2022. It employed several econometric techniques including

ARDL cointegration, dynamic ARDL simulation and KRLS methodology to comprehensively evaluate how resource wealth impacted disparities over time. The findings revealed that resource rents had differing short and long-term effects on inequality. Economic growth reduced disparities in line with an inverted-Kuznets pattern longitudinally. Government expenditures also demonstrated potent equalizing influence over the long run. Manufacturing investment played a modulating role across timeframes. While providing mixed support for existing theories, the study contextualized the relationships to Ethiopia's specific dynamics. This contributed a quantitative analysis of its experience and filled knowledge gaps regarding heterogeneous linkages.

Directions for future work include incorporating additional relevant variables, extending the analysis period as new data emerges and employing alternative econometric approaches. Furthermore, undertaking sub-national studies and comparative analyses across countries may provide additional insights. Continued exploration of conditional relationships through various methods would enhance comprehension of distributional dynamics specific to diverse settings. Ultimately, this would better guide crafting locally relevant, evidence-based inclusive growth agendas.

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