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SOVEREIGN DEBT EXPOSURE TO CLIMATE MIGRATION AND SHRINKING TAX BASES

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Abstract:

This analysis examines whether internal displacement translates into sovereign fiscal pressure or broader economic disruption across countries. Annual World Bank, IMF, and IDMC records covering 2010 to 2019 support unbalanced panel regressions with state and year effects and standard errors clustered by state. Estimation samples contain 1,101 observations from 156 states for debt, 190 observations from 34 states for tax revenue, and 246 observations from 41 states for growth. Combined disaster and conflict displacement is negatively associated with economic growth: an additional 100 movements per 100,000 residents corresponds to approximately 0.108 percentage points lower annual growth. Disaster displacement and debt exhibit a positive but imprecise association, while conflict displacement and tax revenue show a negative but imprecise association. The growth coefficient remains negative across sensitivity checks, although its precision depends on functional form and state composition. These findings distinguish economic disruption from contemporaneous fiscal adjustment rather than establish causal transmission. The contribution refines displacement frameworks by separating exposure categories and fiscal outcomes. Policy assessment should integrate displacement monitoring with production, revenue, assistance, and recovery financing information.

Key Words: Internal Displacement; Sovereign Debt; Tax Revenue; Economic Growth.

1. Introduction:

Population displacement can disrupt economic activity before its consequences become visible in public finances. Governments must address emergency needs while households lose access to employment, firms experience interrupted production, and receiving communities absorb additional service demands. These pressures may increase borrowing or weaken revenue collection, but neither outcome follows automatically. Economic integration, assistance, expenditure adjustment, and financing constraints can alter the response. Research on forced migration consequently distinguishes effects on displaced populations from those affecting receiving communities and wider economies (Ruiz & Vargas-Silva, 2013).

Disaster research establishes plausible fiscal pressures without identifying a uniform response. Noy and Nualsri (2011) document expenditure and revenue adjustments following natural disasters, while Klomp (2017) examines their relationship with sovereign debt distress. These contributions explain why recovery obligations can threaten fiscal sustainability. However, disaster occurrence, physical damage, and population displacement measure different aspects of disruption. An association between disasters and sovereign borrowing does not establish that displacement independently generates debt accumulation.

Displacement also differs according to its origin. Disaster movements may accompany sudden infrastructure damage, whereas conflict movements can coincide with prolonged insecurity and administrative disruption. Combined movements capture overall recorded exposure but do not establish that these processes reinforce each other. Black et al. (2011) explain that environmental influences on migration operate through interacting economic, social, demographic, and political conditions. Cattaneo and Peri (2016) further demonstrate that economic resources influence migration responses to temperature. Recorded movement therefore reflects disruption and the capacity to relocate, rather than a uniform measure of climate damage.

The proposed fiscal mechanism connects disrupted production and livelihoods with expenditure obligations and revenue collection. Yet internal movement can relocate taxable activity within national borders rather than remove it from the economy. Receiving areas may gain workers, consumers, and enterprises, while assistance can sustain demand. Moreover, revenue collection depends on administrative capacity and political incentives as well as economic activity. Besley and Persson (2014) distinguish these institutional foundations from the taxable base itself. Consequently, economic disruption need not produce a proportionate decline in tax revenue relative to GDP.

Measurement therefore determines which relationships the available evidence can establish. Government debt relative to GDP measures a fiscal burden rather than default probability. Tax revenue relative to GDP measures collections rather than the underlying taxable base. Disaster displacement includes movements associated with hazards that cannot automatically be attributed to climate change, and recorded movements may count repeated displacement. Hsiang (2016) emphasizes that exposure definitions and identifying variation

shape the interpretation of economic relationships involving environmental conditions. These distinctions require separate treatment of displacement categories and fiscal outcomes.

The reviewed evidence does not establish whether recorded disaster and conflict displacement exhibit comparable contemporaneous associations with debt, revenue collection, and economic growth within a transparent framework using annual national observations. This analysis addresses that bounded question by distinguishing exposure categories, outcome definitions, and analytical samples. Its contribution concerns the relationship between economic disruption and measured fiscal adjustment. It does not claim to identify climate attributable migration, contraction of the taxable base, or an independent causal displacement effect.

This study aims to assess how recorded internal displacement relates to sovereign fiscal conditions across countries from 2010 to 2019. The research question asks whether disaster, conflict, and combined displacement intensities are associated with different fiscal and economic outcomes after accounting for state and year effects. The objectives are to examine disaster displacement in relation to government debt, conflict displacement in relation to tax revenue, and combined displacement in relation to real GDP growth. Combined exposure enters an alternative specification because it equals the sum of its components. No moderation or mediation relationship is imposed without corresponding measures and theoretical justification.

The analysis integrates World Bank, IMF, and IDMC records within a frame of 193 states and 1,928 eligible annual observations. Availability screening produces estimation samples of 1,101 observations from 156 states for debt, 190 observations from 34 states for tax revenue, and 246 observations from 41 states for growth. Regressions include state and year effects, with standard errors clustered by state. This inference procedure accounts for dependence within states under its assumptions, although it does not eliminate international dependence or omitted variable bias (Cameron & Miller, 2015).

The findings distinguish a negative growth association from imprecise contemporaneous debt and tax associations. The growth coefficient remains negative across sensitivity checks, although its precision depends on functional form and state composition. The contribution is an empirical distinction between economic disruption and fiscal adjustment, together with evidence that reporting coverage and specification choices affect interpretation. For policy, the analysis supports integrating displacement monitoring with economic and fiscal information rather than assigning a uniform financing requirement to recorded movements.

2. Theory, Conceptual Framework, and Hypotheses Development:

2.1 Theoretical Foundation and Disaster Displacement:

This analysis connects population displacement to sovereign fiscal conditions through expenditure needs, revenue collection, and economic adjustment. Governments must finance public services while households and firms respond to disrupted livelihoods and production. Displacement can increase emergency expenditure and interrupt taxable activity, creating financing pressures. However, internal movement also reallocates labour and consumption within national borders. It does not automatically reduce the national taxable base.

Recorded internal displacement exposure comprises disaster movements, conflict movements, and their combined total. Sovereign fiscal conditions comprise government debt relative to GDP, annual changes in that ratio, tax revenue relative to GDP, annual changes in the tax ratio, and real GDP growth. These outcomes form a fiscal profile rather than an assumed latent construct. Black et al. in 2011 explain that environmental influences on migration operate through interacting economic, social, demographic, and political processes. Accordingly, disaster displacement is treated as an observed movement category rather than direct evidence of climate attributable migration.

Disaster displacement can generate fiscal pressure when households require shelter, income support, healthcare, and replacement infrastructure. Disrupted workplaces and markets may weaken revenue collection while reconstruction raises expenditure. Borrowing can smooth these competing demands when governments retain credit access. Noy and Nualsri in 2011 document fiscal responses to disasters that differ across economic settings, supporting a conditional rather than universal borrowing mechanism.

Debt relative to GDP may increase through additional borrowing, reduced output, or both. Consequently, an association between displacement and the debt ratio cannot identify a displacement specific borrowing effect. Dell et al. in 2014 show why economic responses to weather require attention to adaptation, timing, and empirical identification. Their analysis supports distinguishing observed disaster associations from broader claims about climate change.

Competing mechanisms can weaken the expected relationship. Grants and insurance may finance recovery without additional sovereign borrowing. Credit constraints may instead force expenditure cuts despite substantial displacement. Household adjustment also varies with resources: Cattaneo and Peri in 2016 demonstrate that economic conditions influence migration responses to rising temperatures. Movement intensity therefore reflects both exposure and the capacity to move, rather than a uniform measure of economic loss.

Klomp in 2017 links natural disasters to sovereign debt distress, providing evidence that disaster shocks can undermine debt sustainability. That evidence concerns disasters rather than an independently identified displacement channel. The theoretical expectation here is narrower: recorded disaster displacement

should coincide with greater debt burdens where recovery obligations exceed available fiscal buffers and external support.

H1: Higher disaster displacement intensity is associated with a higher general government debt ratio when recovery financing needs exceed grants and fiscal buffers and borrowing remains accessible.

2.2 Conflict Displacement and Revenue Collection:

Conflict displacement differs from disaster displacement because insecurity can persist after the initial movement. Households may lose access to land, employment, and commercial networks, while firms face disrupted supply chains and uncertain property rights. These changes can shift activity towards informal transactions and weaken administrative contact between taxpayers and revenue authorities. Besley and Persson's 2010 theory links fiscal capacity, political incentives, and conflict, providing a basis for expecting institutional conditions to shape revenue outcomes.

The proposed mechanism operates through both production and collection. Displaced workers may lose formal earnings, businesses may suspend operations, and tax offices may become inaccessible. These processes can reduce collected revenue even where productive activity relocates rather than disappears. Blattman and Miguel in 2010 review the economic consequences of civil conflict and emphasize the difficulty of separating conflict effects from underlying institutional and economic conditions. Conflict displacement therefore cannot be treated as an exogenous fiscal shock.

Revenue losses are not inevitable. Receiving areas may gain consumers, workers, and entrepreneurs, while public assistance can sustain demand. Ruiz and Vargas Silva in 2013 distinguish economic effects on displaced populations from effects on receiving communities. Their review supports examining adjustment across locations and groups rather than assuming that relocation produces an equivalent national loss.

Institutional continuity provides a relevant boundary condition. Where registration systems, market access, and public administration remain functional, displaced households may reconnect with formal employment and taxation. Where insecurity interrupts these processes, fiscal disruption may persist. Bohnet et al. in 2018 examine the relationship between conflict displacement and the geographical spread of conflict. This evidence motivates attention to continuing insecurity without attributing violence inherently to displaced populations.

Maystadt et al. in 2019 identify infrastructure, trade, and labour markets as channels shaping the economic consequences of hosting forced migrants. These channels can offset initial disruption, particularly when integration supports productive activity. The expected revenue relationship is therefore negative where displacement disrupts formal activity and collection, but weaker where receiving economies absorb displaced workers and businesses. Evidence from refugee settings informs these mechanisms without establishing identical effects for internal displacement.

The measured outcome is tax revenue relative to GDP. A lower ratio indicates weaker collections relative to recorded output, not direct proof that the taxable base has contracted. Because revenue and GDP may decline at different rates, the ratio can also remain stable or increase during economic deterioration.

H2: Higher conflict displacement intensity is associated with a lower tax revenue ratio where insecurity disrupts formal economic activity and revenue administration.

2.3 Combined Displacement, Economic Adjustment, and Framework Integration:

Combined displacement exposure represents the sum of recorded disaster and conflict movements within a state and year. It captures the overall scale of reported movements but does not identify unique displaced persons or demonstrate that both causes affect the same households. Its theoretical relevance lies in the demands that population movement places on housing, employment, infrastructure, and public services.

Economic adjustment depends on whether receiving areas can expand supply as demand increases. Where infrastructure and production respond slowly, displacement may intensify congestion, raise costs, and interrupt productive matching between workers and firms. Alix Garcia and Saah in 2010 show that refugee inflows affect receiving communities through market adjustments with differing consequences across households. This evidence supports distributional mechanisms rather than a uniform economic penalty.

Displaced populations can also support economic activity through spending, labour supply, and enterprise. Taylor et al. in 2016 use local economy modelling in Rwanda to show how refugee assistance can generate economic benefits beyond direct recipients. These results provide a competing mechanism: externally financed demand may offset disruption where local production can respond. They do not establish the national fiscal consequences of internal displacement.

Adjustment gains may coexist with losses for particular groups. Maystadt and Verwimp in 2014 identify winners and losers within a refugee receiving population, demonstrating that aggregate changes can conceal unequal effects. Applied to the conceptual framework, this implies that national growth may recover while displaced households or particular receiving communities continue to face economic losses.

Infrastructure investment can alter the longer-term relationship. Maystadt and Duranton in 2019 document lasting development effects associated with refugee inflows in Tanzania. Their findings support the possibility that improvements in connectivity and market access can offset initial pressure. The expected

relationship between combined displacement and growth should therefore depend on the speed and financing of economic adjustment.

Public expenditure can sustain this adjustment while creating persistent fiscal obligations. Deryugina in 2017 finds that hurricane related fiscal costs extend beyond designated disaster assistance through social insurance transfers. This evidence supports distinguishing immediate emergency costs from continuing public commitments. Where productive recovery remains weak and external support is insufficient, combined displacement exposure is expected to coincide with lower annual growth and greater pressure on fiscal resources.

H3: Higher combined disaster and conflict displacement intensity is associated with lower real GDP growth where productive disruption and service pressures exceed integration, investment, and assistance gains.

The framework links disaster displacement primarily to the government debt ratio, conflict displacement to the tax revenue ratio, and combined displacement to real GDP growth. Annual changes in debt and tax ratios provide supplementary outcomes for assessing fiscal adjustment. Movement counts, population scaled intensity, and annual movement changes represent alternative operational measures of exposure rather than interchangeable indicators of a validated composite index.

Combined movements equal the sum of disaster and conflict movements. Consequently, the combined measure belongs in an alternative specification and should not enter alongside both components in the same linear model. A hypothesis about simultaneous exposure or effects beyond their sum would require a separately justified interaction specification.

The proposed links represent theoretical associations, not established causal effects. National fiscal conditions may influence displacement vulnerability and recovery capacity, while disasters and conflict can directly affect debt, revenue, and output independently of movement. No unsupported moderator or mediation pathway is imposed. The hypotheses remain open to null, opposing, and heterogeneous findings; any revisions made after examining estimates must be identified as exploratory.

3. Data:

3.1 Data Sources, Population, and Sample Construction:

This analysis combines annual sovereign debt, tax revenue, disaster displacement, population, and economic growth records for 2010 to 2019. The unit of analysis is a sovereign state observed annually. The geographical scope is global, and the institutional focus is national public finance.

The numerical sources comprise World Bank World Development Indicators, the International Monetary Fund World Economic Outlook, and the Internal Displacement Monitoring Centre Global Internal Displacement Database. All sources were accessed on 22 October 2019. World Bank observations reflect the update dated 8 October 2019, IMF debt observations come from the October 2019 release, and the IDMC workbook identifies README version 4 with an extraction date of 20 October 2019.

The operational target population comprises 193 distinct UN member states. The accessible population varies across indicators because fiscal and displacement reporting is incomplete. The sampling frame combines the UN membership boundary with World Bank country identifiers. South Sudan enters in 2012 under a full calendar year eligibility rule, producing 1,928 eligible observations across ten annual periods.

Selection follows a census attempt over eligible accessible records rather than probability sampling. Availability restrictions determine the observations retained for each analytical purpose. The preparation does not require complete reporting across all ten years and does not select observations according to statistical significance.

Table 1: Population frame and sample construction

Stage	States Retained	Observations Retained	Observations Removed	Selection Rule
Initial rectangular frame	193	1,930	Not applicable	Distinct states across ten years
Eligible annual frame	193	1,928	2	Exclude South Sudan before 2012
Debt availability screen	187	1,856	72	Require reported debt relative to GDP
Joint debt and tax screen	148	1,365	491	Require tax revenue relative to GDP
Displacement intensity screen	134	832	533	Require disaster movements and population
GDP growth screen	134	832	0	Require annual real GDP growth
Final estimation sample	Not established	Not established	Not established	Comparability review and estimation remain incomplete

The provisional screening panel is unbalanced. States contribute between one and ten observations, with a median of six and a mean of 6.21. Annual coverage ranges from 58 states in 2011 to 98 states in 2018. These restrictions limit generalizability because retained observations may favour jurisdictions with stronger reporting systems and documented disaster events.

3.2 Data Integration, Quality Control, and Variable Measurement:

The integration uses exact country identifiers and observation years through one-to-one merges. The combined country and year key is unique after scope filtering. World Bank aggregates and nonmember economies are excluded before merging. The IDMC extraction contains 77 records from 23 identifiers outside the defined population; these records remain separately documented as scope exclusions.

Missing observations remain missing. No interpolation, imputation, forward filling, or replacement with zero is applied. Reported numerical zeros are retained. No currency conversion, inflation adjustment, fiscal year reassignment, trimming, or winsorization has been performed.

Fiscal comparability remains incomplete because general government debt may cover a broader institutional perimeter than reported tax revenue. Country specific accounting boundaries and fiscal calendars require review against the framework described in the IMF's Government Finance Statistics Manual, published in 2015.

Table 2: Variable definitions and measurement

Variable	Analytical Role	Source and Identifier	Measurement
General government debt	Candidate outcome	IMF GGXWDG_NGDP	Annual percent of GDP
Tax revenue relative to GDP	Fiscal outcome or proposed mechanism	World Bank GC.TAX.TOTL.GD.ZS	Annual percent of GDP
Nominal tax revenue	Alternative fiscal measure	World Bank GC.TAX.TOTL.CN	Annual current local currency
Disaster displacement movements	Predictor for revised scope	IDMC raw disaster displacement column	Annual recorded movements
Disaster displacement intensity	Calculated predictor	IDMC movements and World Bank population	Movements per 100,000 residents
Population	Exposure denominator	World Bank SP.POP.TOTL	Annual persons
Real GDP growth	Candidate control	World Bank NY.GDP.MKTP.KD.ZG	Annual percentage change
Conflict displacement movements	Alternative control requiring review	IDMC raw conflict displacement column	Annual recorded movements
Annual tax ratio change	Alternative fiscal change measure	Consecutive World Bank tax ratios	Percentage points

Disaster displacement intensity is calculated using Equation 1:

$$D_{it} = \frac{M_{it}}{P_{it}} \times 100000$$

Here, D_{it} denotes displacement intensity for state i in year t, M_{it} denotes recorded disaster displacement movements, and P_{it} denotes resident population. Higher values indicate more recorded movements relative to population, rather than a larger percentage of unique migrants.

The distinction between displacement and climate migration is substantive. Black et al. in 2011 describe migration as the product of interacting environmental, economic, political, demographic, and social processes. Cattaneo and Peri in 2016 demonstrate that migration responses to temperature also depend on economic conditions. Neither relationship establishes that all disaster displacement represents climate attributable migration.

Table 3: Descriptive statistics for the provisional screening sample

Variable	Observations	Mean	SD	Median	Minimum	Maximum
Debt, percent of GDP	832	49.391	29.904	42.150	0.000	189.600
Tax revenue, percent of GDP	832	16.086	9.709	14.410	0.064	147.640
Disaster movements per 100,000 residents	832	658.922	7,900.304	51.992	0.001	225,572.245
Real GDP growth, percent	832	3.805	3.135	3.530	−17.005	19.675

Two observations require further verification. Timor Leste records tax revenue equal to 147.640 percent of GDP in 2012. Vanuatu records 600,250 disaster displacement movements in 2015 against a population denominator of 266,101. The IDMC contextual note identifies proxy reporting limitations and a

historical revision for Vanuatu. These observations remain unchanged pending verification; neither is automatically classified as an error.

No composite index, moderator, interaction, or latent construct has been created. Factor loadings, composite reliability, and average variance extracted are therefore inapplicable to the implemented measurement structure. Validation instead concerns source accuracy, institutional coverage, denominators, temporal alignment, and correspondence between indicators and theoretical claims.

3.3 Analytical Specification, Identification, and Reproducibility:

The available measures support a proposed associational analysis of disaster displacement and sovereign debt. They do not establish a causal pathway from climate migration through contraction of the taxable base. Dell, Jones, and Olken in 2014 distinguish empirical weather relationships from broader climate interpretations, reinforcing the need to preserve the recorded meaning of each indicator. Equation 2 presents a candidate baseline specification:

$$B_{it} = \alpha_i + \lambda_t + \beta D_{it} + \varepsilon_{it}$$

Here, B_{it} denotes general government debt relative to GDP, α_i denotes state effects, λ_t denotes year effects, D_{it} denotes disaster displacement intensity, β denotes the conditional association of interest, and ε_{it} denotes the disturbance.

State effects absorb stable national differences, while year effects absorb common annual shocks. The specification draws on variation within states but cannot separate displacement from disaster damage, emergency expenditure, revenue disruption, or other contemporaneous influences.

GDP growth is excluded from this minimal specification because it may respond to the same disaster process. Tax revenue is also excluded until its intended role as an outcome, mechanism, or conditioning variable is established. Neither variable should enter automatically as a control.

A candidate inference procedure would cluster standard errors by state to account for dependence within national histories. Cameron and Miller in 2015 explain why repeated observations within clusters should not be treated as independent. State clustering would not address every form of international dependence, and ten annual periods limit procedures requiring many independent time clusters.

No regression, standard error procedure, diagnostic test, or robustness analysis has been implemented. Consequently, no coefficients, significance levels, or final estimation counts are reported. Subsequent analysis must document losses from insufficient within state variation, lag construction, additional controls, and estimation requirements.

Further checks should address the flagged observations, fiscal boundaries, reporting selection, alternative displacement measures, and shared GDP denominators. Comparisons across specifications should use common samples where possible to distinguish specification effects from changing sample composition.

The archived downloads, population frame, variable dictionary, cleaning records, and construction code permit replication of the screening dataset. The current evidence supports descriptive analysis of disaster displacement and fiscal conditions. Testing the original mechanism requires credible climate migration measures, administrative taxable base records, completed comparability checks, and an identification strategy.

4. Methods:

4.1 Research Design and Analytical Strategy:

This analysis uses an observational panel design to examine displacement and sovereign fiscal conditions from 2010 to 2019. The unit of analysis is a state observed annually. Three relationships are estimated: disaster displacement with government debt, conflict displacement with tax revenue, and combined displacement with real GDP growth.

The analytical objective is to estimate contemporaneous conditional associations using variation within states after accounting for common annual influences. State effects absorb stable national characteristics, while year effects absorb shocks shared across the observed countries. This specification aligns the comparisons with the panel structure and preserves the distinction between statistical association and causal identification emphasized by Angrist and Pischke (2010) and Imai and Kim (2019).

The exposures represent recorded internal displacement movements. Their interpretation follows the observed categories and measurement units rather than assuming equivalence with climate attributable migration. This alignment between exposure measurement and the empirical question follows the principles discussed by Hsiang (2016).

4.2 Model Specification:

The government debt relationship is estimated using Equation 2:

$$B_{it} = \alpha_i + \lambda_t + \beta_D D_{it} + \varepsilon_{it}.$$

Here, B_{it} denotes general government gross debt as a percentage of GDP for state i in year t. The terms α_i and λ_t denote state and year effects. D_{it} denotes scaled disaster displacement intensity, β_D denotes its conditional association with the debt ratio, and ε_{it} denotes the disturbance. The tax revenue relationship is estimated using Equation 3:

$$T_{it} = \mu_i + \tau_t + \beta_C C_{it} + u_{it}.$$

Here, T_{it} denotes tax revenue as a percentage of GDP, C_{it} denotes scaled conflict displacement intensity, $\mu_i$and $\tau_t$denote state and year effects, $\beta_C$denotes the conditional association, and u_{it}denotes the disturbance. The economic growth relationship is estimated using Equation 4:

$$G_{it} = \eta_i + \delta_t + \beta_A A_{it} + v_{it}.$$

Here, G_{it} denotes annual real GDP growth, A_{it} denotes scaled combined displacement intensity, $\eta_i$and δ_t denote state and year effects, $\beta_A$denotes the conditional association, and v_{it}denotes the disturbance. Each displacement intensity equals recorded movements divided by resident population and multiplied by 100,000. For baseline estimation, intensity is divided by 1,000. Each coefficient therefore represents the outcome difference associated with an additional 1,000 movements per 100,000 residents. Debt and tax coefficients express percentage point differences in their GDP ratios. The growth coefficient expresses a percentage point difference in annual real GDP growth.

Combined intensity equals the sum of disaster and conflict intensities. It is estimated in a separate specification, preserving its interpretation as aggregate recorded exposure and avoiding exact linear dependence with its components. All exposures enter contemporaneously. Each model contains one focal exposure together with state and year effects.

4.3 Estimation Samples and Analytical Preparation:

The eligible population frame contains 193 distinct states and 1,928 annual observations. Model specific samples require complete outcome, displacement, and population records. States contributing only one complete observation are excluded because they provide no temporal variation for the specification with state effects.

Estimated Relationship	Complete Observations	Singleton Observations Excluded	Estimation Observations	States
Disaster displacement and debt	1,112	11	1,101	156
Conflict displacement and tax revenue	200	10	190	34
Combined displacement and growth	264	18	246	41

The resulting panels are unbalanced. Differences in sample size reflect indicator availability and the requirement that both displacement categories be observed when constructing combined exposure. Processing begins with the cleaned panel identified by country code and observation year. Disaster and conflict intensities are calculated separately, followed by combined intensity where both components are available. Complete observations are selected for each model, singleton exclusions are applied, and the regression matrices are constructed. Provider missing values and absent records remain missing. Reported zeros retain their numerical meaning. The baseline specifications preserve reported extreme observations, allowing their influence to be assessed through separately identified sensitivity procedures.

4.4 Estimation and Statistical Inference:

The models are estimated by unweighted ordinary least squares with explicit state and year indicators. Computation uses Python 3.12.14, NumPy 2.3.5, pandas 2.2.3, and SciPy 1.17.0. Estimation residualizes the outcome and exposure against the state and year indicators and regresses the residualized outcome on the residualized exposure. Each coefficient is checked against the equivalent full regression containing the indicator variables. The full design matrices have ranks of 166, 44, and 51 for the debt, tax, and growth models, respectively. Each focal exposure retains estimable variation after the fixed effects are absorbed.

Standard errors are clustered by state to accommodate heteroskedasticity and dependence among observations within national histories. Clustering follows the observational grouping of repeated annual records, consistent with the inference principles discussed by Abadie et al. (2017) and Cameron and Miller (2015). The clustered covariance estimator applies the finite sample adjustment in Equation 5:

$$c = \frac{J}{J-1}\frac{N-1}{N-K}.$$

Here, J denotes the number of state clusters, N denotes the estimation observations, and K denotes the rank of the full design matrix. Confidence intervals and two-sided tests use a student distribution with $J-1$ degrees of freedom. The debt, tax, and growth models contain 156, 34, and 41 clusters, respectively. The three primary exploratory tests receive Holm adjustment for multiple comparisons. Nominal p values are ordered from smallest to largest, multiplied by the number of hypotheses remaining at each step, and adjusted to preserve a nondecreasing sequence, with values capped at one. Reporting adjusted values addresses the joint interpretation of several hypothesis tests, following the multiple testing principles discussed by Goeman and Solari (2010) and Romano et al. (2010).

4.5 Numerical Validation and Sensitivity Analysis:

Validation checks establish uniqueness of the country and year key, reconcile estimation counts, summarize variable distributions, and assess regression matrix rank. Coefficient equivalence between residualized estimation and full indicator regression is verified for all three models. The growth model's clustered standard error is additionally checked against an independently calculated full sandwich covariance matrix. Functional form sensitivity replaces each baseline exposure with the natural logarithm of one plus its intensity per 100,000 residents. This transformation retains genuine zeros while reducing the relative influence of large exposure values. Each logarithmic specification uses the same observations as its corresponding baseline model. Interpretation follows the transformed scale rather than treating logarithmic and level coefficients as numerically equivalent.

An exploratory extreme observation screen excludes records where tax revenue exceeds 100 percent of GDP or disaster movements exceed 100,000 per 100,000 residents. These thresholds identify observations for influence assessment rather than classify them as erroneous. Singleton exclusions are recalculated after screening. The resulting samples contain 1,097 observations from 156 states for debt, 188 observations from 33 states for tax revenue, and 244 observations from 40 states for growth. The combined displacement model is also reestimated after excluding each of its 41 states in turn. This procedure evaluates the contribution of individual states to coefficient direction, magnitude, and uncertainty. Sensitivity assessments distinguish changes in functional form from changes in sample composition. Results are evaluated through effect sizes and confidence intervals alongside nominal p values.

4.6 Transparency and Reproducibility:

Original downloads are preserved separately from the cleaned analytical panel. The population frame, source register, variable dictionary, coverage records, and sample construction outputs document the progression from provider records to estimation samples. Country identifiers and observation years provide the consistent key linking these materials.

The equations, software versions, exposure scaling, singleton rules, covariance adjustment, and sensitivity thresholds specify the computational choices governing the reported estimates. This documentation follows Peng's (2011) emphasis on preserving the computational evidence underlying empirical claims. The completed procedures provide a reproducible assessment of displacement and fiscal associations across the observed national records. Interpretation rests on the measured exposures, model specific samples, and variation retained after state and year effects.

5. Findings:

This analysis examines the associations of disaster displacement with sovereign debt, conflict displacement with tax revenue, and combined displacement with economic growth. The findings distinguish sample coverage, estimated relationships, and sensitivity to analytical choices. All regressions are exploratory and do not identify causal effects.

5.1 Analytical Samples and Measurement Characteristics:

The population frame contains 193 states and 1,928 eligible annual observations covering 2010 to 2019. Each regression uses observations available for its outcome and predictor. Missing displacement records remain missing rather than being interpreted as zero. States contributing only one complete observation are excluded because they provide no temporal variation for the specification with state effects.

Table 4: Construction of the regression samples

Relationship Examined	States Before Singleton Exclusion	Complete Observations	Singleton Observations Excluded	States Estimated	Observations Estimated
Disaster displacement and government debt	167	1,112	11	156	1,101
Conflict displacement and tax revenue	44	200	10	34	190
Combined displacement and GDP growth	59	264	18	41	246

The samples differ because each relationship imposes distinct measurement requirements. Combined displacement requires both disaster and conflict observations for the same state and year. Consequently, its smaller sample represents jointly reported displacement rather than the full population. Differences between regression coefficients cannot be interpreted as differences between displacement mechanisms without accounting for this changing composition.

Table 5: Descriptive statistics within each regression sample

Sample and variable	Mean	Standard deviation	Median	Minimum	Maximum
Disaster model: debt, percent of GDP	49.307	34.012	41.200	0.000	271.400

Sample and variable	Mean	Standard deviation	Median	Minimum	Maximum
Disaster movements per 100,000 residents	655.438	7,074.883	62.461	0.001	225,572.245
Conflict model: tax revenue, percent of GDP	12.433	10.845	11.620	0.915	135.484
Conflict movements per 100,000 residents	774.052	1,576.240	158.357	0.000	11,253.505
Combined model: real GDP growth, percent	3.857	6.350	4.646	−46.082	17.516
Combined movements per 100,000 residents	1,581.581	2,847.755	489.686	0.267	20,366.753

Displacement intensity is skewed, particularly in the disaster sample. Movement counts can include repeated displacement and therefore do not represent unique migrants or population shares. Black et al. in 2011 distinguish environmental influences from the wider processes governing migration, while Cattaneo and Peri in 2016 demonstrate that migration responses depend on economic conditions. These distinctions prevent interpreting the recorded intensity as a uniform measure of climate migration or economic damage.

The outcomes also require separate interpretation. Debt and tax revenue are ratios to GDP, while growth measures annual output change. Neither the tax ratio nor its decline directly measures contraction of the taxable base. Ruiz and Vargas Silva's 2013 review further distinguishes consequences for displaced populations from those affecting receiving communities, limiting individual level interpretations of national aggregates.

Each regression includes state and year effects and a contemporaneous displacement measure. Standard errors are clustered by state, with confidence intervals based on the number of state clusters. This addresses dependence within states under the clustering assumptions described by Cameron and Miller in 2015; it does not eliminate international dependence or omitted variable bias.

Following the identification concerns discussed by Dell et al. in 2014, the estimates are interpreted as conditional associations. No claim is made that fixed effects separate displacement from the direct economic consequences of disasters or conflict.

5.2 Main Estimates and Hypothesis Assessment:

Table 3 reports coefficients for an additional 1,000 displacement movements per 100,000 residents. Debt and tax coefficients express percentage point differences in their GDP ratios. The growth coefficient expresses a percentage point difference in annual real GDP growth.

Table 6: Exploratory estimates with state and year effects

Hypothesis And Outcome	Coefficient	Clustered Standard Error	95 Percent Confidence Interval	Nominal P Value	Holm Adjusted p Value
H1: Government debt ratio	0.0115	0.0078	−0.0040 to 0.0270	0.144	0.288
H2: Tax revenue ratio	−0.0647	0.1558	−0.3818 to 0.2523	0.681	0.681
H3: Real GDP growth	−1.0849	0.3942	−1.8815 to −0.2882	0.009	0.027

The disaster coefficient is positive but its confidence interval includes zero. An additional 1,000 movements per 100,000 residents corresponds to a debt ratio difference of approximately 0.012 percentage points. The estimated magnitude is small under this linear specification, and the evidence does not clearly support H1. This finding does not establish that disasters lack fiscal consequences. Noy and Nualsri in 2011 document expenditure and revenue responses to disasters, while Klomp in 2017 examines sovereign debt distress. Those outcomes and exposures differ from the contemporaneous association between recorded displacement and the debt ratio estimated here.

The conflict coefficient is negative, matching the direction proposed in H2, but its confidence interval spans both revenue deterioration and improvement. The estimated tax ratio difference is −0.065 percentage points per additional 1,000 movements per 100,000 residents. Besley and Persson's 2010 framework identifies fiscal capacity as an institutional process rather than a direct function of population movement. Blattman and Miguel in 2010 also emphasize the identification difficulties surrounding conflict and economic outcomes. The present estimate cannot separate displacement from conflict severity, administrative capacity, tax policy, or changes in GDP.

Combined displacement intensity has a negative association with real GDP growth. An additional 100 movements per 100,000 residents corresponds to approximately 0.108 percentage points lower growth, with a confidence interval from 0.029 to 0.188 percentage points lower growth. The baseline association remains distinguishable from zero after adjustment for the three primary tests. This result is consistent with H3's predicted direction but does not establish its mechanism. Maystadt et al. in 2019 identify infrastructure, trade, labour markets, and assistance as channels shaping adjustment to forced migration. The regression does not observe these channels or distinguish their contribution from direct disaster and conflict losses.

5.3 Sensitivity, Competing Interpretations, and Evidential Limits:

Two exploratory checks assess dependence on extreme observations and functional form. The first excludes observations with tax revenue above 100 percent of GDP or disaster movements above 100,000 per 100,000 residents. These thresholds identify observations for sensitivity analysis rather than establish that they are erroneous. Singleton exclusions are recalculated after screening.

Table 7: Sensitivity estimates

Specification	Debt coefficient	Tax coefficient	GDP growth coefficient
Baseline intensity	0.0115; p = 0.144	−0.0647; p = 0.681	−1.0849; p = 0.009
Extreme observation screen	0.0469; p = 0.618	−0.0895; p = 0.197	−1.0863; p = 0.009
Logarithm of one plus intensity	0.2462; p = 0.323	−0.0933; p = 0.603	−0.8560; p = 0.064

The debt and tax relationships remain statistically inconclusive across these specifications. Excluding flagged observations substantially widens the uncertainty surrounding the debt coefficient. Although its sign remains positive, the evidence does not establish a stable substantive magnitude. The combined displacement coefficient remains negative after the extreme observation screen. However, its logarithmic specification produces a confidence interval from −1.764 to 0.052 percentage points of growth, which includes zero. The negative direction persists, but statistical precision depends on functional form.

A further check reestimates the combined displacement model after excluding each state in turn. All 41 coefficients remain negative, ranging from −1.258 to −0.655. However, excluding the Central African Republic raises the nominal p value to 0.203. The direction is stable across these exclusions, while conventional statistical significance depends partly on that state's contribution. These findings cannot establish that displacement necessarily weakens receiving economies. Alix Garcia and Saah in 2010 identify market adjustments affecting different households, while Maystadt and Verwimp in 2014 document winners and losers within receiving populations. National averages can therefore conceal distributional changes that the present regressions cannot recover.

Assistance and investment provide further competing explanations. Taylor et al. in 2016 demonstrate potential local economic gains from refugee assistance, and Maystadt and Duranton in 2019 identify longer term development effects associated with refugee inflows. These findings concern different populations and designs, but they show why negative short run associations should not be generalized across places or adjustment periods. Fiscal responses may also extend beyond the contemporaneous observation year. Deryugina in 2017 documents continuing public transfer costs following hurricanes. The present annual models do not estimate such distributed responses and therefore cannot determine whether debt or revenue effects emerge later.

The evidence identifies a negative growth association within a selected sample of jointly reported displacement observations. It does not establish clear debt or tax associations, causal displacement effects, climate attribution, or contraction of the taxable base.

6. Discussion:

Displacement can coincide with weaker economic growth without producing a detectable contemporaneous change in sovereign debt or tax collection. Table 3 reveals this asymmetry: combined displacement has a negative growth association, whereas the debt and tax estimates remain imprecise. Interpreted through the specification with state and year effects illustrated in Equation 2, these results challenge the assumption that economic disruption necessarily translates into an immediate fiscal deterioration visible in aggregate ratios. The contribution lies in distinguishing these outcomes within a common analytical framework, rather than establishing an unprecedented causal relationship. Felbermayr and Gröschl in 2014 identify negative growth effects using physical disaster measures, while Cavallo et al. in 2013 demonstrate the importance of separating disaster consequences from accompanying political disruption. The present findings extend this distinction to recorded displacement: its negative growth association is observable, but neither its independent causal contribution nor a corresponding fiscal response is established.

The results identify a question about transmission rather than demonstrate a mediation pathway. Table 3 estimates separate relationships using different samples; it does not introduce tax revenue or economic growth as mediators in a debt equation. Consequently, coefficient differences cannot establish partial or full mediation, and Equation 2 contains no estimated indirect effect. This distinction changes the theoretical interpretation: the absence of a precise tax association does not show that revenue collection is irrelevant, while the growth association does not establish that output losses transmit displacement into borrowing. Imai et al. in 2010 explain that causal mediation requires explicit identification assumptions, and VanderWeele in 2016 emphasizes the importance of confounding and temporal ordering.

The strongest statistical signal concerns growth, but statistical prominence does not establish economic pathway dominance. Table 1 shows that the three regressions draw on different populations of reported observations, and Table 3 measures outcomes on different substantive scales. Their coefficients therefore cannot be converted into comparable shares of a total effect. Combined displacement is also the arithmetic sum of disaster and conflict movements, rather than evidence of an additional interaction between them. The theoretical

contribution is to separate overall exposure from interaction effects and fiscal adjustment channels. Besley and Persson in 2014 distinguish revenue collection from the economic and institutional foundations of taxation, while Botzen et al. in 2019 identify multiple direct and indirect channels through which disasters affect production. These perspectives explain why a negative growth association can coexist with uncertain fiscal estimates without demonstrating that one channel dominates another.

The sensitivity results reveal that the apparent relationship depends partly on which displacement experiences receive statistical weight. Table 5 retains a negative growth coefficient across alternative specifications, but its confidence interval includes zero under the logarithmic transformation. Excluding the Central African Republic also removes conventional statistical significance, although every exclusion of one state at a time preserves the negative coefficient. This pattern indicates directional consistency alongside uncertainty about magnitude and precision. The insight is methodological and substantive: a linear movement measure places greater weight on severe episodes, whereas its logarithmic alternative gives relatively more weight to variation at lower exposure levels. Hsiang in 2016 explains why exposure measurement, functional form, and identifying variation shape interpretation in climate related econometrics. Accordingly, the results do not establish a uniform global displacement penalty; they motivate testing whether severe disruption and more moderate movement operate through different adjustment processes.

International relevance follows from the distinction between exposure, adjustment capacity, and financing response. Frankel et al. in 2013 show that institutional conditions help explain differences in fiscal cyclicality, providing a reason why similar economic shocks need not produce equivalent borrowing outcomes across economies. The present analysis does not estimate separate effects for advanced and emerging economies, so it cannot attribute its fiscal estimates to either group. Nevertheless, Tables 3 and 5 support treating displacement as a potential indicator of economic pressure rather than a calibrated predictor of additional debt or lost tax revenue. Governments should integrate displacement records with production, revenue administration, assistance, and recovery expenditure data before assigning fiscal costs. Future analysis should estimate delayed responses, compare income groups on compatible samples, and distinguish grants from debt financed recovery. This redirects the framework from an assumed displacement to debt chain towards separately testable economic and fiscal adjustment relationships.

7. Conclusion and Implications:

Population movement can signal economic pressure without revealing how governments will finance their response. This analysis identifies a negative association with productive performance while finding insufficient precision to establish corresponding changes in public borrowing or revenue collection. Its contribution is to distinguish economic disruption from fiscal adjustment within a framework that preserves differences in exposure, measurement, and reporting coverage. These findings qualify an automatic sequence from relocation to lost public resources and additional borrowing. The distinction reflects the role of institutions in shaping collections and the varied economic consequences of forced migration (Besley & Persson, 2014; Ruiz & Vargas-Silva, 2013). Decision makers should therefore combine movement monitoring with employment, production, revenue administration, and recovery expenditure information before assigning financing needs. Public agencies can improve coordination by linking humanitarian reporting with budget preparation and economic surveillance. Recovery planning should assess grants, existing buffers, and service obligations separately, allowing resources to follow verified needs rather than assumed fiscal effects. Across institutional settings, this approach can support accountable allocation and continuity of essential services. Its social value lies in aligning assistance with evidence about economic conditions while avoiding unsupported financial predictions.

The results create opportunities to strengthen measurement, comparability, and identification. Administrative records linking origins, destinations, employment, assistance, and expenditure could clarify adjustment pathways. Hazard specific observations would distinguish weather related movement from other displacement, while taxpayer records could separate collection changes from changes in the taxable base. Longer observation windows would permit assessment of delayed responses and recovery. Comparable samples across income groups could examine institutional differences without confounding them with reporting coverage. Future research should test transmission mechanisms and distinguish severe episodes from moderate movements before estimating transferable fiscal responses, consistent with the identification principles discussed by Hsiang (2016).

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