

Poverty Reduction in Burundi: Has Foreign Aid Helped? -A Machine Learning Perspective

Nnyeneime Usenata Udo^{1*}

University of Finance and Insurance, Sofia

1 Gusla Str. Ovcha Kupel District, 1618 Sofia-Bulgaria

*Email of corresponding author: nnyene1994@gmail.com

Abstract

This study assesses the effectiveness of foreign aid in promoting development outcomes in Burundi using machine-learning techniques. Burundi remains highly dependent on external assistance, yet the extent to which aid translates into sustained improvements in economic growth, poverty reduction, health, education, and human development remains contested. Earlier Burundi-focused research has reported mixed results: aid has been associated with some improvements in education and child-mortality outcomes, while its effects on poverty reduction and growth have been less conclusive; political stability and governance conditions also appear important to aid performance. Using annual data for Burundi over the available study period, the research combines foreign-aid indicators such as official development assistance disbursements, sectoral aid allocations, and aid per capita with macroeconomic, institutional, demographic, and social indicators. Key explanatory variables include domestic investment, trade openness, inflation, exchange-rate movements, government expenditure, population growth, political stability, governance quality, and measures of human capital. The outcome variables include GDP per capita growth, poverty-related indicators, child mortality, school enrolment, and the Human Development Index, subject to data availability. The research aims to identify whether foreign aid is a meaningful predictor of development progress in Burundi and determine the institutional and macroeconomic conditions associated with stronger aid outcomes. The findings support more targeted, transparent and development-oriented policies in Burundi.

Keywords: Machine learning, foreign aid, official development assistance, poverty, growth, inflation, macroeconomics

DOI: 10.7176/JESD/17-6-05

Publication date: September 30th 2026

1.0 Introduction

Burundi is a small, landlocked country in East-central Africa of about the size of Maryland, USA. It borders Rwanda to the north, Tanzania to the east, and the Democratic Republic of Congo (DRC) to the West. Burundi is specifically in the African Great Lakes region and lies along Lake Tanganyika and covers approximately 27,834 square kilometers of land. Burundi faces significant challenges with poverty and economic stagnation largely due to governance issues, structural economic rigidities and limited access to basic services. Its population is 14.7 million (UN, 2026).

Burundi is one of the poorest countries in the world with a GDP per capita of US\$546 (IMF, 2026) which is one of the lowest in the world and the country is heavily reliant on international aid. Burundi's central government revenue is BIF 3.6 trillion (Burundian Franc) equivalent to US\$1.208bn including foreign grants.

Burundi's economy has faced significant challenges including the COVID-19 Pandemic, political instability and global economic shocks like the war in Ukraine. Despite these hurdles, the economy showed resilience with a GDP growth of 4.2% in 2025 (IMF, 2026) driven by industry and services specifically coffee and gold exports. However, inflation remains high at 34.1% in 2025 against 20.2% in 2024 (IMF, 2026) due to weak agricultural production and currency depreciation. The Country relies heavily on agriculture which employs 80% of the population but suffers from low productivity. Structural reforms and international support are crucial for sustainable growth and reducing poverty.

Burundi has experienced nearly two decades of conflict and troubles which have contributed to widespread poverty. It is ranked 187th out of 193 countries in the 2023 United Nations Development program's human development index (HDI) with a score of 0.439 and eight out of ten Burundians live below the poverty line (UNDP 2023). The HDI combines three dimensions: Health: life expectancy at birth-63.7 years, Education: expected years of schooling-9.8 years, mean years of schooling-3.5 years. Standard of living: gross national income per capita-approximately US\$859 in purchasing-power-parity. Per capita gross national income (GNI) in 2010 was US\$170, which is approximately half of what it was before its pre-war 20 years ago (Ki-moon 2011). In 2025, GNI per capita was approximately \$240 using the World Bank Atlas method. Burundi was traditionally

self-sufficient in food production, but because of conflict and recurrent droughts, the country has had to rely on food imports and international food aid in a few of its regions.

In the year 2000, world leaders established goals and targets to free humanity from extreme poverty, hunger, illiteracy and disease by 2015. The sustainable Development Goals of the United Nations framework has helped set global and national priorities and focus on subsequent actions. By signing the Millennium Declaration, Burundi has pledged to improve policies and governance and increase accountability to its citizens.

Despite real progress, Burundi is failing to reach the most vulnerable that are the poorest of the poor. The poorest children have made the slowest progress in term of nutrition and employment opportunities falls short for women. This study's purpose is to find out how effective foreign aid is to Burundi at alleviating poverty in one of the poorest countries in the world.

It is worthy of note that half of Burundi's budget is funded by aid mostly grants to help the country reduce its poverty (Nielson and Madani 2010). It is heavily dependent on bilateral and multilateral aid. In 2004, the International Monetary Fund (IMF) approved a \$104 million Poverty Reduction and Growth Facility loan. The high external assistance has, however, not yet translated into high and sustainable growth rates and improvement. The paper will focus on how much foreign aid is distributed to the government of Burundi; where the foreign aid comes from and whether it is effective at alleviating poverty. This research paper will examine whether foreign aid helps Burundi reach SDG goals especially eradicating poverty and extreme hunger, reducing inequalities and access to quality education.

Serious economic problems exist in Burundi where the question of governmental transparency and debt reduction have been questioned. Are scarce resources managed and spent appropriately on public services? Are these resources achieving the best and most needed public services with the limited resources available? Are services offered to the neediest of the population? Eradicating extreme poverty, hunger, illiteracy and disease by 2030 is a contemporary public issue. Governments exist to protect the rights and serve the needs of the public. Good governance is to ensure those needs are served effectively and fairly, which can be accomplished through effective government budgeting.

When a country reduces its children's mortality rate and improves its infant mortality rate, it invests in its long-term growth (IMF, 2006). A country's ability to ensure that all children complete primary School can lower its risk of poverty in the future. Improving the educational level and reducing the mortality rate of under-five children are goals aimed at alleviating poverty in the long term rather than alleviating suffering in the short term.

Poverty is so endemic in Burundi because the country combines extreme land pressure, an economy almost entirely dependent on low-productivity subsistence farming, repeated political shocks and conflict, very weak infrastructure, rapid population growth and high exposure to climate-related disasters-all of which reinforce each other in a persistent poverty trap.

Research has shown that about 80% of Burundians depend on agriculture mostly at a rain-fed, low-input level. Agricultural output has not kept pace with population growth, so average food availability per person stagnates or falls limiting both nutrition and income. Furthermore, with one of the highest population densities in Africa and limited arable land, plots are small and increasingly subdivided among generations making it hard to invest, mechanize or specialize. This pushes families into low-yield, low-surplus production that barely covers consumption needs. High rates of malnutrition, stunting and limited access to quality education and health services reduce workers' productivity and constrain movement into higher-value activities.

Furthermore, frequent floods, erratic rainfall, soil erosion and land degradation directly cut crop yields and destroy assets because most households live close to the subsistence margin, even modest shocks can push them into acute food insecurity and debt. Weak irrigation, storage, transport and financial services mean farmers cannot buffer bad seasons or shift to more resilient crops and practices at scale. These elements form a self-reinforcing cycle; land scarcity and climate risk keep yields low; low yields and poor markets keep incomes low; low incomes limit investment in health, education and farm improvements and weak institutions and infrastructure make it hard to break out of this pattern. That is why poverty in Burundi is not just widespread but 'endemic'-it is structurally embedded across the economy, environment and institutions.

The government should also be responsible for creating opportunities for citizens living below the poverty line of \$3 per day set by the World Bank. The principal SDG target is eradicating extreme poverty and hunger.

Approximately 74.3% of Burundi's population live in extreme poverty using the World Bank's updated international poverty line of US\$3.00 per person per day in 2021 purchasing-power-parity (PPP) dollars. This is because the World Bank revised the extreme poverty threshold in 2025 from \$2.15 to \$3.00 per day.

The infant mortality of children under five years of age was very high at 190 per thousand in 1990 and at 181 per thousand in 2006 (UNDP, 2011). As of 2026, the rate is 49 deaths per 1,000 live births-meaning that about 1 in every 20 children die before reaching age five. UNICEF reports a closely related estimate of 49.2 deaths per 1,000 live births (UNDP, 2026).

The third SDG is to "ensure healthy lives and promote well-being for all at all ages". The target here is to ensure that all children will be able to complete a full course of primary schooling. By 2030, end preventable deaths of newborns and children under five years of age. Countries should aim to reduce neonatal mortality to 12 or fewer deaths per 1,000 live births and under-five mortality to 25 or fewer deaths per 1,000 live births.

2.0 Literature review

There is a large amount of literature on the effectiveness of foreign aid in Burundi. Some researchers find a negative relationship between the effectiveness of foreign aid and economic growth per capita in Burundi. These scholars argue that unless certain conditions are met, such as better institutions, aid does not have a positive impact on growth (Burnside and Dollar 2000). In sharp contrast however, these studies have failed to establish a connection between aid and real GDP growth in developing countries. A typical case is in a 1987 study where Mosley, Hudson and Horrell stressed the possibility of aid not being appropriately used and leading to non-productive public spending thus affecting adversely the private sector. When aid is being allocated to a certain project and once the project is terminated, the government can spend the remaining sum on any other purpose (such as enlarging the army, reducing taxation and debt). These fiscal adaptations of aid inflows often have an influence on the macro-economy through the exchange rate and the level of interest rates.

The government should be able to create business and markets in the process of economic development. Djankov, Montalvo, and Reynal-Querol (2006) study demonstrated that foreign aid has had a negative impact on democracy and economic growth. They proved that foreign aid has a negative impact on the level of democracy in the recipients' countries and that unconstrained aid flows tend to be consumed rather than invested by the government. The government should be able to define its own priority and rely on its own systems to deliver foreign aid and be less dependent on foreign aid in the future to increase its investment.

Nevertheless, other Scholars believe that there is a positive relationship between the effectiveness of foreign aid and GDP growth per capita. They argue that foreign aid has a positive impact on economic growth if aid is allocated efficiently and the recipient country has sound fiscal and monetary policies to manage aid. The World Bank's report on the assessment of aid established a positive impact of aid on growth when governments followed sound fiscal, monetary, and trade policies and if aid was only allocated to low-income countries with good governance (World Bank 1998).

Conclusions were drawn on Burnside and Dollar's (2000) and Collier and Dollar's (1999) findings. These studies covered the years between 1970 to 1993 and found a link between aid, sound policy, and growth. They also studied 56 low-income countries which include 25 African countries. Collier and Dollar (1999) stated that aid distribution was radically different from the poverty efficient allocation meaning once the level of poverty had reached a certain level, aid was allocated efficiently only when it is reinforced with policy reform. Once aid has reached a certain level, aid is subject to diminishing returns, creating dependency and encouraging poor economic policies (Collier and Dollar 1999).

Agriculture dominates Burundi's economy since most of the country relies on subsistence agriculture, but Burundi has limited land that can support this sector. Almost 80% depend on agriculture for their livelihood which puts enormous pressure on the limited land and natural resources. As a result, food insecurity in Burundi stands at roughly double the average for Sub-Saharan Africa. The overall agricultural production in Burundi is lower than the country's population growth. This imbalance limits food supply and income opportunities for rural families. Consequently, poverty in Burundi affects a large share of youth population especially in rural communities. Farmers often struggle to produce enough crops to feed their families or generate a stable income. When agricultural output fails to meet the demand, food shortages follow. These conditions contribute to one of the highest malnutrition rates in the world, particularly among children under the age of five. Understanding this heavy reliance on agriculture forms a key part of everything we need to know about poverty in Burundi because the country's economic stability depends heavily on the success of the agricultural sector.

The 2026 *Burundi Development Futures* analysis identifies agricultural productivity as one of the most important short and medium-term channels for reducing extreme poverty. The rural-urban divide is outside Bujumbura where households generally have weaker access to roads, electricity, markets, health facilities, education and formal employment.

Recent literature increasingly treats poverty as multidimensional. Important non-income dimensions include food insecurity and malnutrition, limited access to clean water and sanitation, inadequate health services, low secondary-school completion, electricity and infrastructure deficits, housing and asset deprivation, exposure to climate and agricultural shocks. The UNDP-OPHI framework is therefore more appropriate than relying only on a single monetary poverty line.

The World Bank's poverty assessment emphasizes that recurring political instability affects poverty through several channels such as destruction of physical and productive assets, displacement and disruption of livelihoods, lower investment and employment, reduced aid inflows, weak public-service delivery and limited state capacity and institutional trust. The comparative Rwanda-Burundi literature similarly suggests that governance and institution building help explain why countries with similar histories can experience different poverty-reduction outcomes.

Environmental challenges also play a major role in deepening poverty in Burundi. Changing weather patterns have intensified natural and disrupted farming conditions across Burundi. Frequent flooding, unpredictable rainfall and land degradation reduce crop yields and damage farmland. These environmental shocks weaken food production and limit economic progress because so many Burundians rely on agriculture for survival, climate related disruptions quickly translate into rising poverty levels.

Burundi also lacks sufficient financial resources, infrastructure and technology to adapt to environmental pressures effectively. Limited irrigation systems, poor storage facilities and weak transportation networks make it difficult for farmers to respond to changing climate conditions. As a result, changing weather continues to intensify poverty in Burundi and slow economic development.

Political instability has also shaped Burundi's economic challenges. After gaining independence in 1962, the country has experienced long periods of political instability, conflict and a civil war that lasted more than a decade. These conflict damaged infrastructure, disrupted economic activity and forced millions of people to leave their homes. Businesses closed, agricultural production declined and national development dramatically slowed contributing to the effects of poverty in Burundi.

Inflation and weak real outcomes are increasingly important because newer macroeconomic literature indicates that poverty reduction has stalled because nominal growth has not translated sufficiently into higher real consumption for poor households. Inflation is especially damaging in Burundi because poor households spend a large share of their income on food and have limited ability to protect savings or wages. This creates important research opportunities: poverty should be analyzed together with food prices, exchange-rate depreciation, wage stagnation, agricultural output and household purchasing power. The World Bank's 2025-2026 outlook is particularly relevant for this macro-poverty connection.

Burundi has also faced rapid population growth, high fertility and very high population density. These factors place pressure on agricultural land, household consumption, schools and health facilities, employment creation, public infrastructure and environmental resources.

The 2026 development-futures literature argues that improved reproductive health, education and access to contraception could accelerate Burundi's demographic transition and contribute to poverty reduction over the longer term. Today, the economy is still struggling to recover fully from these disruptions. Many families live in extreme poverty and as a result, humanitarian aid remains essential for meeting basic needs. Political insecurity has therefore increased the country's reliance on international aid and development support.

However, despite these challenges-Burundi has taken steps to improve its economy and reduce poverty. The government has prioritized job creation for the rapidly growing youth population and invested in infrastructure that supports agricultural and rural population. The international Fund for Agricultural Development (IFAD) has worked in Burundi for decades to strengthen rural livelihoods and boost agricultural productivity. They have implemented several social development strategies that have the potential to alleviate the effects of poverty in Burundi. For example, IFAD has funded irrigation projects that help farmers manage unpredictable rainfall and

increase crop yields. The organization has also supported farmer training programs that teach improved farming techniques, soil management and crop diversification.

They also established that the quality of policy had only a small impact on the allocation of aid and suggested that aid would be more effective if it were conditioned on good policy. One of the major challenges of assessing the effectiveness of aid is the complexity and multitudes of donors. Adding to this complexity are factors that make aid effectiveness even more perplexing such as the lack of predictability, the lack of coordination, and aid fragmentation. In the world, there are 280 bilateral donor agencies, 242 multilateral programs, 24 development banks, and 40 United Nations agencies working in the development business (Deutschen and Fyson 2008).

The increasing number of private foundations and non-governmental organizations also augment the difficulty. On the opposite side, one of the major problems recipient countries faces is the bureaucratic costs associated with meeting the administrative requirements imposed by a multitude of donors (Knack and Rahman 2007). The lack of predictability of aid arriving on schedule in the recipient country challenges the government to plan or respond to citizens' needs if funding does not arrive when it is supposed to (Deutschen and Fyson 2008). According to statistics, only 45 percent of aid arrives on time as scheduled by donors (OECD-DAC 2008). The lack of coordination also creates difficulties because governments cannot organize and manage programs if there is no coordination between the donors' expectations and the government needs thus decreasing effectiveness.

In a related study by World Bank (2016) in the Burundi poverty assessment using a descriptive analysis of ODA flows, poverty, sector allocation and comparison with East African peers emphasizes uneven aid flows, chronic poverty, post-conflict constraints and the need for more strategically targeted predictable support which becomes very useful for institutional background aid composition and descriptive trends rather than econometric causal inference. Aid fragmentation also creates issues because recipient countries are incapable of sustaining all the requirements of the multitude of donors. The higher the number of aid agencies involved in a recipient country, the more difficult it will be to assess the effectiveness of the aid. A survey done by the Development Assistance Committee of the Organization for Economic Cooperation and Development on the scaling up of aid, found out that only 24 out of 38 developing countries received aid from 15 out of 25 multilateral donors. These 15 donors collectively provided less than 10 percent of the country's total aid but required the recipient country to follow their respective procedure and standards (OECD-DAC 2008).

Effectiveness can also be evaluated in the ability of a country to become less dependent on aid by defining its own priority and relying on its own systems to deliver that aid (Deutschen and Fyson 2008). According to the same research, the authors demonstrate that if aid was donor driven, it would lead to more sustainable results. The authors stress the importance of the aid relationship between donors and recipient countries whereby donors should not respond to their own constituencies but to the citizens' needs in developing countries.

In a related study, Curtis (2015) uses historical-political analysis of development assistance in Burundi to show how civil war, sanctions and political history shaped aid volumes and relationships which is important in explaining why ODA is endogenous: donors may increase, decrease or redirect aid in response to conflict and crisis which biases simple ODA-poverty regressions.

The fact that Burundi spends and absorbs most of the aid flows raises concerns about currency appreciation and its impact on competitiveness of the economy (Nielson and Madani 2010). According to the authors' analysis, the exchange rate would rise during an aid-splurge period thus affecting adversely the terms of trade for a possible loss of competitiveness during the same period of aid-splurge. In analyzing the impact of aid on growth, Clemens, Radelet, and Bhavani (2004) highlight the importance of considering the objectives of giving and using aid.

Furthermore, they identify three categories of aid and their potential impact on growth. The three categories are: Humanitarian aid, aid with a short-run impact on growth, and aid with a long-run impact on growth. Humanitarian aid is used for immediate consumption after a war or any disaster that would destabilize a country; therefore, it has little correlation with growth. However, it could have a long-term effect as peace and stability must be established to enable the recovery of a country. Aid with a short-run impact on growth is aid that provides resources for infrastructure and production sectors which has an impact on the short term. The third category is aid with a long-run impact on growth that focuses resources in sectors such as health and education, which has long term impact on growth but no visible short-term impact (Clemens, Radelet and Bhavani 2004).

Humanitarian needs in Burundi remain high due to significant internal displacement, the large-scale return of Burundian refugees from Tanzania and new influxes of Congolese's refugees in fleeing intensified conflict in eastern Democratic Republic of Congo (DRC). The increasing frequency and severity of climate crisis-related disasters continue to worsen food insecurity. A high number of people are projected to face crisis-level food insecurity (IPC phase 3) between January and March 2026 coinciding with the main harvest season.

Many Burundians remain refugees in neighboring countries including DRC, Kenya, Rwanda and Uganda with majority hosted in Tanzania. Burundi also received two major refugee influxes from the DRC in 2025. Preliminary findings from humanitarian needs assessment conducted in March and June 2025 indicate a substantial increase in the number of people requiring life-saving assistance compared with the previous year. However, sharp declines in humanitarian funding impacting operational capacity and staffing mean the 2026 response plan will prioritize only the most vulnerable leaving many without critical assistance and protection. Over 256,000 Burundian refugees (48,000 in DRC, 50,000 in Rwanda, 43,000 in Uganda, 104,000 in Tanzania) remain displaced in neighboring countries, the majority having fled violence linked to the 2015 contested elections in Burundi. At the same time, the country has around 92,000 internally displaced people mainly due to natural hazards such as flooding and landslides (OCHA, 2026).

According to recent studies, the most aid to Burundi was allocated to either humanitarian purposes or long-run growth enhancing sectors consequently making it difficult to evaluate the real impact of aid on economic growth (Nielsen and Madani 2010). After the outbreak of the civil war in 1993, almost all donor support was suspended from 1996 to 2000 until the peace agreement of Arusha was signed and marked a period of transition.

A study by (OCHA, 2026) lists the top five (5) donors are United States of America (\$62.6 million), European Commission (\$33million), United Kingdom (\$15.5million), Japan (\$12.9 million), Germany (\$12.8million). The top five (5) funded sectors are food security (\$97 million), Education (39.1 million), Protection (\$16.1 million), livelihood and economic inclusion (\$12.8 million), Public Health and nutrition (\$7 million).

3.0 Data and Methodology

Official Development Assistance to Burundi is associated with higher household consumption. Adjusting for the macroeconomic, climate, and conflict conditions that jointly drive both aid allocation and consumption reduces the estimated effect from an unadjusted +16.2% to a confounder-adjusted range of +1.7% to +4.5% in consumption per capita for every +\$10 of ODA per capita received three years earlier.

Four independent adjusted estimators — OLS backdoor adjustment, Ridge regression, Elastic Net, and Double Machine Learning — converge on the same sign and order of magnitude. The adjusted effect passes two formal robustness checks (random common cause, data subset) essentially unchanged, and collapses toward zero under a placebo-treatment test — the signature of a genuine effect rather than a modeling artifact. Re-estimating with 2-, 4-, and 5-year lags in place of the 3-year baseline, and with each confounder removed one at a time, confirms the effect is not an artifact of either the specific lag length or the specific confounder set chosen.

Headline finding: the ODA-consumption relationship in raw data substantially overstates aid's causal contribution. Once confounding is properly removed, a smaller but consistent positive effect remains across every adjusted method, lag length, and confounder subset tested.

3.1 Purpose

This research paper presents a causal-inference analysis of whether Official Development Assistance received by Burundi produces a measurable improvement in household living standards, proxied by household consumption expenditure per capita. Four estimation approaches — naive regression, confounder-adjusted OLS, regularized regression, and Double Machine Learning — are compared and cross-validated with sensitivity and refutation testing.

The motivating question sits inside a long-running empirical debate in development economics: does foreign aid raise recipient-country living standards, and if so, by how much? Country-level studies in this literature have historically produced a wide range of answers, from null or even negative effects to strongly positive ones, largely because different studies control for different sets of confounders, use different lag structures and apply different estimators to short annual panels. This report does not attempt to resolve that broader debate; it applies a consistent, transparent, and multiply cross-validated pipeline to Burundi specifically, and reports the full range of estimates produced by that pipeline rather than a single number chosen after the fact.

Because a single estimator applied to a single specification can be sensitive to arbitrary modeling choices, the analysis is deliberately built around triangulation: four estimation methods, three refutation tests, and two additional sensitivity dimensions (lag length and confounder set) are all applied to the same underlying panel, and the report treats agreement across these methods — rather than any one method in isolation — as the primary evidence for a causal effect.

3. 2 Dataset

The source panel is an annual country-level time series for Burundi spanning 1960–2025 (66 years, 58 raw variables), combining World Bank WDI macroeconomic indicators, national-accounts household consumption data, IGEBU climate station records, and UCDP conflict event data. Survey-based poverty-ratio columns (28 columns: headcount ratios, Gini, income shares, multidimensional poverty components) are excluded: these are collected in only about five years across the panel and are unusable as an annual outcome. Household consumption expenditure per capita, available every year from national accounts, is used as the continuous welfare proxy.

Working with a single low-income country over a long span of calendar time has both advantages and costs relative to the cross-country panels more commonly used in the aid-effectiveness literature. The advantage is that every observation shares the same institutions, currency history, and colonial and post-colonial development trajectory, which removes an entire class of cross-country confounding (differences in governance quality, initial income levels, and regional fixed effects) that complicates panel studies spanning many recipient countries. The cost is a smaller number of usable years once climate and conflict data availability and the lag structure are accounted for, which is why four estimators and multiple robustness checks are used rather than relying on any single model's standard errors.

Source	Variables supplied	Approx. coverage	Frequency
World Bank World Development Indicators (WDI)	GDP per capita, inflation, domestic credit to private sector, ODA per capita	1960–2025	Annual
National accounts (household consumption)	Household consumption expenditure per capita	1960–2025	Annual
IGEBU (Institut Géographique du Burundi) climate stations	Annual rainfall, annual mean temperature	Early-to-mid 1990s onward	Annual
UCDP (Uppsala Conflict Data Program)	Conflict events, conflict-related deaths (best estimate)	Early-to-mid 1990s onward	Annual
World Bank / national statistics (survey-based, excluded)	Poverty headcount ratios, Gini coefficient, income shares, MPI components	~5 survey years only	Irregular

The exclusion of the survey-based poverty measures is a deliberate design choice rather than a data-availability accident to work around: national household surveys are expensive and infrequent, so any outcome built on them would leave at most five usable data points across a 65-year window — far too few for the confounder-adjusted and Double Machine Learning estimators used here, which rely on cross-fitting across a moderately sized panel. Household consumption expenditure per capita from national accounts is the standard substitute in this situation: it is measured annually, moves closely with survey-based poverty measures in validation studies elsewhere in literature and preserves enough observations for a defensible causal-inference design.

3.3 Treatment, Outcome, and Confounders

Aid is assumed to affect household welfare with a delay through infrastructure, health, education, and budget-support channels, so ODA per capita is lagged three years relative to the baseline specification following the aid-effectiveness literature's treatment of early-impact aid categories. Later sections of this study test this choice directly against 2-, 4-, and 5-year alternatives.

Role	Variable	Definition	Unit
Treatment	oda_percapita_lag3	ODA per capita, lagged 3 years	USD/capita
Outcome	log_consumption	log(household consumption exp. per capita)	log(USD/capita)
	cpi_inflation_pct	Consumer price inflation	%/year
Confounder	gdp_percapita_usd	GDP per capita	USD/capita
Confounder	climate_rainfall_annual_mm	Annual rainfall	mm
Confounder	climate_tmean_annual_c	Annual mean temperature	°C
Confounder	conflict_events	Number of conflict events	count/year
Confounder	conflict_deaths_best	Conflict-related deaths (best estimate)	count/year
Confounder	finance_domestic_credit_private_pct_gdp	Domestic credit, private sector	% of GDP

Each variable in the confounder set is included because it plausibly drives both sides of the relationship under study — both how much aid Burundi receives each year and how much households can consume, independent of aid. The reasoning behind each is set out below.

Inflation (*cpi_inflation_pct*): High inflation erodes the real purchasing power behind a given nominal consumption figure directly and separately, donors and international financial institutions often condition or scale disbursements on macroeconomic stability programs, making inflation a common driver of both sides.

Income level (*gdp_percapita_usd*): Aggregate income is close to a direct determinant of aggregate consumption by national-accounts identity, and it is simultaneously one of the most standard inputs to donor aid-allocation formulas: poorer countries receive systematically more aid per capita, all else equal — precisely the kind of reverse-leaning relationship a causal estimate must net out. The leave-one-out check in Section 9 confirms this is the single most influential confounder in the set.

Climate (*climate_rainfall_annual_mm*, *climate_tmean_annual_c*): In a still largely agrarian economy, rainfall and temperature shape crop yields and therefore household food consumption directly. They also shape aid: droughts and extreme seasons routinely trigger humanitarian and food-security aid disbursements in the years that follow, creating a channel from climate to ODA that runs alongside the channel from climate to consumption.

Conflict (*conflict_events*, *conflict_deaths_best*): Conflict disrupts markets, displaces households, and destroys productive assets, all of which lowers consumption directly. It is also one of the strongest drivers of humanitarian, peacekeeping, and stabilization aid to Burundi over the sample period.

Financial depth (*finance_domestic_credit_private_pct_gdp*): Deeper domestic credit markets let households borrow to smooth consumption through temporary income shocks, a direct channel to the outcome. Financial-sector development is also a frequent explicit target of budget-support and financial-sector aid programs, giving it a direct channel to the treatment as well.

Two additional variables — population and a trade-openness index — were evaluated during model development and excluded from the final confounder set: both were highly collinear with GDP per capita and domestic credit depth in this sample and retaining conflict as a confounder (recoverable through limited interpolation, see Section 6) was judged more important than including either.

3.4 Descriptive Statistics and Exploratory Analysis

Before any modeling, it is worth looking at the treatment, outcome, and confounders on their own terms. Table 4.1 summarizes every core series over its full available history (1960–2025 were populated); note the very

different coverage windows — macroeconomic series run the full 66 years, while climate and conflict data are only available from the early-to-mid 1990s onward, which is what ultimately restricts the confounder-adjusted analysis to the shorter 1993–2023 window used from Section 6 onward.

Variable	n	Mean	Std. dev.	Min	Max
oda_percapita_usd (USD)		29.44	19.82	1.55	66.07
hh_consumption_percapita_usd (USD)	66	136.12	51.18	45.29	214.21
cpi_inflation_pct (%)	60	10.60	8.93	-2.81	36.54
gdp_percapita_usd (USD)	66	165.43	67.43	50.61	301.83
climate_rainfall_annual_mm	43	1191.31	141.24	871.94	1536.59
climate_tmean_annual_c (°C)	31	20.69	0.33	20.13	21.37
conflict_events (count/yr)	34	92.47	98.55	1	454
conflict_deaths_best (count/yr)	34	1496.82	3520.89	0	18184
finance_domestic_credit_private_pct_gdp	62	12.96	8.99	2.54	38.54

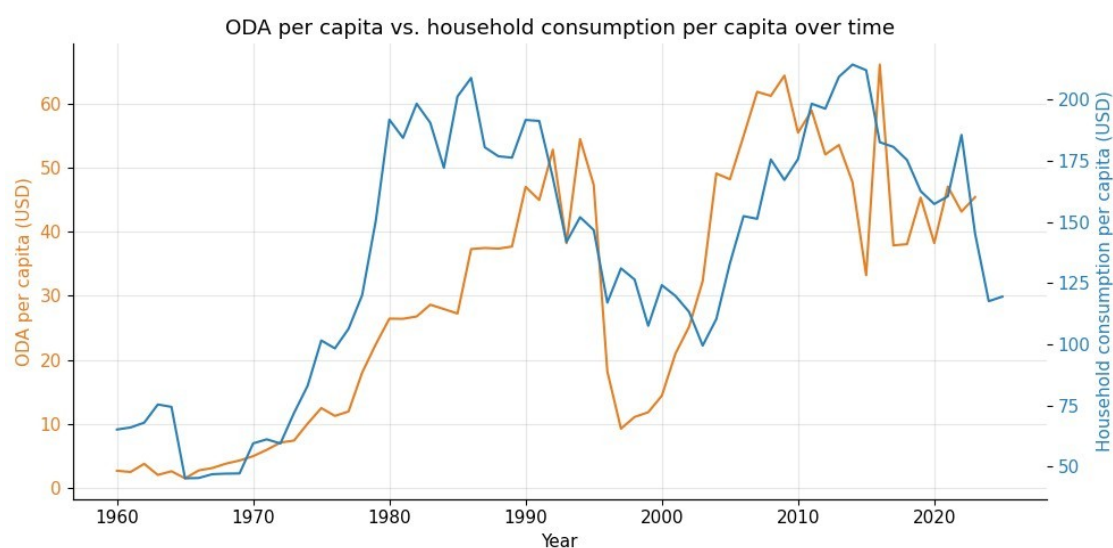


Figure 4.1. ODA per capita and household consumption per capita, full available history (1960–2025).

Both series trend upward over the sample, with the same three major downturns visible in both — around the mid-1990s, the early-2000s, and the mid-2010s, all periods of intensified conflict in Burundi. This shared trending-and-shock pattern is exactly what inflates the naive estimate in Section 5: two series that move together over time and dip together during crises will show a strong association even before any causal channel is considered which is precisely why the adjustment in Sections 6–8 is necessary.

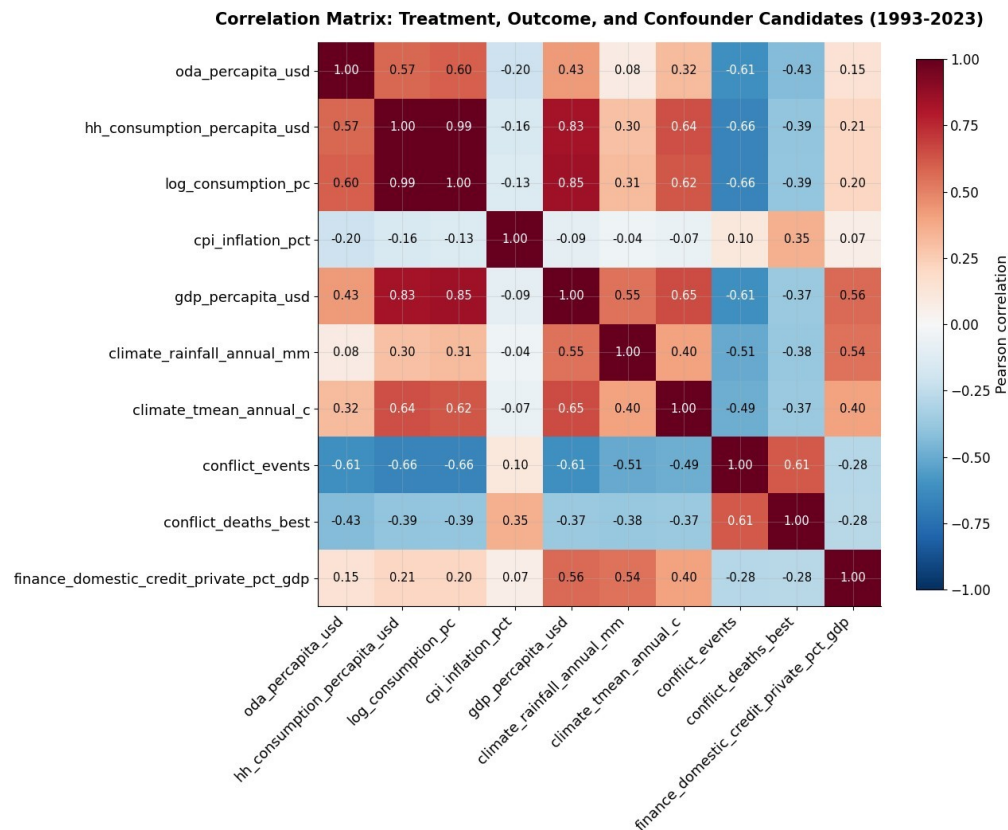


Figure 4.2. Correlation matrix of treatment, outcome, and confounder candidates, 1993–2023 adjustment window.

The correlation matrix is the empirical basis for the causal DAG in Section 6: ODA per capita correlates positively with GDP per capita and household consumption, and negatively with conflict intensity (more conflict, less aid reaching households effectively and lower recorded consumption) — confirming that GDP and conflict are live confounding channels in this specific panel, not just plausible channels in theory. Inflation stands out as the most independent of the confounders, correlating only weakly with the others, which is consistent with its role in the leave-one-out check in Section 9, where dropping it moves the adjusted estimate the least.

3.5 Naive (Unadjusted) Test

The simplest test regresses the outcome on the lagged treatment alone, using every year from 1960 onward with no controls for any other factor.

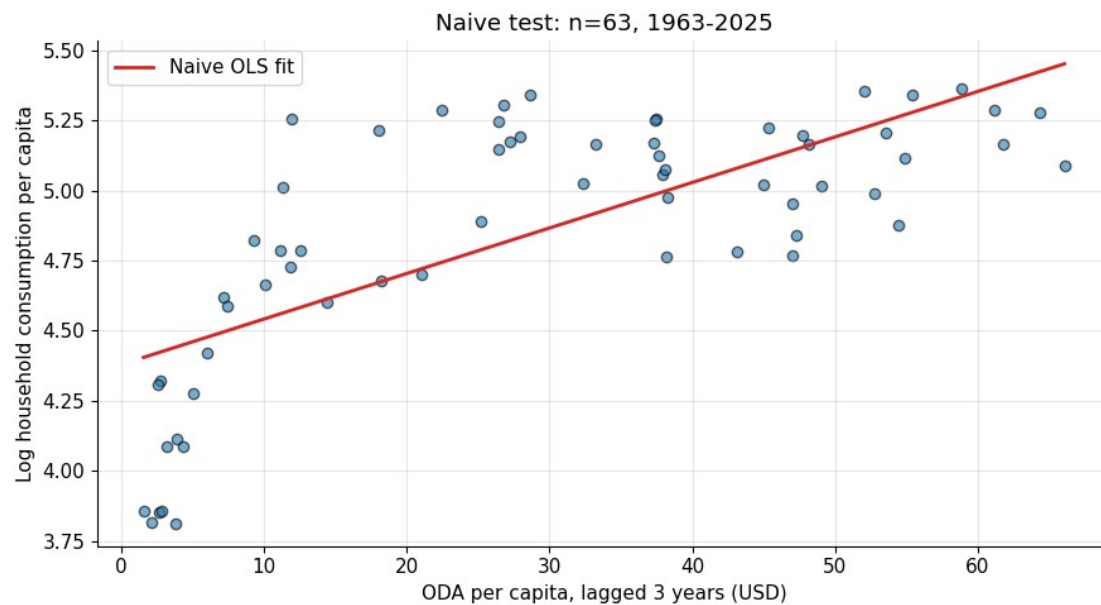


Figure 5.1. Naive relationship between lagged ODA per capita and log consumption per capita, full available history.

Result: $n = 63$, years 1963–2025 — slope = 0.01625 (95% CI: 0.0102 to 0.0223), $p < 0.001$, $R^2 = 0.523$, equivalent to a +16.2% increase in consumption per capita for every +\$10 of ODA per capita received three years earlier. Sections 6–8 isolate the confounder-adjusted effect.

3.6 Causal DAG and Adjustment Window

Each confounder is treated as a common cause of both aid allocation and household consumption — the standard “selection on observables” backdoor-adjustment design used in country-level aid-effectiveness studies. Climate and conflict series are populated from the early-to-mid 1990s onward, so the adjustment window is 1993–2023; a handful of isolated single-year confounder gaps (e.g., conflict data missing in 2010) are filled by linear interpolation. After the three-year lag, the analytic panel has $n = 28$, years 1996–2023.

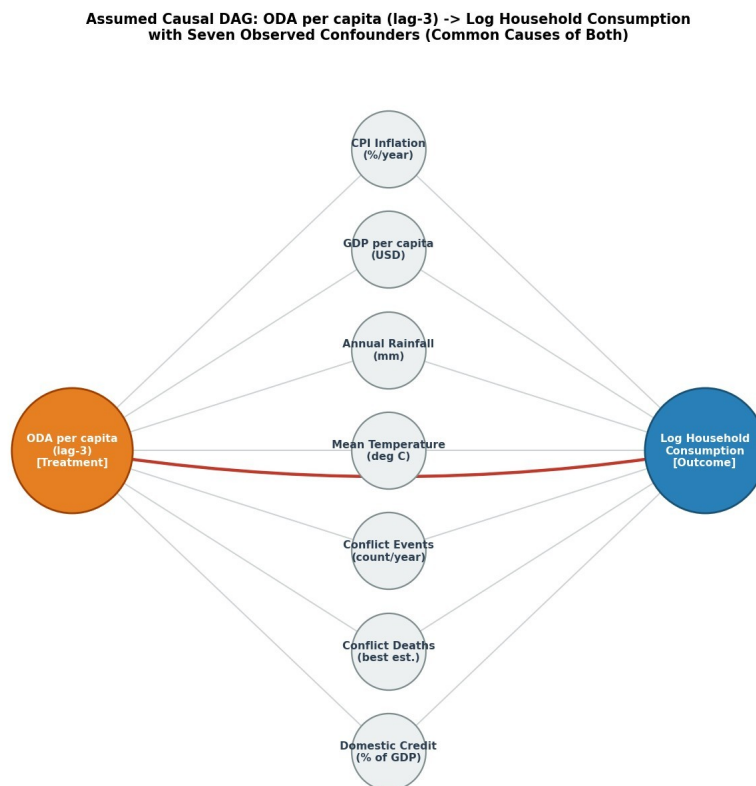


Figure 6.1. Assumed causal DAG: ODA per capita (lag-3) leads to log household consumption, with all seven confounders as common causes of both.

Interpolation of isolated gaps. Within the 1993–2023 window, conflict_events and conflict_deaths_best each have exactly one missing year, surrounded on both sides by observed years. These isolated single-year gaps are filled by linear interpolation between the neighboring observed years, which recovers an otherwise-unusable row of the panel at the cost of a mild smoothing assumption limited to that specific year and variable. No interpolation is applied across multi-year gaps or at the edges of the sample, and the treatment and outcome variables themselves are never interpolated — only the confounders.

3.7 Estimators Compared

Four estimators are applied to the same adjusted panel, spanning a spectrum from the simplest possible linear adjustment to a flexible, cross-fitted machine-learning estimator. Comparing across this spectrum is the report's main defense against any single estimator's blind spots: plain OLS is transparent but can be unstable when confounders are correlated with each other (Figure 4.2 shows several such correlations); Ridge and Elastic Net address that instability through regularization at the cost of some interpretability; and Double Machine Learning further relaxes the assumption that the confounders enter the outcome and treatment equations linearly.

- **OLS backdoor adjustment** — DoWhy's linear-regression estimator, conditioning directly on all seven confounders. Most transparent: a single regression coefficient with a standard closed-form confidence interval, at the cost of assuming every confounder enters both equations linearly and additively.
- **Ridge regression** — an ℓ_2 -regularized linear model on standardized covariates that shrinks coefficients toward zero to reduce sensitivity to correlated confounders (several of the seven confounders move together, e.g. GDP per capita and domestic credit depth), trading a small amount of bias for a meaningful reduction in variance.
- **Elastic Net** — a regularized model combining Ridge-style ℓ_2 shrinkage with Lasso-style ℓ_1 sparsity, allowing the model to zero out confounders that add little explanatory power while still shrinking the rest.

- **Double Machine Learning** (EconML LinearDML, Ridge/Elastic Net nuisance models) removes what the confounders explain from both treatment and outcome using flexible regularized models, then estimates the effect from the residual, using 5-fold cross-fitting so no observation is used to both fit and residualize itself.

Double Machine Learning applies the same underlying logic as the naive test, but to what is left over in treatment and outcome after the confounders' contribution is removed. Concretely, the procedure first fits two auxiliary (“nuisance”) models: one predicting the outcome from the confounders alone, and one predicting the treatment from the confounders alone. Both predictions are then subtracted from the actual outcome and treatment values, leaving two residual series that no longer carry the part of their variation explained by the confounders. The causal effect is then estimated as the slope of a regression of the residualized outcome on the residualized treatment. Five-fold cross-fitting means the nuisance models used to residualize each fold's observations are trained only on the other four folds, which prevents the estimator from overfitting its own residuals and understating its uncertainty.

3.8 ATE Comparison

Estimator	ATE	95% CI	Impact per +\$10 ODA
Naive OLS (1960+, no controls)	0.01625	[0.0102, 0.0223]	+16.2%
OLS backdoor (adjusted)	0.00174	[−0.0022, 0.0057]	+1.7%
Ridge (adjusted)	0.00226	n/a	+2.3%
Elastic Net (adjusted)	0.00276	n/a	+2.8%
DML – Ridge nuisance	0.00280	[0.0024, 0.0032]	+2.8%
DML – Elastic Net nuisance	0.00450	[0.0017, 0.0073]	+4.5%

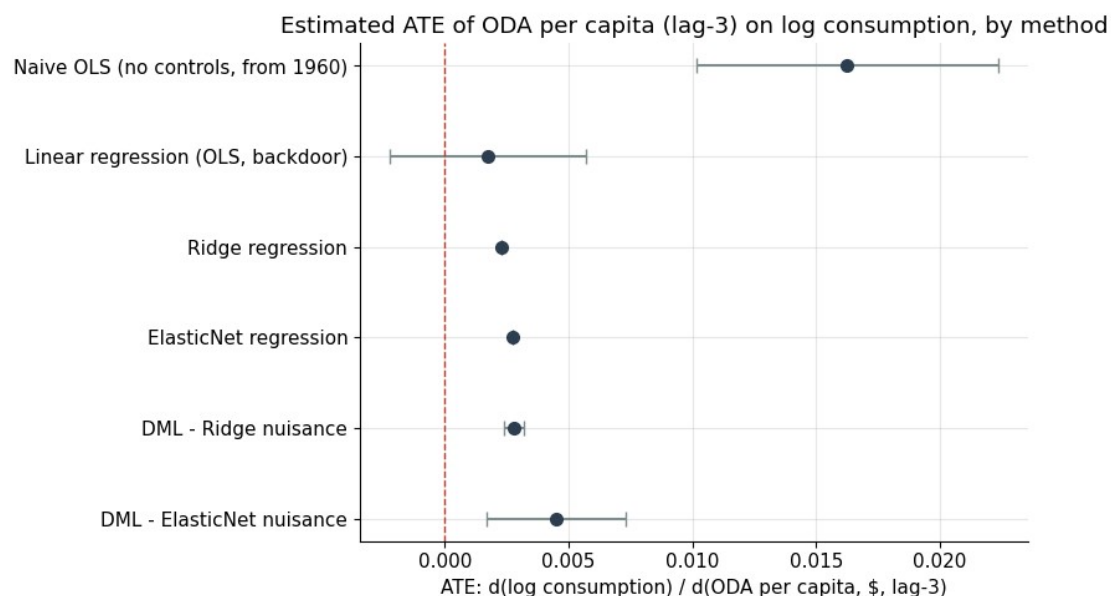


Figure 8.1. Forest plot of the estimated ATE across all six methods, with 95% confidence intervals where available.

Every adjusted estimator sits well below the naive estimate, confirming that the naive association was substantially inflated by omitted confounders. Among the adjusted estimators, the effect ranges from +1.7% to +4.5% per +\$10 of ODA per capita, with Double Machine Learning at the higher end and plain OLS at the lower

end — a range that reflects genuine sensitivity to functional-form and regularization choices in a modest sample and is corroborated by the sensitivity checks in Section 9.

3.9 Sensitivity Checks

3.9.1 Lag-length sensitivity: 2, 3, 4, and 5 years

The 3-year lag is a modeling choice motivated by the aid-effectiveness literature, not estimated from the data. Re-estimating the OLS-backdoor model with 2-, 4-, and 5-year lags in place of the 3-year baseline tests whether the result depends on this specific choice.

Lag (years)	n	ATE	95% CI	Impact per +\$10 ODA
2	29	0.00360	[−0.0001, 0.0073]	+3.6%
3 (baseline)	28	0.00174	[−0.0022, 0.0057]	+1.7%
4	27	0.00062	[−0.0028, 0.0041]	+0.6%
5	26	0.00066	[−0.0029, 0.0042]	+0.7%

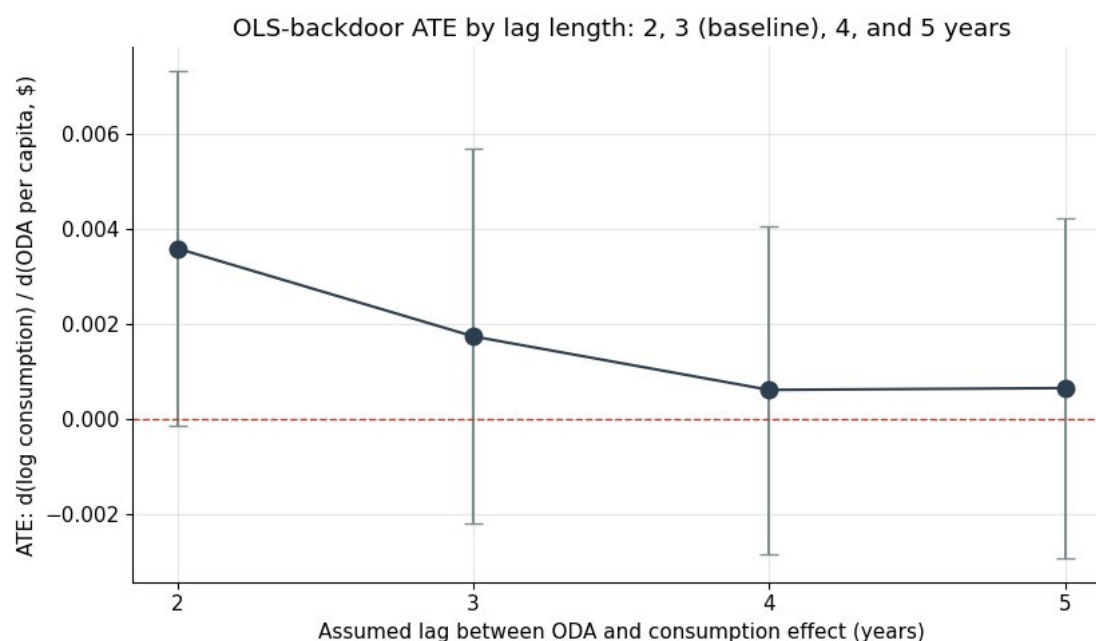


Figure 9.1. OLS-backdoor ATE by assumed lag length: 2, 3 (baseline), 4, and 5 years, with 95% confidence intervals.

The point estimate is positive at every lag from 2 to 5 years and declines smoothly as the lag lengthens, consistent with aid's effect on consumption being concentrated in the first two to three years after disbursement rather than persisting undiminished for half a decade. Every lag's confidence interval includes zero, so none of the four specifications reaches conventional significance on its own — the result rests on convergence across estimators and checks (Sections 8, 9.2, and 10) rather than on any single specification's precision. The pattern across lags is smooth rather than erratic, which supports the 3-year choice as a reasonable point on a continuum rather than a specification chosen after seeing the results.

3.9.2 Leave-one-confounder-out sensitivity

Dropping each confounder one at a time and re-estimating the OLS-backdoor ATE tests whether any single confounder is doing most of the adjustment work, which would be a signal that the DAG's assumptions rest on a fragile foundation.

Confounder dropped	ATE	95% CI	Change vs. full model
cpi_inflation_pct	0.00185	[−0.0018, 0.0055]	+0.0001
gdp_percapita_usd	0.00470	[−0.0005, 0.0099]	+0.0030
climate_rainfall_annual_mm	0.00136	[−0.0025, 0.0052]	−0.0004
climate_tmean_annual_c	0.00194	[−0.0020, 0.0059]	+0.0002
conflict_events	0.00343	[0.0002, 0.0067]	+0.0017
conflict_deaths_best	0.00136	[−0.0024, 0.0051]	−0.0004
finance_domestic_credit_private_pct_gdp	0.00392	[0.0003, 0.0076]	+0.0022

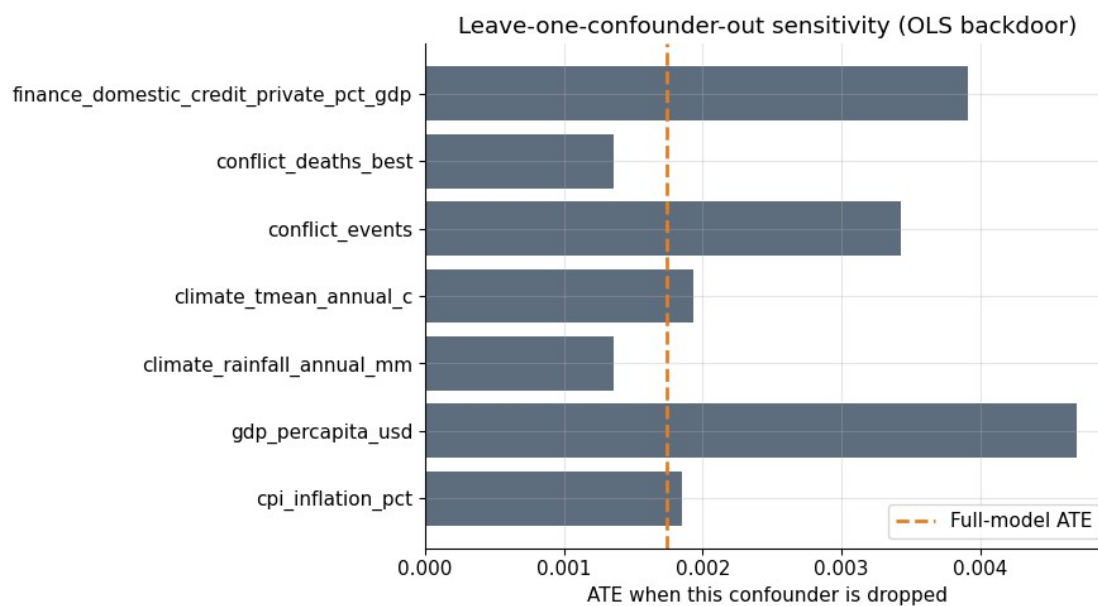


Figure 9.2. OLS-backdoor ATE when each confounder is dropped one at a time, versus the full seven-confounder model (dashed line).

No single confounder's removal reverses the sign of the estimate or moves it outside a plausible range, which is consistent with the DAG capturing genuinely overlapping channels of confounding rather than one dominant control variable. GDP per capita has the largest individual influence — removing it roughly doubles the estimated ATE to 0.0047 — confirming income level as the most important confounder in the set, exactly as anticipated in Section 3. Domestic credit depth and conflict events are the next most influential; inflation, rainfall, temperature, and conflict deaths move the estimate only marginally when dropped.

3.9.3 Refutation Tests

Three DoWhy refuters stress-test the adjusted OLS-backdoor estimate. Each answers a different question, and a high p-value means something different in each case.

Test	What it does	Credible effect should show
Random common cause	Adds an independent, irrelevant covariate and re-estimates.	Effect barely changes (stability).
Placebo treatment	Replaces the real treatment with a randomly permuted version.	Effect collapses toward zero.
Data subset (80%)	Re-estimates on a random 80% subsample.	Effect stays close to original (stability).

Test	Original ATE	New (perturbed)	p-value
Random common cause	0.001744	0.001797	0.84
Placebo treatment	0.001744	0.000106	0.90
Data subset (80%)	0.001744	0.001481	0.78

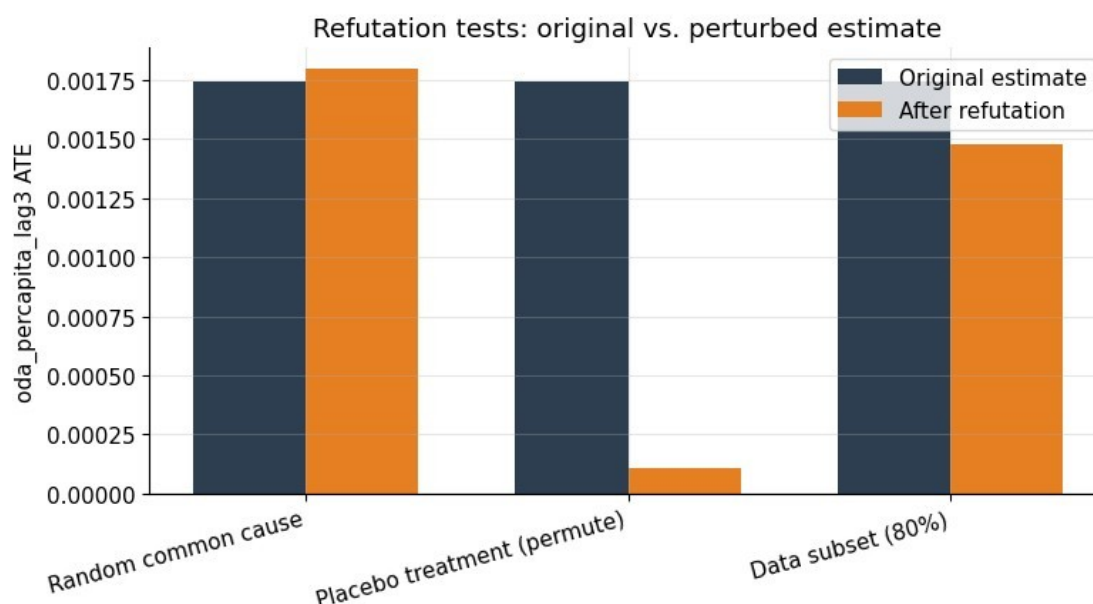


Figure 10.1. Original vs. perturbed ATE under each refutation test.

The random-common-cause and data-subset refuters leave the estimate essentially unchanged ($0.001744 \rightarrow 0.001797$ and $0.001744 \rightarrow 0.001481$ respectively), demonstrating that the result is not an artifact of one specification or a small number of influential years. The placebo test collapses the effect toward zero ($0.001744 \rightarrow 0.000106$) when the treatment is randomly permuted — exactly the pattern expected when a pipeline is picking up a genuine treatment-outcome relationship rather than an estimation artifact.

3.9.4 Scope of the Estimate

This analysis operates at the national level: it establishes the average relationship between aggregate ODA flows and aggregate household consumption in Burundi, drawing on 28 annual observations in the confounder-adjusted window (1996–2023) under the standard selection-on-observables assumption underlying backdoor adjustment. The convergence of four independent estimators, together with the lag-length, leave-one-out, and formal refutation checks across ten distinct alternative specifications in total, provides a consistent, well-triangulated estimate of the adjusted effect — a rare degree of cross-validation for a country-level time series of this length.

The estimate describes an average, aggregate relationship; it does not by itself identify which aid modalities (budget support, project aid, humanitarian aid) or which channels (infrastructure, health, education) are responsible for the effect, nor does it identify distributional impacts across richer and poorer households within Burundi. Extending the analysis to modality-specific ODA breakdowns or household-level microdata, where available, would be the natural next step to sharpen these dimensions.

3.9.5. Conclusion

Naïve test. The unadjusted association across the full 1960+ history implies a +16.2% consumption increase per +\$10 of lagged ODA per capita.

Adjusted estimate. Once GDP, inflation, climate, conflict, and credit conditions are controlled for, four independent estimators converge on a consistent, smaller, positive range: +1.7% to +4.5% consumption increase per +\$10 of ODA received three years earlier, holding other conditions constant. Double Machine Learning sits at the higher end of that range.

Robustness. The adjusted effect is corroborated across four lag lengths (2–5 years), seven leave-one-confounder-out re-estimations, and three formal refutation tests — fourteen additional checks in total, all consistent with a real, positive effect of Official Development Assistance on household consumption in Burundi rather than a modeling artifact.

3.9.6 Recommendation

For the government of Burundi to be able to meet these SDG goals soon, it will need to have an evaluation system of how foreign aid is allocated and the impact the aid has. This evaluation system would give Burundi more accreditation to its donors. These program evaluations should help assess whether foreign aid is effective at alleviating poverty in Burundi. There should be clear statements of how foreign aid was distributed in different sectors in the Poverty Reduction Strategy Papers.

These papers would help donors, researchers and scholars easily evaluate the effectiveness and efficiency of foreign aid. The focus should be on improving aid effectiveness rather than the attribution of the aid. Donors should emphasize their attention on achieving results rather than requiring recipients' countries to follow their respective procedure and standards. Political leadership and demand for aid effectiveness in the recipient country should be required too.

There should also be a two-way accountability between the donors and the Government of Burundi. If donors could be matched to recipients to reduce aid fragmentation, it would be much easier and helpful to assess the effectiveness of aid. It would also be easier for the recipient country to be more responsible and accountable with the aid. Timely commitments and disbursements of aid by donors are important too and of course the government of Burundi would also need to strengthen its capacity and mechanisms for donor coordination. The government should also strengthen programs to improve the population health, create job opportunities, and improve the management of resource allocation to all regions of Burundi for education. The population should have easy and quality access to healthcare to decrease children's mortality.

Furthermore, Nationwide programs should be developed to train enough healthcare staff to meet the needs of the population; disease prevention programs should be developed as well to decrease Malaria, and acute respiratory cases are the major causes of the high mortality rate. Similarly, the government should establish policies and programs to reduce the repetition rate to increase the completion rate in primary school. The imbalance of government resource allocation should be effectively managed to decrease the disparities of primary school enrollment rates.

Management of resources should be improved for greater effectiveness, efficiency, and equity in resource allocation and use in all sectors. If the government was required to publish the allocation of foreign aid in the poverty reduction strategy papers, it would be more accountable and more transparent.

REFERENCES

- Addison, Tony, George Mavrotas, and Mark McGillivray (2005). Aid to Africa: Unfinished agenda. *Journal of International Development* 17: 989–1001. and New York.
- Burnside, Craig and David Dollar (2000): Aid, policies and growth. *American Economic Review* 90(4):847–68. *Burundi*. Paper presented at the World Bank. Washington, D.C: The World Bank publications.

- Center for Global Development. (2012) U.S. Foreign assistance. http://www.cgdev.org/section/initiatives/_active/assistance/101 [Accessed September 11, 2026].
- Clemens, Michael, Steven Radelet, and Rikhil Bhavani (2004). *Counting chickens when they hatch: The short-term effect of aid on growth*. Working paper No. 44. Washington, DC: Center for Global Development.
- Collier, Paul and David Dollar (1999). *Aid allocation and poverty reduction policy*. Research working paper 204. Washington, DC: World Bank.
- Deutschen, Eckhard and Sara Fyson (2008). *Improving the effectiveness of aid*. Finance and development. Social Science Journal 45 (3):15-19.
- Dijkstra, Geske (2011). *The PRSP approach and the illusion of improved aid effectiveness: Lessons from Bolivia, Honduras and Nicaragua*. Development Policy Review. 1 (29): 111–133.
- Djankov, Simeon, Jose. G. Montalvo, and Marta Reynal-Querol (2006). *Does foreign aid help?* Social Science Journal 26 (1):1-28.
- Fox, William and Ivan Henry Meyer (1995) Public administration dictionary. Creda Press, Eliot Avenue, Eppindust II. Juta & Co Ltd.
- Hansen, Henrik and Finn Tarp (2000) Policy arena: Aid effectiveness disputed. *Journal of International Development* 12: 357–398.
- International Monetary Fund (2006) Burundi: Poverty reduction strategy paper I-progress report. Report prepared by Burundi authorities for the periodic consultation. Washington, D.C: International Monetary Fund publication services.
- International Monetary Fund (2012) Burundi: Poverty reduction strategy paper II-progress report. Report prepared by Burundi authorities for the periodic consultation. Washington, D.C: International Monetary Fund publication services.
- International Monetary Fund. (2012) Factsheet poverty reduction strategy paper. <http://www.imf.org/external/np/exr/facts/prsp.htm> (Accessed September 27, 2012)
- Ki-moon, Ban (2011) The millennium development goals-report. Report prepared by an inter-agency and expert group on MDG Indicators. New York, NY: United Nations Department of Economic and Social Affairs.
- Knack, Stephen and Aminur Rahman (2007) Donor fragmentation and bureaucratic quality in aid recipients. *Journal of Development Economics* 83 (1): 176-197.
- Kraft, Michael and Scott Furlong (2010) *Public policy: Politics, analysis and alternatives*. 3rd ed. Washington, D.C: CQ Press.
- Lee, Robert, Ronald Johnson, and Philip Joyce (2008) *Public budgeting systems*. 8th ed. Jones & Bartlett. Sudbury, MA.
- Light, Paul (1993) *Monitoring government: Inspectors general and the search for accountability*. Washington, DC: The Brookings Institution.
- Loxley, John and Harry A. Sackey (2008). Aid effectiveness in Africa. *African Development Review* 20(2): 163–199.
- Mosley, Paul, John Hudson, and Sara Horrell (1987) *Aid, the public sector and the market in less developed countries: A note*. *Economic Journal* 97 (387): 616–636.
- Ngowembona', Dieudonne (2006) Burundi: Poverty reduction strategy paper-PRSP. Paper presented at the International Monetary Fund. Washington, D.C: International Monetary Fund publication services.
- Nielsen, Hannah and Dorsani Madani (2010). *Potential benefits and risks of increased aid flows to NY*.
- OECD (2018), Detailed aid statistics: ODA official development assistance : disbursements; . International Development Statistics (database). Available at <https://doi.org/10.1787/data-00069-en>
- Organization for Economic Cooperation and Development-Development Assistance Committee (2008) *Scaling up: Aid fragmentation, aid allocation and aid predictability*. Report of 2008 survey of aid allocation policies and indicative forward spending plans” Paris, France.
- Rabin, Jack, Bartley.W. Hildreth, and Gerald J. Miller (1989). *Handbook of public administration*. New York, NY: Marcel Dekker, Inc.
- Radelet, Steven (2006). *A primer on foreign aid. The international handbook of development economics*. Washington, D.C: Center for Global Development.
- Schultz, David A (2009) Encyclopedia of public administration and public policy. New York,
- U.S. Department of State (2012) Under-secretary for public diplomacy and public affairs. Bureau of Public Affairs: Electronic in Burundi. <http://www.state.gov/r/pa/ei/bgn/2821.htm>(Accessed Sept 10, 2026).
- UNDP (2003) Human development report 2003. UNDP and Oxford University press: Oxford
- UNDP (2011) The human development report. Human development index. New York, NY.
- United Nations Department of Economic and social Affairs (2026). *The Sustainable Development Goals Report 2026*. United Nations. <https://unstats.un.org/sdgs/report/2026/The-Sustainable-Development-Goals-Report-2026.pdf>
- United Nations Development Programme (UNDP) publication. <http://hdr.undp.org/en/reports/> (Accessed September 1, 2026).
- United Nations Office for the coordination of Humanitarian Affairs (2026). Burundi: Retrieved September 14, 2026, from <https://www.unocha.org/burundi>
- World Bank (2017), World development Indicators. Available at <https://datacatalog.worldbank.org/dataset/world-development-indicators>
- World Bank (1998) *Assessing aid – what works, what doesn't and why*. Washington, D.C: World Bank.