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On the empirics of violence, inequality, and income

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Abstract

Aim/purpose – This paper aims to examine with new empirical evidence the joint relationships between violence, income inequality, and real income per capita in a simultaneous equation framework using a worldwide sample at the country level.

Design/methodology/approach – To examine the several simultaneous relationships between the variables, this study uses the Seemingly Unrelated Regression (SUR) and Three-Stage Least Squares (3SLS) with two-way fixed effects on a linear system of regression equations. The data used for analysis are sourced from the World Bank, the SWIID inequality database, and the Penn World Table. The final sample for the estimations includes 110 countries in the period between 1994 and 2019.

Findings – Based on the estimations, the results confirm a strong positive relationship between violence and income inequality. Conversely, a negative but non-robust relationship exists between violence and real income per capita. Additionally, the findings show that human capital based on years of schooling plays a critical role in reducing both inequality and violence.

Research implications/limitations – The negative relationship between income and violence is sensitive to the sample size. The institutional framework characterized by high levels of democracy does not ensure by itself a reduction in violence. The SUR model is limited to the endogeneity of the variables. Instruments selected for the 3SLS are based on previous lags of the endogenous variables, no external instruments were used. Data availability also compromises extending the estimations with a greater number of controls.

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Originality/value/contribution – This study considers the explicit joint simultaneous endogenous behavior of income inequality, violence, and real income in a worldwide sample, which contrasts most of the traditional individual-type analysis of previous studies with limited samples. Furthermore, it provides evidence of the importance of human capital and the existence of the non-robust relationships between income and violence.

Keywords: violence, inequality, income, simultaneous, worldide.
JEL Classification: O11, O50, F52.

1. Introduction

In the last two centuries, there has been a growing concern in the fields of economics and political science about the problems and consequences of income inequality and violence. Several empirical studies and discussions, such as those by Anser et al. (2020), Coccia (2018), Deaton (1997), Jawadi et al. (2021), and Parashari and Kumar (2022), have made valuable efforts to identify the relationships between these phenomena.

Important theoretical approximations have been formulated in the field of economics of crime and conflict. These are directly related to the works of Hirshleifer (1989, 1991a, 1991b), Jia and Skaperdas (2012), and Verwimp et al. (2019) based on microeconomic approaches, which are gradually starting to include the role of income in the optimal decision-making of agents for whom inequality is a given situation that can potentially trigger conflict. When these formulations involve the relationships between economic growth and income inequality, empirical evidence shows heterogeneous and differential results across different econometric techniques, specifications, and samples (Banerjee & Duflo, 2003).

The relationships between violence, inequality, and income are studied because they are directly related to the economics of development, and the policy implications of the "explosion of violence" (Currie, 2019) in recent decades demand a rapid understanding of the multiple issues related to these problems. How does inequality interrelate with violence? How does income affect both? Do they affect each other simultaneously or individually? Most of these questions are still the subject of ongoing debate. The purpose of this paper is to contribute to this discussion with new empirical evidence of the joint dynamics of these variables, instead of the traditional isolated non-simultaneous approaches that have mainly focused on developed economies.

The research gap is identified as the lack of analysis at the global level when income, inequality, and violence are related at this scale. This includes not only the examination of individual dynamics but also the investigation of simultaneous joint dynamics of these variables.

Under the framework of the technologies of conflict,[1] the present research uses the country-level data available from the World Bank (2022), the Penn World Table (https://www.rug.nl/ggdc/productivity/pwt/?lang=en), and the SWIID inequality database (https://fsolt.org/swiid/) to examine the interdependence between violence, real income per capita, and income inequality across the world through a linear system of regression equations. The methodology begins with the Seemingly Unrelated Regression (SUR) (cf. Godwin, 1985; Greene, 2018; Zellner, 1962) and then proceeds to examine the dynamics under Three--Stage Least Squares (3SLS) to identify inner dynamics within the system in the presence of endogenous variables (Zellner & Theil, 1962). During the first stage of the 3SLS estimations, a two-way fixed effects specification is used to control for the potential endogeneity raised from the unobserved country and time factors. The instruments used for the 3SLS estimations are based on the scores of the first principal components of the three previous lagged values of the endogenous variables of income, inequality, homicide rates, human capital, political rights, unemployment, and international trade to create an exactly-identified system.

The results show robust evidence, through the different estimations (SUR and 3SLS), of a positive relationship between income inequality and violence. In contrast, the relationship between violence and the real income per capita is not robust and negative in nature, but with changes in the statistical significance during the estimations. An additional result that emerges from the estimations is a strong inverse relationship between human capital and violence, with the former also having a strong inverse relationship with income inequality.

The next parts of the paper are divided as follows; Section 2 presents a literature review on income inequality, real income per capita, and studies on violence. Section 3 provides a theoretical framework to identify the relationships between these variables. Section 4 describes the research methodology. Section 5 presents some stylized facts around the world, and the results of the SUR and 3SLS estimations. Section 6 provides a general discussion of the main results, possible causes, and concerns. Finally, Section 7 presents the study's general conclusions along with the primary limitations involved.

[1] Theory with developments in Jia and Skaperdas (2012), and Hirshleifer (1989, 1991a, 1991b).

2. Literature review

Several studies provided essential insights into the research process about the relationship between violence, inequality, and real income per capita, where two main branches start respectively with the relationship of inequality and income and move further to the research of inequality and violence. Moreover, the joint dynamics in some of these variables have gained particular interest in the last twenty years.

The starting point of this literature is credited to Kuznets (1955), which established the hypothesis that across the development path of the economies, increases in the real income per capita are associated with decreasing levels of income inequality. Similarly, Alesina and Rodrik (1994) provided a theoretical framework that relates inequalities with negative consequences in economic growth; this framework is confirmed with the empirical information of cross--countries regressions using the Gini coefficient and income (dependent variable) under least squares estimates and two-stage approaches. Chen and Fleisher (1996), using panel data with fixed effects in China, stated that interregional convergence in income is achieved by adequate politics of spatially equalized human capital. Persson and Tabellini (1994) studied the dynamics of inequality and economic growth using panel data of 56 selected economies considering pre-tax income share of the third quintile as a measure of equality to provide evidence through least squares regressions that growth is affected by inequality under democracies, Clarke (1995) with influential research, provided evidence at the world level that economic growth is negatively correlated with inequality measured by the Gini coefficient, involving controls associated with political instability, human capital, size of the government and initial GDP.

The study by Barro (2000), based on the Kuznets hypothesis, studied how inequality is associated with income per capita, government (government consumption), institutions (rule of law and democracy indexes), inflation, education (years of schooling), and international trade. This study uniquely addressed the joint determination of these variables employing the 3SLS and using lagged values as instruments. In general, the results appointed that when the Gini coefficient is introduced directly in the simultaneous system, there is a negative effect of inequality over economic growth for the poorest countries. An exercise of determinants of inequality is carried out with the SUR method applied to the available data, where inequality rises when income increases, controlling for the same set of variables as the 3SLS.

Deininger and Squire (1998), Mo (2000), and Panizza (2002), among others, supported the idea of an inverse (or negative) correlation between inequality and economic growth. These authors applied cross-country regressions of income on inequality measures involving the Gini, land distribution, investment, and education. The direct evidence which contradicts the previous statement about the inverse correlation of inequality and income is described in De Dominicis et al. (2008), where authors such as Castelló-Climent (2004), Forbes (2000), Li and Zou (2002), and Voitchovsky (2005) provided further insights on the heterogeneities of the results linked to positive correlations and potential reverse-causality between growth and income inequality, this section of the literature identified the problem of simultaneous relationships which was often neglected in previous studies.

Related to the second branch that incorporates violence within the studies, authors like Neumayer (2003) provided evidence that violence/crime measured through intentional homicides in cross-national panel data revealed an inverse relationship with economic growth; this evidence was based on a sample of 117 countries with the fixed effects approach, controlling for variables related to democracy, income, and human rights (institutional framework). Hence, higher income levels (and several covariates oriented to good political governance) are associated with lower rates of homicides across countries.

In this same line of reasoning, Fajnzylber et al. (2001) studied the correlation between income inequality (measured by the Gini coefficient) and the levels of homicides and robbery in different countries of the world. These authors used least squares and the Generalized Method of Moments (GMM) to inspect if inequality is related to these measures of violence by controlling for factors associated with income, urbanization, and education. The main results pointed out that crime and inequality are linked positively within and between countries, implying that increasing levels of crime tend to be associated with higher levels of income inequality. An important insight into the topic can be found in Cornwell and Trumbull (1994) where it was stated the potential endogeneity raised from two sources, the unobserved heterogeneity and the simultaneity raised through the inner dynamics in an economy (endogeneity raised from the economic forces related to the structure of the labor supply and strategies to counter-attack crime).

The perspective of Pickett and Wilkinson (2010) remarked that social and health problems like crime, illness, murders, and mortality in an economy are a consequence of income inequality (and not precisely poverty), which must be attenuated by the redistribution frameworks to reduce the likelihood of occur-

rence these problems. The idea is that general inequality under the social structure creates distress and feelings of anxiety in individuals. Which later affects the confidence in the rules and institutions within a society. To reach these conclusions, the authors analyzed the 50 richer countries of the world, using inequality data (gap of the average richest and poorest 20% decile of the population), compared with life expectancy, income, and consumption patterns.

In a panel data study using Auto-Regressive Distributed Lag models (ARDL) from Jeke et al. (2021) in the South African economy, crime, development, economic growth, and investment interdependence were investigated. The results established that crime reduces economic growth, discouraging investment and fueling migration, deteriorating human development. However, an essential theoretical design, but more oriented to the evolution of political institutions, can be found in Cervellati et al. (2008), where conflict (as an expression of violence) is an inherent outcome of the decisions between two agents in the economy, the elite and the people in the form of static and dynamic games, which eventually lead to the "taxonomy of political regimes" where inequality translates a state of nature among individuals (heavily conflictive and violent) before the democratic republic emerges.

One of the most important contributions in the recent time which studied the dynamics of income inequality, growth, crime (measured by intentional homicide rates), and poverty can be found in Anser et al. (2020) that employed the GMM in a panel data sample of 16 countries from 1990 to 2014. The study was also segmented by income levels, where differential dynamics were found across the estimations. Aspects like income inequality (measured by Gini) and the unemployment rate tend to increase the size of crime rates in the economies. The study presented some meaningful relationships to be considered: education, health, and wealth are inversely correlated with crime rates; meanwhile, social expenditure has a positive impact in terms of reducing the crime rate. The results also mentioned the U-shape relationship between income and poverty, and that economic growth has an inverted U-shape with inequality. Hence, under the improvement in income distributions, there is a reduction in poverty and crime. However, the study did not state that the equations are estimated with joint dynamics and limited to the sample size given the large amounts of controls available only for developed countries.

In general, the research gap in this literature exists in what relates to the absence of studies addressing the joint and simultaneous dynamics of violence/crime, inequality, and income. Most of the studies are based on single-type regressions, which neglects the simultaneity bias, and the reverse causality prob-

lems, although some of them deal with the latter by using instrumental variables. The general problem of simultaneity and joint dynamics remains, and this is intended to be treated in the present study using the currently available world data.

3. Theoretical framework

Consider a single economy in which two groups (parties) may exist. Let j be a specific group, where $j = 1$ defines the first group (the rich), and $j = 2$ the second group (the poor). According to the technologies of conflict by Hirshleifer[2] (1989) and recent developments in Garfinkel and Skaperdas (2007), Jia and Skaperdas (2012), and Parashari and Kumar (2022), in this single economy, each group possesses an exogenous initial amount of resources R_j that are disaggregated into "useful production" denoted by E_j, and "wasteful production of guns" denoted by G_j. This is formulated in the following Resource Partition Equations (RPE):

$$\begin{aligned} R_1 &= E_1 + G_1 \\ R_2 &= E_2 + G_2 \end{aligned} \tag{1}$$

In Hirshleifer's (1991a) framework, only useful production is given by the variables E_1 and E_2, thus it directly neglects the role of guns and weapons in the aggregate production function defined as:

$$Y = A\left(E_1^{\frac{1}{s}} + E_2^{\frac{1}{s}}\right) \tag{2}$$

Where A is the total productivity index, and s is a parameter that captures the complementarity between each useful production E_j, referred to as the synergistical link with international trade.[3] In general, if $s = 1$ then complementarity does not exist between useful production. Furthermore, each group has a probability p_j of winning given by the Contest Success Function (CSF), which only takes into account the production of guns and weapons. For analytical tractability, the technologies of conflict are presented in the "power form" of the CSF:

$$\begin{aligned} p_1 &= \frac{G_1^m}{G_1^m + G_2^m} \\ p_2 &= \frac{G_2^m}{G_1^m + G_2^m} \end{aligned} \tag{3}$$

[2] And further developed in Hirshleifer (1991a, 1991b).

[3] In Hirshfield (1991a) larger values of *s*, determinate the level of complementarity of aggregate production between groups; for $s = 1$ it is an additive form of the aggregate production function where no complementarity exists.

Hence, the probability of winning for a certain group in this economy is the ratio of the individual and total production of weapons. Let m be a parameter that defines the "decisiveness of conflict" originally formulated in Tullock (1980). This parameter is crucial in determining the degree of superiority of the ratio G_1/G_2, which is the ratio of superiority in conflict with a certain group over another. Therefore, it directly translates changes in the probable success ratio of winning p_1/p_2.

Finally, the income distribution takes place from a common pool of the aggregate production represented in (2) and it directly depends on the probability of winning for a certain group to appropriate all the income left in the economy.

$$\begin{aligned} Y_1 &= p_1 Y \\ Y_2 &= p_2 Y \end{aligned} \tag{4}$$

Note that the income of a certain group Y_j will be a function of the probability to win the aggregate production. Hence, the problem to optimize for each group becomes:

$$\begin{aligned} \max_{E_j, G_j} \quad & Y_j = p_j Y \\ s.t. \quad & R_j = E_j + G_j \end{aligned} \tag{5}$$

That is, each j group will choose optimally the amount of useful production E and guns G to maximize their income Y_j for $j = 1,2$. By using equations (2) and (3), the standard solution of this optimization problem for the first group derives in the Reaction Curve (RC) as:

$$\frac{G_1 E_1^{\frac{1-s}{s}}}{G_2^m} = \frac{m\left(E_1^{1/s} + E_2^{1/s}\right)}{G_1^m + G_2^m} \tag{6}$$

This result is analogous to the second group. As noted by Hirshleifer (1991a), total productivity A disappears during the optimal allocation of resources. Equation (6) is valid when the production of guns and weapons is lower than the income of the group, that is $Y_j > G_j$. Finally, in the special case where resource endowments are equal across groups $R_1 = R_2$, and the decisiveness of conflict is linear ($m = 1$), the symmetrical Cournot equilibrium emerges:

$$G_1 = G_2 = E_1 = E_2 = \frac{Y_1 + Y_2}{4} \tag{7}$$

Which determines that half of the resources are dissipated in wasteful fighting efforts. This result implies that total the output of the economy deviates

from its potential (peaceful scenario) whenever conflict arises in the optimal path of the groups. In the case where $s = A = 1$, the exact same allocation of the production of guns and weapons is obtained across groups in equilibrium, hence $G_1 = G_2$.

A crucial concept that arises from this theoretical framework is the Paradox of Power, where, regardless of the initial resource distribution, the poor group will be better off when it decides to fight. Income inequality analysis characterizes both the strong and weak forms of the paradox.[4] The strong form implies that even if the groups start with an unequal distribution of resources (as $R_1 > R_2$), the achieved income ratio will be identical ($Y_1 = Y_2$) after fighting. The weak form is characterized by the fact that even when $R_1 > R_2$ holds, the achieved income inequality after fighting will be less than the initial state of inequality of the resource distribution.[5] Hence, fighting is attractive for the weaker group as it can obtain a form of "redistribution" even when the rich group holds most guns and useful production.

For the simple tractable case where $m = s = 1$, it turns out that:

$$\frac{\partial Y_2}{\partial G_2} > \frac{\partial Y_2}{\partial E_2} \tag{8}$$

This represents that the poorest group ($j = 2$) has a larger marginal gain in income when it decides to fight than if it dedicates itself to useful production. Even at the extreme case where the poor side only dedicates itself to fighting ($R_2 = G_2$), marginal gains in (8) still hold. Interestingly, this could be reversed if the synergistical parameter of trade rises toward the complementarity of productions ($s > 1$), as the poor group may consider more attractive to invest in useful production than in guns (and the richer group as well).

The paradox of power does not hold (even in the weak form) when the parameter of decisiveness of conflict m is sufficiently large, where the marginal gain of fighting for the richest group overcomes the marginal gain of useful production. Hence, the rich group, being better resource-endowed, invests heavily in fighting. This is interpreted as the case of "annihilation" of the weak group when the decisiveness of conflict becomes too large ($m > 3$) as simulated by Hirshleifer (1991a).

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[4] Cf. Hirshleifer (1989, 1991a, 1991b), and Garfinkel and Skaperdas (2007).

[5] This is $\frac{R_1}{R_2} > \frac{Y_1}{Y_2} > 1$ where the initial inequality of resources in favor of the rich group is larger than the resulting income distribution after choosing optimally the allocation of useful and wasteful production.

Interestingly, Hirshleifer's theory associates decisiveness of conflict with institutional attainments involving rules and political agreements that may prevent the desire of investing in fighting activities for the richest group. Hence, institutions may play a crucial role in preventing the annihilation of weak and poor groups in an economy, even if inequality remains the same or higher.

The analytical framework provides insight into the following: (i) Conflict may become attractive when there is inequality in an economy provided that the decisiveness of conflict is not too large. (ii) The level of trade may encourage groups to invest more in useful productive activities (raising income) rather than in conflicting activities, by making the latter less attractive. (iii) Institutions may have a significant impact on the decisiveness of conflict, which determinates the level of destructiveness of conflict between groups.

These analytical results are determined by the key parameters of the model. However, in practice, it is impossible to estimate them as they are unobservable and unmeasurable across (and within) economies.[6] Nevertheless, the framework provides a useful scheme for understanding the relationships between income, distribution/inequality, and conflict. Remarkably, any form of income distribution after a conflict can be viewed as the next initial resource endowment for the groups within an economy, leading to a dynamic framework where conflict will emerge whenever inequality rise. Therefore, it is expected that conflict prevails with high inequality but inversely related, however conflict may not be strongly affected by rises in income alone as it depends on the degree of inequality within the groups.

4. Research methodology

Given the several potentials and simultaneous relationships between the variables of income inequality, violence, and real income levels, the following system of equations resumes the dynamics suggested in previous studies, based on a simplified version of Anser et al. (2020) specification but using a similar approach of Barro (2000) and Mao (2016), which jointly combines the variables in a linear system as follows:

$$C_{i,t} = \boldsymbol{\beta}' \boldsymbol{X_c} + \boldsymbol{\alpha}' \boldsymbol{Z_c} + e^{c}_{i,t} \tag{9}$$

$$\ln(y_{i,t}) = \boldsymbol{\beta}' \boldsymbol{X_y} + \boldsymbol{\alpha}' \boldsymbol{Z_y} + e^{y}_{i,t} \tag{10}$$

$$\ln(G_{i,t}) = \boldsymbol{\beta}' \boldsymbol{X_G} + \boldsymbol{\alpha}' \boldsymbol{Z_G} + e^{G}_{i,t} \tag{11}$$

[6] An effort to inspect the influence of this parameters through simulations is done in Durham et al. (1998).

Let $\boldsymbol{\beta}'$ to be a 1x3 vector of parameters, $\boldsymbol{X_c}$ be a 3x1 vector of endogenous simultaneous variables where $\boldsymbol{X_c}' = \left[1 \;\; \ln(y_{i,t}) \;\; \ln(G_{i,t})\right]$, $\boldsymbol{Z_c}$ a vector of control variables (not defined within the system) with a vector of $\boldsymbol{\alpha}$ parameters. By defining analogous the other equations with $\boldsymbol{X_y}' = \left[1 \;\; C_{it} \;\; \ln(G_{i,t})\right]$, and $\boldsymbol{X_G}' = [1 \;\; \ln(y_{it}) \;\; C_{it}]$ the simultaneous framework is defined. The vector of controls $\boldsymbol{Z}$ is subject to the availability of the data around the world, as only for developed economies well data exist, while for most developing economies, they do not.

The novelty of the analysis is to identify relationships among violence, inequality, and income around the world, without mutilating the sample to favored countries. Therefore, the system is a "simplified version" of individual panel-type regressions from Anser et al. (2020) but including important determinants as possible. C is the violence/crime variable, y is the real income per capita, and G as the income inequality variable, considering the $i = 1,2,\dots,n$ countries and $t = 1,2,\dots,T$ years. In the literature, equation (9) is commonly estimated by assuming full exogeneity of the regressors of income y_{it} and income inequality G_{it} but these could be considered simultaneously determined inside the full system. The "violence equation" is represented in (9), followed by the "income equation" in (10), and the "inequality equation" presented in (11). It should be noted that an important contemporaneous correlation is implied between the unobserved components terms e_{it} across the system. Therefore, formulating this structure allows addressing the problems of the contemporaneous/cross-sectional correlations in the residuals (where the covariances between $e^{c}_{i,t}$, $e^{y}_{i,t}$ or $e^{G}_{i,t}$ may be different from zero). Moreover, the simultaneous relationships among these variables are explicitly taken into consideration.

Within this framework, it is necessary to incorporate the cross-correlation of unobservable components and the simultaneous joint determination of the variables in the system (9)-(11); this can be achieved using the SUR approach, similar to Barro (2000) and Mao (2016). This baseline estimation is carried out with a set of controls encountered in the literature, including the share in the educational expenditure of the total government expenditure, the share in health expenditure from the total GDP, the poverty headcount over 2.5 USD a day, human capital accumulation based on the average schooling years of the countries, the role of institutional characteristics related to political rights, the unemployment rate, and the levels of international trade (cf. Appendix 1 and Table 3 for details of the variables, controls, and related references).

As a robustness check and to attempt causal identification, 3SLS is applied to an augmented version of the previous system. This version assumes not only as endogenous the variables of inequality, real income per capita, and violence, but also assumes as endogenous the human capital accumulation, the role of institutions (in terms of the level of political rights), the unemployment rate and the levels of trade of the economies. This process involves the selection/construction of exogenous variables to create instrumented values of the endogenous variables since these variables can be correlated with the error terms in this contemporaneous setup (such a situation cannot be addressed by the SUR method). A source of ideas to select instruments in this macroeconomic context can be found in Barro (2000), Clemens et al. (2012), Murray (2006), and Reed (2015), where lagged variables of the endogenous regressors may provide an alternative (internal) type of instruments available within the sample.

Since using multiple lags may induce overidentification issues, it is proposed to use the Principal Component Analysis (PCA) technique to obtain the scores of the first principal component of the previous three lags of each endogenous variable to instrument their contemporaneous values. These instruments are exogenous in that instead of being the contemporaneous observed values, they are a linear combination composed of the processes' historical information (excluding current information) over the most recent three years. Since these linear combinations are the scores of the first principal component from the PCA, they will capture the highest amount of variance across the yearly signals into a single variable, potentially allowing the control of other unobserved factors present in the data.

This approach using the scores of the first principal component enables to exactly-identify each of the endogenous variables, avoids simultaneity problems, selects relevant instruments, and when combined with the two-way fixed effects, allows to clear some of the potential endogeneity that may exist from the individual country effects (time-invariant) and time-specific effects for each year in the sample. The first-stage specifications for the 3SLS and each endogenous variable are summarized in the following expression:

$$\widehat{\mathbf{Y}} = \mathbf{Z\beta} + \boldsymbol{\mu} + \boldsymbol{\gamma} + \mathbf{e} \tag{12}$$

Where $\widehat{\mathbf{Y}}$ is a 7x1 vector containing the instrumented values of the new set of endogenous variables, which includes not only violence, real income per capita, and inequality but also standard determinants of macroeconomic variables (such as human capital accumulation, unemployment rate, institutional quality,

and international trade). Let **Z** be a 7x7 matrix containing the instruments, created from the first three lags of each endogenous variable and collapsed into their first principal component. With country fixed effects **μ** and time fixed effects **γ**. For the detail of the matrix structure of the 3SLS estimation (Appendix 3). The first principal components' score of the previous joint three lags ($k = 1,2,3$) of the set of endogenous variables are considered as the main instruments. This implies that the values of the first, second and third lags for each endogenous variables are used to create the scores of the first principal component individually for each variable. These instruments exactly identify the proposed augmented system since they equal the number of all endogenous variables.

Conditional on these, during the first stage the two-way fixed effects are included to potentially remove spurious relationships in the regressions driven by common trends. For the detail of the variables, source, and links of the data to estimate the augmented 3SLS (Appendix 1, Table 3).

Multiple data sources have been used to increase the number of observations from the world level, including among others: the World Development Indicators (WDI) from the World Bank (2022) obtained using the package of Arel-Bundock (2022) for violence, real income per capita, trade, and unemployment. The Penn World Table (updated in 2022) of Feenstra et al. (2015) for human capital (based on years of schooling); the SWIID inequality data of Solt (2020) for the Gini coefficient; and Freedom House (2020) data for institutional quality related to political rights. The final sample consists of 110 countries between the years 1994 and 2019 for the estimations. The variable used to proxy violence is the intentional homicide rate per 100,000 individuals, the income is proxied by the real GDP per capita at common real USD of 2015, the income inequality is measured by the Gini coefficient (SWIID data), and the rest of the data of the controls are obtained from the World Bank. As an additional robustness check, the augmented 3SLS system is also estimated using alternative data on inequality and real income per capita (from the World Bank and the Penn World Table, respectively) to potentially inspect drastic changes in the dynamics (additional PCA scores are also generated for these robustness tests).

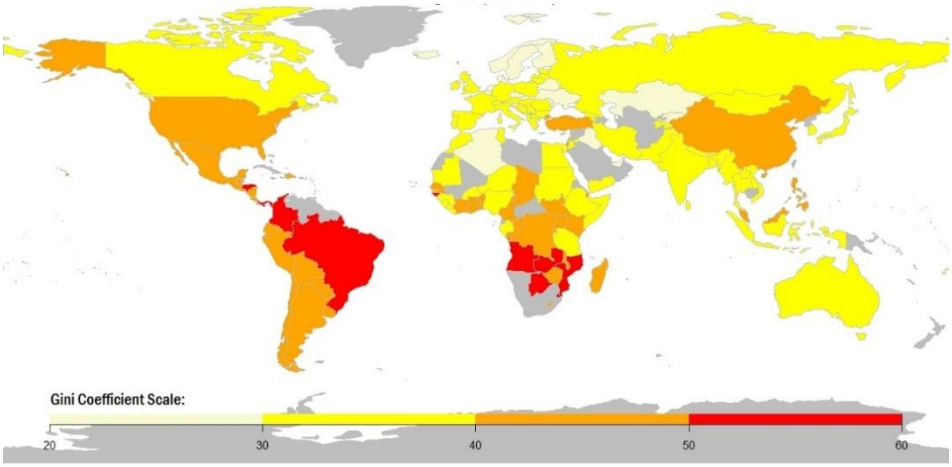
5. Research findings

This section presents the stylized facts, empirical correlations, and descriptive statistics of the variables as preliminary results, followed by the results of the system (9)-(11) by the SUR and the augmented version with the 3SLS approach.

5.1. Stylized facts and empirical correlations

The following figure depicts that the income inequality, measured by the Gini coefficient (average from 2009 until 2019), reflects a dominant pattern of high-income inequality in some developing regions, such as South America and Sub-Saharan Africa (Figure 1).

Figure 1. Average Gini coefficient (2009-2019) by countries around the world

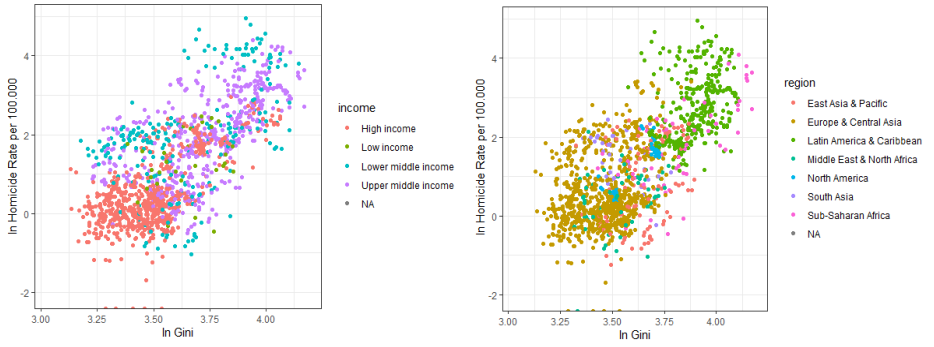


Source: Author's own elaboration based on the information from the World Bank (2022).

In Figure 1, gray countries indicate missing values of the Gini coefficient. Specifically, the American continent possesses a significant amount of high-end income inequality levels across its three main geographical regions, concerning North, Central, and South America, with the worst cases located in Colombia and Brazil. In the same line of reasoning, and accordance with previous studies, Figure 2 presents the positive correlations between income inequality (via the Gini coefficient) and violence[7] (measured by the intentional homicides per 100,000 people).

[7] Intentional homicides are defined as "estimates of unlawful homicides purposely inflicted as a result of domestic disputes, interpersonal violence, violent conflicts over land resources, inter-gang violence over turf or control, and predatory violence and killing by armed groups." (World Bank, 2021).

Figure 2. Scatterplots of violence and Gini by income class and region



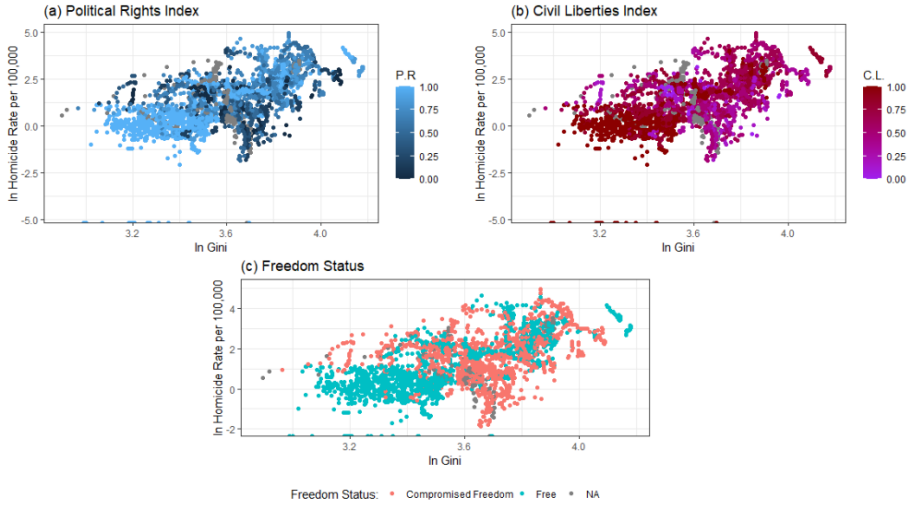
Source: Author's own elaboration based on the information from the World Bank (2022).

Figure 2 depicts the dispersion between inequality and violence (in logs). The left panel represents the income class type (from the World Bank classification) and right panel represents the regional (geographical) cluster. High-income countries exhibit an unclear correlation, in contrast with the other income classes, in which a stronger positive correlation is found. Similarly, the regional cluster for Europe and Central Asia exhibits the same unclear relationship between inequality and violence, however, moving toward the other regional parts of the world, particularly Latin America and the Caribbean, the same positive correlation emerges, and it reflects a concentration of high levels of violence and high inequality.

Alternatively, since institutions expressed in the form of political rights and civil liberties may be correlated with violence and inequality, Figure 3 represents these relationships using the data from Freedom House (2022). Unlike the original, the measures are rescaled from 0 to 1, where in the case of the index of political rights, 1 represents the existence of full political rights, while 0 represents the absence of such rights. Similarly, for the civil liberties index, 1 implies full liberties for civilians, while 0 implies the opposite. For this analysis, the classification of "free" countries and those with "compromised freedom" is also included.

Figure 3 allows the classification of countries based on their institutional characteristics. Countries with a degree of compromised freedom are reflected in low values of the indexes of rights and freedom (which can be associated with authoritarian institutions). Meanwhile, free countries are the opposite (which are strongly associated with democratic institutions).

Figure 3. Scatterplots of violence and Gini by rights, liberties, and freedom



Note: Panel (a) contains the dispersion associated with the index of political rights where 0 (black) is the inexistence of rights and 1 (light blue) the full existence. Panel (b) contains analogous the civil liberties index where 0 (purple) is the absence and 1 (red) is the existence of full liberties, panel (c) contains the discrimination of completely free countries (light blue) and countries whose freedom is compromised (light red). Compromised freedom gathers the categories of "not-free" and "partially-free".

Source: Author's own elaboration based on the information from the World Bank (2022), Penn World Table (Feenstra et al., 2015), and Freedom House (2020).

An interpretation that emerges from Figure 3 is that despite the level of political rights, civil liberties, and freedom, there are some mixed correlations between violence and inequality. In general, high levels of these rights and liberties are concentrated in a cloud of points. However, after inequality reaches a certain threshold around a Gini of 36.59 (or ln Gini = 3.6), violence tends to explode with a visible positive correlation, even for countries with high levels of political rights, liberties, and freedom.

The general panel descriptive statistics are presented in Table 4 in Appendix 2. As noted, the intentional homicide rate per 100,000 individuals contains values of 0, therefore it will be not transformed into logarithms. The same applies to the variables in percentage form involving educational government expenditure, health expenditure, human capital, unemployment rate, political rights score, international trade, and the poverty headcount of 2.5 USD a day.

5.2. SUR estimates

The estimates of the system (9)-(11) are presented in Table 1 (with controls). The main results (Eq. Violence) indicate a positive correlation between income inequality measured by the natural logarithm of the Gini coefficient and the levels of violence measured by the intentional homicide rate. The second main result reflects a negative correlation between the natural logarithm of the GDP per capita and the homicide rate.

Table 1. SUR estimates with controls (full sample)

Variables	Violence	Ln GDP	Ln Gini
Ln GDP	–2.991***		–0.0402***
	(0.518)		(0.00674)
Ln Gini	36.21***	–0.974***	
	(2.414)	(0.163)	
Human capital	–4.366***	0.178**	–0.103***
	(1.140)	(0.0748)	(0.0145)
Unemployment rate	–0.214**	–0.0174***	0.00478***
	(0.0845)	(0.00538)	(0.00109)
Political rights	4.469***	1.587***	0.0376*
	(1.719)	(0.0961)	(0.0224)
Trade	0.0233***	–0.000446	–0.000814***
	(0.00747)	(0.000480)	(9.32e–05)
Educ. Gvmnt. Exp.	–0.225**	–0.0183***	0.00820***
	(0.104)	(0.00663)	(0.00132)
Health Exp.	1.332***	0.109***	–0.00552**
	(0.199)	(0.0125)	(0.00263)
Pov._Headcount. 2.5 USD	–0.279***	–0.0321***	0.00126*
	(0.0540)	(0.00332)	(0.000707)
Violence		–0.0123***	0.00614***
		(0.00213)	(0.000409)
Constant	–89.82***	10.85***	4.114***
	(11.46)	(0.690)	(0.0667)
Observations	881	881	881
R-squared	0.284	0.688	0.587

Note: Period sample: 2001-2019, No. of countries = 98.

Source: Author's own elaboration based on the information from the World Bank (2022), PWT (Feenstra et al., 2015), and SWIID (Solt, 2020) using Stata 15.

The previous estimations using the suggested controls in the literature have considerably reduced the sample size, resulting in the use of only 881 observations. The controls that tend to have the largest number of missing values are the educational government expenditure, health expenditure as % of GDP, and the poverty headcount of 2.5 USD a day. These missing observations tend to mutilate the developing and poorest countries from the sample.

In Table 1, the results for the violence equation also imply negative correlations of human capital and educational government expenditure with respect to violence (increases in these tend to lower the violence). Abnormal correlations are found relative to unemployment, political rights, health expenditure, and the poverty headcount, which contradicts the standard economic theory.

The equation for income presents negative correlations with income inequality, violence, unemployment rate, and poverty. Moreover, positive correlations exist with human capital, political rights, and health expenditure, whereas trade is not statistically significant. Abnormal correlations are found with the educational expenditure of the government, which has a negative effect on income.

The equation for inequality shows the same positive correlations with violence, unemployment, educational expenditure of the government, political rights, and the poverty headcount. Additionally, there are negative correlations with respect to real income levels, human capital, trade, and health expenditure.

5.3. 3SLS estimates

The previous baseline estimates are subject to a large degree of endogeneity within the variables in the system (9)-(11). Therefore, for comparison purposes, and considering the sample size reductions caused by the inclusion of some controls, the augmented 3SLS results using as instruments the first principal component's score of the previous three lags for the set of endogenous variables are presented in Table 2. The results do not differ concerning the relationship between income inequality and violence since a positive relationship is found among these variables.

Table 2 presents the output for the 3SLS estimation. The two-way fixed effects are included during the first stage. The instruments for the endogenous variables are statistically significant according to the first-stage F-tests. The system is exactly identified, and the linear adjustment improves considerably during the first stage due to the inclusion of the fixed effects.

Table 2. 3SLS estimates with two-way fixed effects (full sample)

Variables	Violence	Ln GDP	Ln Gini	Human capital	Unemployment	Political rights	Trade
Ln GDP	–0.0261		0.00973**	0.278***	–1.251***	0.197***	19.75***
	(0.340)		(0.00459)	(0.00879)	(0.151)	(0.00524)	(1.619)
Ln Gini	42.65***	0.249**		–1.149***	9.856***	–0.233***	–7.466
	(1.468)	(0.119)		(0.0493)	(0.747)	(0.0343)	(8.457)
Human capital	–1.454**	1.298***	–0.208***		5.087***	–0.073***	3.721
	(0.718)	(0.0411)	(0.00890)		(0.317)	(0.0141)	(3.561)
Unemployment	0.249***	–0.0328***	0.01***	0.0286***		0.0064***	–0.793***
	(0.0557)	(0.004)	(0.000759)	(0.00178)		(0.00112)	(0.274)
Political rights	12.03***	2.564***	–0.117***	–0.189***	3.068***		–86.35***
	(1.221)	(0.0678)	(0.0171)	(0.0392)	(0.550)		(5.861)
Trade	–0.00616	0.004***	–6.71e–05	0.0002	–0.0065***	–0.001***	
	(0.00500)	(0.0003)	(6.97e–05)	(0.000163)	(0.00222)	(9.68e–05)	
Violence		–0.000363	0.0086***	–0.00177**	0.0495***	0.005***	–0.157
		(0.002)	(0.0003)	(0.000797)	(0.0110)	(0.0005)	(0.121)
Constant	–150.9***	2.502***	4.020***	4.299***	–32.33***	0.0423	0.0987
	(6.708)	(0.488)	(0.0302)	(0.211)	(3.285)	(0.148)	(36.71)
Observations	1,733	1,733	1,733	1,733	1,733	1,733	1,733
R-squared	0.251	0.582	0.475	0.569	0.028	0.353	0.034
Chi2	1497.9	5168.27	3367.15	4019.32	472.27	2480.6	364.26

Note: Controls included due to the availability of data and their instruments are human capital, unemployment, political rights, and international trade. Sample: 110 countries from 1994 to 2019.

Source: Author's own elaboration based on the information from the World Bank (2022) and Stata 15.

In the violence equation, an increase in inequality is associated with an increase the violence levels. Furthermore, the real income per capita is no longer significant even when the point estimate is negative. Human capital is still significant and negatively associated with violence, while political rights are positively related. In the income equation, inequality, human capital, political rights, and trade are positively associated with income per capita, meanwhile, violence is no longer significant to explain changes in the income. In the inequality equation, a positive relationship is found between the real income per capita, violence, and unemployment. Interestingly, human capital and political rights are negatively related concerning inequality. The analyses of the additional controls are the following: (i) human capital is positively related to income per capita and unemployment, but negatively related to violence and political rights; (ii) unemployment is positively related to inequality, violence, human capital, and political rights, but negatively associated with income and trade; (iii) political rights are positively associated with income, violence, and unemployment, but negatively related to inequality, human capital, and trade; (iv) trade is negatively

associated with political rights and unemployment, but positively related to income. It should be noted that from all estimated equations, this is the one with the most insignificant coefficients.

All the previous models were re-estimated using the small-sample adjustment in their statistics to confirm the robustness of statistical significance. No changes are witnessed using this adjustment.

6. Discussion

6.1. General results

The previous results using the available world data contribute to the empirical literature on income inequality and violence (measured through intentional homicide rates) with new evidence in line with most of the previous studies, where a positive relationship, statistically significant, is encountered within these two variables. This is consistent with the findings of Anser et al. (2020), Fajnzylber et al. (2002), Grover (2013), Hagan & Peterson (1995), Kelly (2000), and Witt et al. (1998), among others. The results are similar and robust across the estimations, which link increases in the Gini coefficient with increases in the levels of violence via intentional homicides. However, non-robust results are found in what relates to the negative relationship between real income per capita and violence since the statistical significance is no longer maintained in the 3SLS estimates, even when the coefficient appoints to be negative across the estimations. This absence of robustness may be driven by potential nonlinearities which are not captured in the parametric approach conducted in this research.

It is important to highlight that human capital is also strongly negatively related to violence. That is, with increases in human capital there is a reduction in the levels of violence in the economies. This is in line with findings provided by Koppensteiner and Menezes (2021), León (2012), Lochner (2004), and Zheng et al. (2019). From the perspective of the technologies of power, this relationship can be explained if human capital is the driving force of useful production for both groups. Hence not only the richest group in the economy is incentivized to generate useful production but also the poorest group, leading to a decrease in the marginal gains to fight and increase the marginal gains of useful production. This is reflected in a positive significant relationship between human capital and economic production (in terms of real income per capita).

This theoretical highlight can be explained by the non-rival properties and spillover effects of human capital accumulation by endogenous growth models (Frankel, 1962; Lucas, 1988; Romer, 1986), where any of the groups can benefit themselves from the existing stock of knowledge in the economy. Human capital captures the underlying (and explanatory) force to generate income in the economies, which can equalize and potentially reduce fighting forces despite the existence of oligarchic and democratic institutions; the theoretical framework of this idea is provided in Cervellati et al. (2008).

The most critical result is the relationship between political rights and violence, which is positive and statistically significant. The economic literature, in general, establishes that strong, free, and democratic institutions tend to promote economic development (Acemoglu et al., 2019). This is by allowing all groups in society to have political representation, generating a strong incentive to lower violent activities. Yet, as appointed by Cervellati et al. (2008) and Schwarzmantel (2010), this is not always the case, and the reason could be the underlying pre-existing inequalities and the type of rights allowed in each economy.

For example, a strong democratic economy that allows its citizens to access and carry guns relatively easy could amplify the decisiveness of conflict, and under the civil right of self-defense, this may imply more confrontations among social groups (under the theory technologies of power, more guns is translated into more conflict especially if inequality is high); therefore freedom and political rights themselves are not drivers to reduce violence. Instead, it may depend on other institutional characteristics (especially in terms of welfare and rules toward unfavored groups to disincentivize the marginal gains of fighting).

Another critical point linked to the previous one is the negative relationship between human capital and political rights, but this may have a self-explanatory reason based on empirical facts related to access education. As noted by Schultz (1961), the impossibility of individuals to afford education is a compromising factor for human capital accumulation, even in strong democratic countries like United States. That is, being a democratic economy is not a necessary condition to ensure equality, and therefore, inequality can trigger disparities in investment toward education. Figure 4 in Appendix 4 depicts these relationships by discriminating human capital across countries against inequality and political rights. In general, the latter is not a requirement for larger shares of high levels of human capital (panel c), whereas inequality is crucial (panel b).

In the case of income per capita, there are positive relationships with inequality, human capital, political rights (institutions), and trade. While unem-

ployment and violence are negatively related to income. These patterns are in line with standard macroeconomic theory, although the violence is not statistically significant.

6.2. Instruments

Turning the discussion into the instruments of the 3SLS, Table 5 in Appendix 5 provides the important statistics of the first stage for all of the endogenous variables. In particular, the recommendations of Bazzi and Clements (2013) are taken into consideration for this discussion.

The instruments (PCA scores of the lags) performed well during the first stage for all the endogenous variables. To confirm if the instruments are weak, the F-test is applied individually for each first stage only to the instruments. This restricted F-test has in all the equations a strong statistical significance rejecting the null hypothesis that the instruments jointly are equal to 0 with a 5% level of significance, indicating that the instruments are jointly relevant and strong to explain the endogenous regressors. As it is also necessary to conduct the assessment in terms of linear explanation during the first stage, the adjusted coefficient of determination (R-squared) is also included, and the explanatory power is augmented significantly by the inclusion of the two-way fixed effects with good results. At this point, it is possible to establish that the PCAs based on the lags are not weak to explain the endogenous regressors, as the statistical tests confirm.

However, there is a concern regarding the degree of potential correlation that may exist between the scores used during the first stage and the contemporaneous disturbances of the estimated system. A strict causal identification has to rely on the assumptions that instruments are exogenous to these disturbances; but the current approach work on the assumption that conditional on the historical information of the processes (captured in PCA), and the two-way fixed effects (individual and time static factors) in the first stage, the contemporaneous disturbances are uncorrelated to the exogenous linear combination of the lagged values using the scores.[8] In any case, the time fixed-effects may help to control for a persistent correlation of the disturbances during the estimations and potentially help to remove spurious relationships induced by common trends among the variables.

[8] Endogeneity may arise if the disturbances are serially correlated, which will invalidate the exclusion restriction, this is possible since the lagged values may be correlated to previous disturbances. This is hopefully controlled by the explicit inclusion of the two-way fixed effects.

Furthermore, the unknown path of endogeneity that may still arise is due to time-varying unobserved components. Such components should be the remaining parts of this macroeconomic setup that were not captured by the controls during the estimations, worsened by the fact that observations of inequality and other variables may contain measurement errors for poor countries. Hence cautionary interpretations are suggested.

Nevertheless, these results, in the essence of Barro (2000) and Mao (2016)[9] provide more empirical evidence of the relationships within the variables of violence, income, and inequality.

6.3. Robustness check

The robustness test conducted for the 3SLS alternates the data of income and inequality on the world scale. Instead of using the World Bank's data of real income per capita, it is changed to the information from the Penn World Table. Similarly, the data on inequality are alternated too but using the estimates of the World Bank rather than the SWIID data. In general, the estimations are presented in Table 6 inside Appendix 6, and while the relationships of inequality, human capital, and violence reflect the same sign and remain statistically significant, the inverse relationship between income and inequality also turns out to be significant. However, political rights and trade are no longer statistically significant in explaining changes in violence.

These results, however, are not comparable to the main 3SLS. As observed using the alternative data, the number of observations dropped to 668 (and 56 countries only), whereas in the main 3SLS is around 1,733 observations (with 110 countries). This highlights the fact that statistical significance is compromised for the variables of income and violence by the sample size and the source of data.

7. Conclusions

7.1. Research contribution

The present research contributes to the empirical literature by examining the simultaneous joint relationships among income inequality, real income per capita, and violence using the available world sample (over 110 countries covered)

[9] As these authors also implement 3SLS based on lags and SUR approaches, respectively.

between 1994 and 2019. The sample combines different datasets (from the World Bank, Penn World Table, and the SWIID inequality data) to exploit the highest possible number of available observations within these variables and the controls. This is accomplished through a linear system that simultaneously determines the variables in a multi-equation framework based on a simplified version of Anser et al. (2020) specification in the essence of Barro (2000) and Mao (2016). The estimations used the approaches of SUR and 3SLS to confirm a robust positive relationship between income inequality and violence.

However, the negative relationship between real income per capita and violence established in the literature is not significant in the 3SLS estimation. This is confirmed with a robustness check using alternative data, and the conclusion suggests a non-robust relationship (negative in nature) but is sensitive to the sample size, the number of countries included, and the source of the data.

The role of human capital over violence and inequality is particularly important and robust based on the empirical analyses. The estimations pointed out a negative and strong relationship between human capital and these variables. Furthermore, the estimates reflect that human capital is a process that positively influences economic production. Such results under the perspective of the technologies of conflict indicate that human capital can be a major driver to increase useful production as well as a driver to decrease inequality and violence.

A critical empirical pattern that emerges from these estimations is that democracies themselves (proxied by the degree of political rights) are not enough to induce reductions in violence, as the degree of political rights tends to be inversely related to inequality and human capital but positively related to violence. This result is possibly driven by the institutional framework toward inequality and the number of guns legally circulating in some democracies (increasing the decisiveness and the likelihood of conflict). The regressions and the analysis of densities (cf. Appendix 4) between human capital, inequality, and political rights (as an expression of democracy) establish that the latter is not a requirement for larger shares of high levels of human capital, whereas inequality is crucial. This implies that democracies can sustain lower levels of violence if inequality is not too high, but once inequality explodes, it compromises human capital accumulation, disincentivizing the marginal gains of useful production and increasing the marginal gains of conflict, thus increasing violence.

7.2. Research implications

Scientists and policymakers must be aware that the relationships between inequality, income, and violence are particularly sensitive to the selection of the sample, countries, and data sources. Moreover, there is a trade-off between the availability of observations and the macroeconomic controls for poor countries. Researchers must take into consideration that most of the available data on these variables are in developed economies, neglecting the dynamics of less developed economies.

However, an important implication is that human capital plays a significant role in the dynamics of inequality and violence (and not only for income per capita). This implication is subjugated even in strong democratic economies because inequality can harmfully damage the process of human capital accumulation, thereby inducing unfavored groups to be involved in conflict and violence.

7.3. Research limitations and future works

The current research is limited given the lack of external instruments, the assumption of linear relationships of the models, and the inability to use a major number of controls given the current data availability of the multiple datasets used. It is important to highlight that the baseline estimates of the SUR model are strongly limited by the endogeneity of the variables under this macroeconomic setup. This econometrical approach assumes as exogenous the set of explanatory regressors included across the equations. Hence, the motivation to use the 3SLS is to relax this strong assumption, constituting the main estimation for this research.

Moreover, the controls for the main specification aside from violence, income inequality and income per capita included only human capital, unemployment, political rights, and trade. Other types of controls to use can include poverty types, health indicators, and public sector efficiency. The comparison with other types of measures for inequality and violence can improve the present research.

Future works may imply the estimation of nonlinear systems with the previously suggested control variables without neglecting poor countries from the sample. This is to examine potential U-shape or N-shape relationships across the variables. If data allow it in the future, dynamic linear models can also be estimated, including panel vector autoregressive models (PVARs), or auto-

regressive distributed lag models (ARDLs). With these approaches, impulse-response functions (IRF) can be calculated to examine how the variables react in the time horizon to different shocks. Specifically, to examine how these variables (income, inequality, and violence) react to shocks from government intervention such as public expenditure, military expenditure, and institutional performance indicators of the public sector.

8. Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix

1. Variables and sources

Table 3. Variables for main estimation and robustness checks

Short name	Symbol	Description	Source	Related reference	Links
1	*2*	*3*	*4*	*5*	*6*
Ln GDP	$\ln(y_{it})$	Real GDP per capita (constant 2015 US$)	(World Bank) Arel--Bundock (2022)	Alesina & Rodrik (1994), Barro (2000), Chen & Fleisher (1996), Kuznets (1955), Persson & Tabellini (1994)	https://data.worldbank.org/indicator/NY.GDP.PCAP.KD
Violence	C_{it}	Intentional homicides (per 100,000 people)	(World Bank) Arel--Bundock (2022)	Anser et al. (2020), Fajnzylber et al. (2001), Neumayer (2003)	https://data.worldbank.org/indicator/VC.IHR.PSRC.P5
Ln Gini	$\ln(G_{it})$	Gini coefficient from disposable income	(SWIID) Solt (2020)	Alesina & Rodrik (1994), Barro (2000), Chen & Fleisher (1996), Kuznets (1955), Persson & Tabellini (1994)	https://fsolt.org/swiid/
Human capital	HC_{it}	Human capital index based on years of schooling and returns to education	(Penn World Table) Feenstra, Inklaar, & Timmer (2015)	Alesina & Rodrik (1994), Barro (2000), Chen & Fleisher (1996), Deininger & Squire (1998), Mo (2000), Panizza (2002), Persson & Tabellini (1994)	https://www.rug.nl/ggdc/productivity/pwt/?lang=en
Unemp.	U_{it}	Unemployment rate, ILO estimates	(World Bank) Arel--Bundock (2022)	Anser et al. (2020), Jawadi et al. (2021)	https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS
Political rights	PR_{it}	Re-scaled standard setting comparative assessment of political rights	(Fredom House) Freedom House (2022)	Barro (2000), Clarke (1995), Persson & Tabellini (1994)	https://freedomhouse.org/reports/publication-archives
Trade	XM_{it}	Percentage of international trade (% of GDP)	(World Bank) Arel--Bundock (2022)	Anser et al. (2020), Barro (2000)	https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS
Edu. Gov. Exp.	$Educ_{it}$	Government expenditure on education, total (% of government expenditure)	(World Bank) Arel--Bundock (2022)	Anser et al. (2020)	https://data.worldbank.org/indicator/SE.XPD.TOTL.GB.ZS

Table 3 cont.

1	*2*	*3*	*4*	*5*	*6*
Health Exp.	$health_{it}$	Current health expenditure (% of GDP)	(World Bank) Arel--Bundock (2022)	Anser et al. (2020), Wilkinson & Picket (2009)	https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS
Pov. Headcount 1.9 USD	pov_{it}	Poverty headcount ratio at $2.15 a day (2017 PPP) (% of population)	World Bank Arel--Bundock (2022)	Anser et al. (2020), Wilkinson & Picket (2009)	https://data.worldbank.org/indicator/SI.POV.DDAY
Ln GDP (Robustness check)	$\ln(y_{it})$	Real Gross Domestic Production per capita in mil. 2017 USD in natural log.	(Penn World Table) Feenstra, Inklaar, & Timmer (2015)	Same as before	https://www.rug.nl/ggdc/productivity/pwt/?lang=en
Ln Gini (Robustness check)	$\ln(G_{it})$	Gini index (World Bank Estimate)		Same as before	https://data.worldbank.org/indicator/SI.POV.GINI

Note: Due the lack of data in some of the controls, not all of them are included in all the estimations. The SUR estimations contain all of these, but the 3SLS (and the instruments) contains only the controls of human capital, unemployment, political rights, and trade.

Source: Author's own elaboration.

2. Panel descriptive statistics

Table 4. Panel descriptive statistics (Main variables and controls)

Variable	Statistic	Mean	Std. Dev.	Min	Max	Observations
1	*2*	*3*	*4*	*5*	*6*	*7*
Violence	overall	8.297993	12.57472	0	141.7226	N = 3718
	between		10.43402	0.2087792	72.77007	n = 193
	within		5.075458	–28.96525	77.2505	T = 19.2642
Ln GDP	overall	8.347502	1.499578	4.970032	12.22681	N = 9825
	between		1.477374	5.624073	12.03056	n = 210
	within		0.3973522	6.331645	10.6175	bar = 46.7857
Ln Gini	overall	3.622016	0.2335224	2.884801	4.180522	N = 5751
	between		0.2156319	3.148487	4.170377	n = 191
	within		0.0560013	3.076149	3.838759	bar = 30.1099
Human Capital	overall	2.108475	0.7298786	1.007038	4.351568	N = 7904
	between		0.6631523	1.070629	3.453823	n = 143
	within		0.3461572	0.9538063	4.156662	T = 55.2727
Unemp.	overall	8.317457	6.390196	0.1	38.8	N = 5766
	between		5.945624	0.5690968	30.39694	n = 186
	within		2.380782	–5.269318	23.9962	T = 31
Political Rights	overall	0.5443297	0.3717961	0	1	N = 8809
	between		0.3270539	0	1	n = 192
	within		0.1805699	–0.362337	1.220996	bar = 45.8802

Table 4 cont.

1	2	3	4	5	6	7
Trade	overall	78.18976	54.21524	0.0209992	863.1951	N = 8530
	between		52.62625	20.07766	346.5108	n = 196
	within		25.05081	–183.5545	594.8741	bar = 43.5204
Educ. Gov. Exp.	overall	14.60386	5.110958	0	47.27874	N = 3773
	between		4.337904	2.925256	27.92524	n = 200
	within		3.127692	–3.052529	46.03652	bar = 18.865
Health Exp.	overall	6.201359	2.804047	1.263576	24.24389	N = 3714
	between		2.601255	1.951371	16.82022	n = 189
	within		1.036471	0.3359325	17.99345	T = 19.6508
Pov. Headcount 1.9 USD	overall	10.15502	17.60108	0	91.5	N = 1823
	between		21.45492	0	80.6	n = 167
	within		7.442587	–26.24498	61.79031	T = 10.9162

Source: Author's own elaboration.

3. Matrix notation for 3SLS

I start first by defining the vectors as:

$$\mathbf{Y} = \begin{bmatrix} C_{it} \\ \ln(y_{it}) \\ \ln(G_{it}) \\ HC_{it} \\ U_{it} \\ PR_{it} \\ XM_{it} \end{bmatrix}, \quad \boldsymbol{\mu} = \begin{bmatrix} \mu_i \\ \mu_i \\ \vdots \\ \vdots \\ \vdots \\ \mu_i \end{bmatrix}, \quad \boldsymbol{\gamma} = \begin{bmatrix} \gamma_t \\ \gamma_t \\ \vdots \\ \vdots \\ \vdots \\ \gamma_t \end{bmatrix}, \quad \mathbf{e} = \begin{bmatrix} e_{it} \\ e_{it} \\ \vdots \\ \vdots \\ \vdots \\ e_{it} \end{bmatrix}, \quad \boldsymbol{\alpha} = \begin{bmatrix} \boldsymbol{\alpha_1} \\ \boldsymbol{\alpha_2} \\ \vdots \\ \vdots \\ \vdots \\ \boldsymbol{\alpha_7} \end{bmatrix}$$

Where **Y** is the 7x1 vector of endogenous variables involving, violence, real income per capita, inequality, human capital, unemployment rate, political rights, and international trade. **μ** is the 7x1 set of equation-specific country fixed effects, **γ** is the vector of equation specific time fixed effects, **e** is the vector (7x1) of residuals of the first stage and **α** are the coefficients of the final stage.

And defining the 1x7 vector $\boldsymbol{X_j}$ for the $m = 1, 2, \ldots 7$ equations, in which the specific dependent variable is excluded in the m-specific equation, the explanatory matrices of endogenous variables are:

$$\mathbf{X} = \begin{bmatrix} \boldsymbol{X_1} & 0 & \ldots & 0 \\ 0 & \boldsymbol{X_2} & \ldots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \ldots & \boldsymbol{X_7} \end{bmatrix}$$

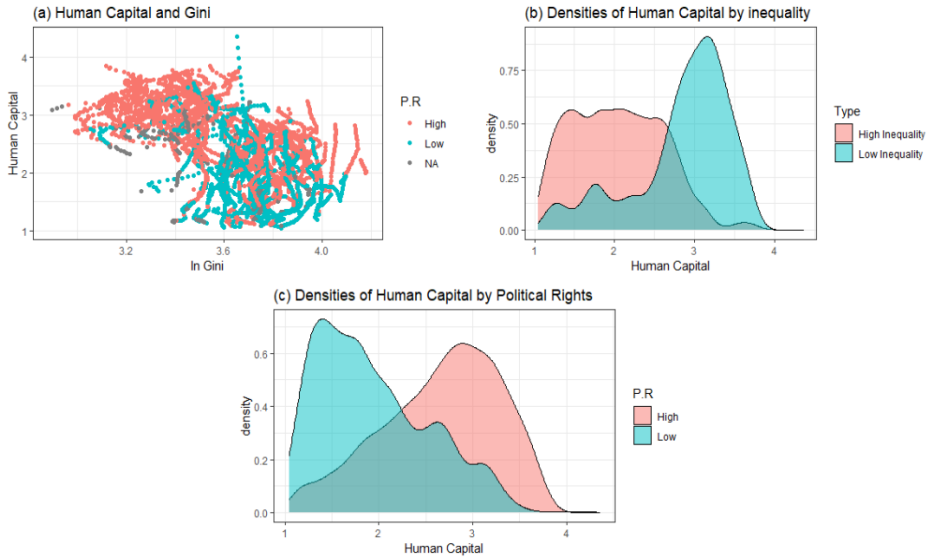
Hence model is represented as $\mathbf{Y} = \mathbf{X}\boldsymbol{\alpha} + \mathbf{u}$ where **u** is a vector of residuals, this summarizes the final stage. Now turning into the first stage. Define the instrumented values of the endogenous variables with a hat, parameters, and variables as:

$$\widehat{\mathbf{Y}} = \begin{bmatrix} \widehat{C_{it}} \\ \ln(\widehat{y_{it}}) \\ \ln(\widehat{G_{it}}) \\ \widehat{HC_{it}} \\ \widehat{U_{it}} \\ \widehat{PR_{it}} \\ \widehat{XM_{it}} \end{bmatrix} \quad , \quad \boldsymbol{\beta} = \begin{bmatrix} \boldsymbol{\beta_1} \\ \boldsymbol{\beta_2} \\ \vdots \\ \vdots \\ \vdots \\ \boldsymbol{\beta_7} \end{bmatrix} \quad , \quad \mathbf{Z} = \begin{bmatrix} \boldsymbol{Z_1} & 0 & \dots & 0 \\ 0 & \boldsymbol{Z_2} & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \boldsymbol{Z_7} \end{bmatrix}$$

Leading to the first stage as: $\widehat{\mathbf{Y}} = \mathbf{Z}\boldsymbol{\beta} + \boldsymbol{\mu} + \boldsymbol{\gamma} + \mathbf{e}$, Also note that $\boldsymbol{\beta_1}' = = [\beta_0 \ \beta_1 \ \dots \ \beta_7]$ and $\boldsymbol{Z_j} = [1 \ S(C_{it,t-k}) \ S(\ln(y_{it,t-k})) \ \dots \ S(XM_{it,t-k})]$ which contains the first principal components of the endogenous variables from t to t–k, (which are the first to the third lag of its own).

4. Human capital, inequality and political rights

Figure 4. Correlations of inequality, political rights and human capital



Note: Panel (a) contains the dispersion associated with the index of political rights reclassified into two components, if the scale is > 0.5, then high political rights are categorized, and <= 0.5 for low (reduced) political rights. Panel (b) contains densities of human capital discriminated by the type of inequality (Ln Gini = 3.6) as the reference point for high and low inequality, the threshold is selected by the scatter plots of inequality and violence in the stylized facts. Panel (c) contains the densities of human capital by the political rights classification, it is visible in panel (b) that a larger concentration of high values of human capital accumulation is related to low inequality.

Source: Author's own elaboration based on the information from the World Bank (2022), Penn World Table (Feenstra et al., 2015), and Freedom House (2020).

5. Test of the instruments of the main 3SLS estimation

Table 5. Instruments analysis

Equation	Restricted F-test statistic (only PCA instruments)	F-Statistic (general)	P-value (restricted F-test)	R-squared adjusted	Interpretation
Violence	224.11	222.75	0.000	94.74%	Relevant
Ln GDP (World Bank)	136.7	2675.54	0.000	99.5%	Relevant
Ln Gini (SWIID)	1305.53	3066.34	0.000	99.6%	Relevant
Human capital	3858.65	10275.39	0.000	99.8%	Relevant
Unemp.	267.82	132.07	0.000	91.41%	Relevant
Political rights	180.95	313.55	0.000	96.51%	Relevant
Trade	394.28	507.71	0.000	97.63%	Relevant

Source: Author's own elaboration.

6. Robustness check

Table 6. 3SLS – alternative data

Vars	Violence	Ln GDP (PWT)	Ln Gini (WB)	Human capital	Unemp.	Political rights	Trade
Ln GDP (PWT)	–5.275***		0.0539***	0.260***	–0.254	0.309***	6.802*
	(0.750)		(0.0111)	(0.0172)	(0.307)	(0.0113)	(4.093)
Ln Gini (WB)	13.54***	0.646***		–1.201***	–8.787***	0.110**	–228.3***
	(2.642)	(0.135)		(0.0546)	(1.051)	(0.0532)	(12.76)
Human capital	–12.70***	0.970***	–0.367***		–4.563***	–0.218***	–77.67***
	(1.357)	(0.0634)	(0.0167)		(0.582)	(0.0284)	(7.647)
Unemp.	–0.701***	–0.00514	–0.0121***	–0.0209***		0.00280	–5.278***
	(0.107)	(0.00528)	(0.00150)	(0.00271)		(0.00206)	(0.537)
Political rights	0.990	2.030***	0.0595**	–0.381***	1.030		49.92***
	(2.063)	(0.0744)	(0.0291)	(0.0509)	(0.793)		(10.44)
Trade	0.00145	0.000615*	–0.00171***	–0.00190***	–0.0283***	0.000690***	
	(0.00768)	(0.000371)	(9.59e–05)	(0.000188)	(0.00283)	(0.000143)	
Violence		–0.0134***	0.00286***	–0.00901***	–0.102***	0.000319	0.0128
		(0.00186)	(0.000545)	(0.000917)	(0.0155)	(0.000777)	(0.210)
Constant	19.64	–3.805***	4.722***	7.301***	56.63***	0.0700	1,129***
	(12.57)	(0.624)	(0.0551)	(0.214)	(4.889)	(0.251)	(60.29)
Observations	668	668	668	668	668	668	668
R-squared	0.493	0.575	0.495	0.621	–0.047	0.303	0.034

Source: Author's own elaboration.