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Dynamic linkages between poverty, inequality, crime, and social expenditures in a panel of 16 countries: two-step GMM estimates

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Abstract

The study examines the relationship between growth–inequality–poverty (GIP) triangle and crime rate under the premises of inverted U-shaped Kuznets curve and pro-poor growth scenario in a panel of 16 diversified countries, over a period of 1990–2014. The study employed panel Generalized Method of Moments (GMM) estimator for robust inferences. The results show that there is (i) no/flat relationship between per capita income and crime rate; (ii) U-shaped relationship between poverty headcount and per capita income and (iii) inverted U-shaped relationship between income inequality and economic growth in a panel of selected countries. Income inequality and unemployment rate increases crime rate while trade openness supports to decrease crime rate. Crime rate substantially increases income inequality while health expenditures decrease poverty headcount ratio. Per capita income is influenced by high poverty incidence, whereas health expenditures and trade factor both amplify per capita income across countries. The results of pro-poor growth analysis show that though the crime rate decreases in the years 2000–2004 and 2010–2014, while the growth phase was anti-poor due to unequal distribution of income. Pro-poor education and health trickle down to the lower income strata group for the years 2010–2014, as education and health reforms considerably reduce crime rate during the time period.

Keywords: Pro-poor growth, Income inequality, Quality education, Healthcare expenditures, Crime rate, System panel GMM

Jel classification: C33, D63, I32, O47

1 Introduction

The study evaluated different United Nation sustainable development goals (SDGs), i.e., goals 1 and 2 (poverty reduction and hunger), goals 3 and 4 (promotion of health and education), goal 10 (reduced inequalities), and goal 16 (reduction of violence, peace and justice) to access pro-poor growth and crime reduction in a panel of 16 heterogeneous countries. The discussion of crime rate in pro-poor growth (PPG) agenda remains absent in the economic development literature, though Bourguignon (2000) stressed to reduce

crime and violence by judicious income distribution; however, a very limited literature is available to emphasize the need of social safety nets for vulnerable peoples that should be included in the pro-growth policy agenda for broad-based economic growth. Kelly (2000) investigated the relationship between income inequality (INC_INEQ) and urban crime, and found that INC_INEQ is the strong predictor to influence violent crime rather than property crime, while poverty (POV) and economic growth (EG) significantly affect on property crime rather than violent crime. The policies should be developed for equitable income and sound EG for reducing POV and crime across the globe. Drèze and Khera (2000) examined the inter-district variations of intentional homicides rate (IHR) in India for the period of 1981 and found that there is no significant relationship between urbanization/poverty and murder rates, while literacy rate has a strong impact to reduce criminal violence in India. The results further indicate the lower murder rate in those districts where female to male ratio is comparatively high. The study emphasized the need to reduce crime, violence and homicides by significant growth policies for sustained EG in India. Neumayer (2003) investigated the long-run relationship between political governance, economic policies and IHR using the panel of 117 selected countries for the period of 1980–1997 and concluded that IHR can be reduce by good economic and political policies. The results specified that higher income level, good civic sense, sound EG, and higher level of democracy all are connected with the lower homicides rate in a panel of countries. The study emphasized the need to improve governance indicators in order to lowering the IHR across the globe. Jacobs and Richardson (2008) examined the interrelationship between INC_INEQ and IHR in a panel of 14 developed democracies nation and found that intentional homicides is the mounting concerns in those nations where the inequitable income distribution exists, while results further provoke the presence of young males associated with the higher murder rates in a region. The policies should be formulated caution with care while devising for judicious income distribution with demographic variables in the pro-growth agenda. Sachsida et al. (2010) found inertial effect on criminality and confirmed the positive relationship between INC_INEQ, urbanization and IHR. The study emphasized the importance of public security spending to reduce IHR in Brazil. Pridemore (2011) re-assessed the relationship between POV, INC_INEQ and IHR in a cross-national panel of US states and found POV-homicides' linkages rather than inequality-homicides' association. The study argued that there is substantially desire to re-assess the inequality-homicides' linkages as it might be the misspecification of the model. Ulriksen (2012) examined the relationship between PPG, POV reduction and social security policies in the context of Botswana and found that broad-based social security policies have a significant impact to reduce POV, thus there is a strong need to include social security protections in the pro-poor growth (PPG) agenda for lowering the POV rates across the globe. Ouimet (2012) investigated the impact of socio-economic factors on IHR in a panel of 165 countries for the period 2010 and found that GIP triangle are strongly connected with the IHR for all countries, while for sub-samples, the results only support the inequality-homicides association rather than POV and EG induced IHR. The results highlighted the importance of GIP triangle to reduce IHR in a panel of selected countries.

Liu et al. (2013) investigated the relationship between national scale indicators of socio-economic and demographic factors and crime rates in 32 Mexican states and

found that EG, wages and unemployment negatively affect crime rates, while increase federal police force that is helpful to reduce crime rates; however, on the other way around, higher public security expenditures are linked with the higher crime rates in Mexican states. Chu and Tusalem (2013) investigated the role of state to reduce IHR in a panel of 183 nations and found that political instability increases IHR, while anocracies is the strong predictor to influence IHR in a panel of countries. The study concluded that IHR increases in those countries where there is high level of political instability and death penalty, while the amalgamation of democratic and autocratic features lead to increased IHR. The policies should be drawn to strengthen political governance across the globe. Adeleye (2014) evaluated the different determinants of INC_INEQ in a large panel of 137 countries using the time series data from 2000 to 2012 and found that per capita income (PCI), secondary education, rule of law index and unemployment rate are the strong predictors for INC_INEQ and IHR, while INC_INEQ considerably affected IHR rate in a region. Dalberis (2015) investigated the relationship between INC_INEQ, POV and crime rates in Latin American countries and found that INC_INEQ has no significant association with the crime rate in Colombia, Brazil, Uruguay and Salvador, while poverty is the strong predictor to influence crime in Brazil, Uruguay and Salvador. The results highlighted the need for pro-poorness of growth reforms that would be helpful to lowering the crime rates in Latin American countries. Harris and Vermaak (2015) considered the relationship between expenditures' inequality and IHRe across 52 districts of South Africa and found that while keeping other district features constant, inequality does appear as a strong dominant player to induce IHR. The rational income distribution along with broad-based EG may play a vital role to reduce IHR in South Africa. Stamatel (2016) investigated the relationship between democratic cultural values and IHR in a panel of 33 democratic countries for the period 2010 and found that democratic cultural values have a positive and negative impact of IHR in the presence of strong democratic institutions and practices. Ahmed et al. (2016) identified the different predictors of economic and natural resources in the context of Iran using the time series data from 1965–2011 and found that labor productivity, exports, capital stock and natural resources are the main predictors of EG, which altogether are important for sustained long-term growth of the country. Enamorado et al. (2016) interlinked crime rates with higher INC_INEQ using a 20-year dataset of more than 2000 Mexican municipalities and confirmed the causal relationships between the two stated factors. The results confined that drug-related crime rates largely increase up to 36% if there is one-point increment in the INC_INEQ during the specified time period. The study concludes with the fact that drug-related violent crime rates are more severe due to high proliferation of large dispersion in the labor market in terms of negative job opportunities in illegal sector. Thus, the sound policies are imperative to seize drug trafficking organizations by force for pro-equality growth. Ling et al. (2017) analyzed the role of trade openness in Malaysian life expectancy using the data from 1960 to 2014. The results show that continued EG and trade openness substantially increase life expectancy during the study time period. Further, the results established the feedback relationship between income and life expectancy in a country. The study concludes that life expectancy may increase through imported healthcare goods, which improves the quality of life of the people, thus trade liberalization policies are imperative for healthy and wealthy wellbeing.

Zaman (2018) extensively surveyed the large weighted sample of intellectuals about crime–poverty nexus and explored the number of socio-economic factors that concerned with high crime rate and POV incidence in Pakistan, including INC_INEQ, injustice, unemployment, low spending on education and health, price hikes, etc. There is a high need to increase social spending on education and health infrastructure in order to combat POV and crime rates in a given country. Imran et al. (2018) considered a time series data of US for a period of 1965–2016 and concluded that incidence of POV increases the intensity of property crime in a given country, while other controlling factors including country's PCI and unemployment rate are not significantly associated with property crime in a country. The study concludes that property crime should be restricted by strong legislative and regulatory measures, judicious income distribution, and increasing minimum wage rate, which altogether would be helpful for the poor to reap economic benefits from PPG reforms in a country. Zaman et al. (2019) evaluated the role of education in crime reduction in a panel of 21 countries for a period of 1990–2015 and found a parabola relationship between PCI and crime rates in the presence of quality education and equitable justice across countries. The study further confirmed few other causal conceptions among the variables for making sound policy implications in the context of criminal justice. Piatkowska (2020) examined the social cost of POV in terms of increasing suicides rates, crime rates, and total violent rates in the United States and across 15 European nations during the period of 1993–2000. The results show that suicides–crime–violent rates are substantially increasing due to increase in relative POV and infant mortality rates across countries. The study argued that relative POV is the strong predictor to increase social cost of nation that needs efficient economic policies to reduce crime rates. Mukherjee (2019) discussed the role of social sustainability in achieving economic sustainability by reducing different forms of violent/crime rates through state intervention in the context of Indian economy by utilizing the data for a period of 2005–2016. The results further highlighted the need of socio-economic infrastructure development that would be helpful to provide safety nets to the poor in order to reduce crime rates in a country. Duque and McKnight (2019) presented the channel through which crime rates and legal system provide a pathway to increase INC_INEQ and POV across countries. The study further discussed and highlighted the socio-economic vulnerability that escalates through unequal distribution of income and high POV incidence, which need effective legal system to reduce crime rates. Khan et al. (2019a) surveyed the Bolivian economy to assess pro-poor environmental reforms that could improve the quality of life of the poor through judicious income distribution and sustainable environmental reforms. The results conclude that services' sector and healthcare infrastructure would be helpful to reduce POV rate and achieve PPG process at country wide. Zaman et al. (2020) surveyed the large panel of countries (i.e., 124 countries) for a period of 2010–2013 to analyze the role of INC_INEQ and EG on POV incidence across countries. The results generally favor the strong linkages among the three stated factors to support GIP triangle, which forms PPG process. The study emphasized the need to adopt some re-corrective measures in order to provide social safety nets and income distribution in order to make a growth process more pro-poor. Kousar et al. (2019) confined its finding in favor of POV reduction through managing international remittances' receipts and financial development that would be helpful to improve the

mechanism of income distribution in a country like Pakistan. The study concluded that international remittances may play a vital role to reduce POV via the mediation of financial development in a country.

The real problem is how to make EG more equitable, which is helpful to reduce POV and crime rates, and make a growth more pro-poor. The SDGs largely provoked the need to sustained economic activities, which helpful to make growth policies more poor friendly. The previous studies are widely discussed crime rates and POV reduction (see Zaman 2018; Khan et al. 2015; Heinemann and Verner 2006; etc.); however, a very few studies interlinked POV–crime nexus under PPG and Kuznets curve (KC) hypothesis (see Saasa 2018; Berens and Gelepithis 2018, etc.). Based on the interconnections between crime, POV, and PPG, the study formulated the following research questions, i.e.,

(i) Does crime rate negatively influenced GIP triangle, which sabotages the process of PPG?

The recent study of Khan et al. (2019b) provoked the need of PPG policies to ensure sustainability agenda by including socio-economic and environmental factors in policy formulation, which gives favor to the poor as compared to the non-poor. In the similar lines, the social spending on education and healthcare infrastructure, and reforms needed to reduce labor market uncertainty in the form of lessen unemployment rate is considered the viable option for crime and POV reduction across countries (Khan et al. 2017). Thus, the study evaluated the question, i.e.,

(ii) To what extent social spending on education, health, and labor market are helpful to reduce crime rate, poverty, and income inequality across countries?

This question would be equally benefited to the developmental economists and policy makers to devise a healthy and wealthy policy by increasing spending on social infrastructure for pro-equality growth (Wang 2017). The last question is based upon non-linear formulation of crime–POV nexus where it is evaluated as a second-order coefficient to check the parabola relationship between them, i.e.,

(iii) Does crime and poverty exhibit a parabola relationship between them?

The question is all about the second-order condition, which confirmed one out of three conditions, i.e., either it is accepted an inverted U-shaped or U-shaped or flat relationship between them. The second-order condition assessed the probability to reduce crime rates and incidence of POV in policy formulation.

In the light of SDGs, the study explored the impact of GIP triangle and crime rates on pro-growth and PPG policies, which is imperative for sustainable development across countries. The study added social expenditures in PPG dynamics to promote healthy and wealthy economic activities, which improves quality of life of the poor and helpful to reduce crime incidence across countries. The study is first in nature, as authors' knowledge, which included GIP triangle and crime rate in PPG framework, while controlling different socio-economic factors, including education and health expenditures, unemployment rate, and trade openness. Further, an empirical contribution of the study is to include second-order coefficient of PCI for evaluating crime- and inequality-induced KC, while the study proceed to analyze forecast relationship between the crime and POV incidence over a next 10-year time period. Finally, the study estimated PPG index while including crime rate as a main predictor factor in GIP triangle for robust policy

inferences. Thus, these objectives are achieved by different statistical techniques for robust analysis.

2 Data source and methodological framework

The study used number of promising socio-economic variables to determine the dynamic relationship between PPG factors and crime rate under the framework of an inverted U-shaped KC in a panel of 16 diversified countries, using system GMM estimator for the period of 1990–2014. The study used the following variables, i.e., crime rate (proxy by intentional homicides rate per 100,000 population), GINI index measures income inequality, poverty headcount ratio at $1.90 a day (2011 PPP) (% of total population), national estimates of unemployment in % of total labor force, education expenditures as % of GDP, per capita health expenditure in current US$, per capita income in constant 2005 US$, and trade openness as % of GDP. The samples of countries are presented in Table 7 in Appendix for ready reference. The data for the study are obtained from World Development Indicators published by World Bank (2015).

These countries are selected because of the devastating crime rate during the study time period. The recorded figures for Argentina crime rates about to 245% increase between the period of 1991 and 2007, while 2002 is considered the highest committed crime data recorded when the POV and INC_INEQ reached at their peak levels (Bouzat 2010). Brazil economy is working out for reduction of crime by focusing on three-point agenda, i.e., reduction in income disparity, to increase spending on education via an increase in enrollment of school dropout children, and to improve labor market conditionings. These three policies design to deter the crime rates in a given country (World Bank 2013). The robbery complaints largely increase since last two decades in Chile, which is being planned by controlling two action strategies, i.e., plan cuadrante and country security plan. Both the plan designed to restructured police force to reduce robbery and violence in a country (Vergara 2012). The rural China is suffered by high INC_INEQ that leads to higher crime rate (South China Monitoring Report 2015) while POV and INC_INEQ lead to crime and violent factor in Colombia (Gordon 2016). The socio-economic factors including low provision of education, health, high POV, and food challenges lead to increase crime in Indonesia (Pane 2017), while generating employment opportunities and increasing wage rate in Malaysia may be beneficial to reduce crime–POV nexus in a given country (Mulok et al. 2017). Mexican economy is suffered with high rate of homicides that negatively affect labor market outcomes, while country inhibits by increasing strict laws to diminish violence (Kato Vidal 2015). The safety situation in Morocco is cumbersome, as one of the country reports shows that an increased rate in crime is about to increase up to 23% in 2016 (OSAC 2017). The number of other factors remains visible in selected sample of panel of countries, including rural POV and social exclusion that is considered the main factor of socio-economic crisis in Poland (European Commission 2008); POV, unemployment, and INC_INEQ chiefly attributed to crime rate in South Africa (Bhorat et al. 2017); politics, democracy, and INC_INEQ arise conflicts in Thailand (Hewison 2014); corruption and high unemployment are the major conflicts in Tunisia (Saleh 2011); and Uruguay economy needs policy actions to reduce POV by investment in children education, modernizing rural sector, and balancing the gender gap (Thamma 2017). Thus, these facts about crime and POV in different

countries put a focus to study crime–POV nexus under PPG framework in this study for robust evaluation. Figure 2 in Appendix shows the plots of the studied variables at level.

The study used the following non-linear equations to determine the dynamic relationship between PPG factors and crime rate in a panel of countries, i.e.,

$$\ln(\text{CRIME})_{i,t} = \beta_0 + \beta_1 \ln(\text{GDPPC})_{i,t} + \beta_2 \ln(\text{GDPPC})^2_{i,t} + \beta_3 \ln(\text{GINI})_{i,t} + \beta_4 \ln(\text{EDUEXP})_{i,t} + \beta_5 \ln(\text{HEXP})_{i,t} + \beta_6 \ln(\text{POVHCR})_{i,t} + \beta_7 \ln(\text{TOP})_{i,t} + \beta_8 \ln(\text{UNEMP})_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$\ln(\text{POVHCR})_{i,t} = \beta_0 + \beta_1 \ln(\text{GDPPC})_{i,t} + \beta_2 \ln(\text{GDPPC})^2_{i,t} + \beta_3 \ln(\text{GINI})_{i,t} + \beta_4 \ln(\text{EDUEXP})_{i,t} + \beta_5 \ln(\text{HEXP})_{i,t} + \beta_6 \ln(\text{TOP})_{i,t} + \beta_7 \ln(\text{UNEMP})_{i,t} + \beta_8 \ln(\text{CRIME}) + \varepsilon_{i,t} \quad (2)$$

$$\ln(\text{GINI})_{i,t} = \beta_0 + \beta_1 \ln(\text{GDPPC})_{i,t} + \beta_2 \ln(\text{GDPPC})^2_{i,t} + \beta_3 \ln(\text{POVHCR})_{i,t} + \beta_4 \ln(\text{EDUEXP})_{i,t} + \beta_5 \ln(\text{HEXP})_{i,t} + \beta_6 \ln(\text{TOP})_{i,t} + \beta_7 \ln(\text{UNEMP})_{i,t} + \beta_8 \ln(\text{CRIME}) + \varepsilon_{i,t} \quad (3)$$

$$\ln(\text{GDPPC})_{i,t} = \beta_0 + \beta_1 \ln(\text{POVHCR})_{i,t} + \beta_2 \ln(\text{EDUEXP})_{i,t} + \beta_3 \ln(\text{HEXP})_{i,t} + \beta_4 \ln(\text{TOP})_{i,t} + \beta_5 \ln(\text{UNEMP})_{i,t} + \beta_6 \ln(\text{CRIME}) + \varepsilon_{i,t} \quad (4)$$

where GDPPC indicates per capita GDP, GDPPC^2 indicates square of per capita GDP, GINI indicates Gini coefficient—income inequality, EDUEXP indicates education expenditures, HEXP indicates health expenditures, POVHCR indicates poverty headcount ratio, TOP indicates trade openness, UNEMP indicates unemployment, and CRIME indicates crime rate.

Equations (1) to (3) assessed the possible inverted U-shaped relationships between crime rate and PCI, between POVHCR and PCI, and between GINI and PCI, while Eq. (4) reviewed the PPG reforms across countries. Arellano and Bond (1991) developed the differenced GMM estimator, whom argued that the GMM estimator eliminates country effects and controls the possible endogeneity of explanatory variables using the appropriate instrumental list that evaluated by Sargan–Hansen test. The process further involves two-step GMM iterations with the time updated weights and adopted the weighting matrix by White period. The tests for autocorrelations by AR(1) and AR(2) and the Sargan test by Sargan–Hansen of over-identifying restrictions are presented for statistical reliability of the given models. The differenced GMM is superior to the 2SLS and system GMM, i.e., 2SLS regression estimator is used when the known endogeneity exists between the variables, which are handled by including the list of instrumental variables at their first lagged. Thus, the possible endogeneity problem is resolved accordingly. The system GMM further be used instead of 2SLS as if there are more than one endogenous issues exist in the model, which is unable to resolve through 2SLS estimator. Finally, the differenced GMM estimator is used as its estimated AR(1) and AR(2) bound values that would be helpful to encounter the issues of serial correlation and endogeneity problem accordingly.

Using the GMM estimator, the study verified different possibilities of KC, i.e., if the signs and magnitudes of $\beta_1 > 0$ and $\beta_2 < 0$, than we may confirm the crime-induced KC, poverty-induced KC, and inequality-induced KC. The inverted U-shaped relationship between crime rate and PCI verified 'crime-induced KC', between POVHCR and PCI verified 'POV-induced KC', and inverted U-shaped relationship between GINI and

PCI verified 'inequality-induced KC'. On the other way around, if $\beta_1 < 0$ and $\beta_2 > 0$, then we consider the U-shaped KC between crime rate and PCI, between POV and PCI, and between GINI and PCI, respectively. There are three other situations we may observe with the sign and magnitude of β_1 and β_2, i.e., (i) $\beta_1 < 0$ and $\beta_2 = 0$, (ii) $\beta_1 > 0$ and $\beta_2 = 0$, and (iii) $\beta_1 = 0$ and $\beta_2 = 0$, referred the monotonically decreasing function, monotonically increasing function, and flat/no relationship with the crime-PCI, poverty-PCI, and inequality-PCI in a panel of cross-sectional countries. The study further employed social accounting matrix by impulse response function (IRF) and variance decomposition analysis (VDA) in an inter-temporal relationship between the studied variables for a next 10-year period starting from 2015 to 2024. As it name implies, VDA explains the proportional variance in one variable caused by the proportional variance by the other variables in a vector autoregressive (VAR) system, while IRF traces the dynamic responses of a variable to innovations in other variables in the system. Both the techniques use the moving average representation of the original VAR system. Figure 1 shows the theoretical framework of the study to clearly outline the possible relationship between the stated variables.

Figure 1 shows the possible relationship between POV and crime rates in mediation of inequality, unemployment, and EG across countries. It is likelihood that POV increases inequality that leads to decrease in EG. The low-income growth further leads to increased unemployment, which causes high crime rates. This nexus is still rotated through crime

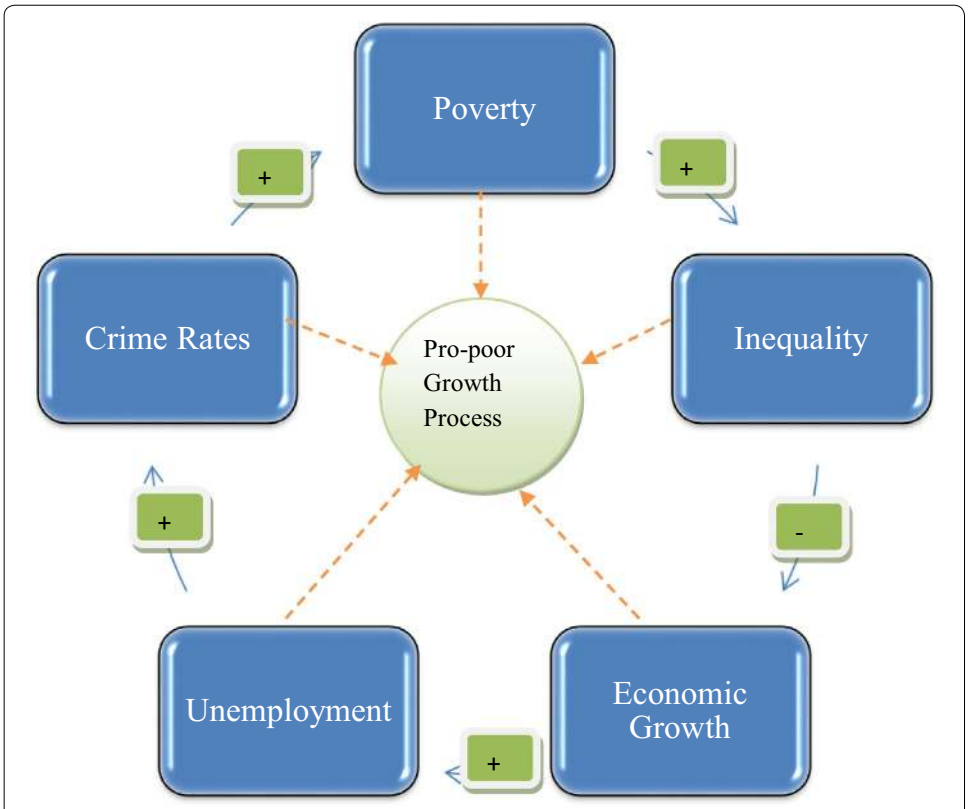

Fig. 1 Research framework of the study. Source: authors' extraction

rates that increase POV incidence across countries. The PPG process still works under the stated factors that need judicious income distribution to reduce crime rates.

The study further proceeds to evaluate the PPG reforms in a panel of selected countries. Kakwani and Pernia (2000) proposed an index of PPG called 'PPG index', which is evaluated by the growth elasticity and inequality elasticity with respect to POV. The same methodology is adopted in this study to assess the PPG and/or pro-rich growth reforms to assess the changes in the crime rate in a panel of countries. PPG defined as a state in which where the growth trickles down to the poor as compared to the non-poor. Poverty is largely affected by two main factors, i.e., higher growth rate may reduce the POV rates, while higher INC_INEQ reduces the impact of EG to reduce POV; therefore, the PPG index included the following mathematical illustrations, i.e.,

$$\text{Growth elasticity of poverty (GEP)}: \ \eta = \frac{\Delta(\text{GDPPC})/\text{GDPPC}}{\Delta\text{POVHCR}/\text{POVHCR}} = \frac{d\ln(\text{GDPPC})}{d\ln(\text{POVHCR})}, \tag{5}$$

$$\text{Inequality elasticity of poverty (IEP)}: \ \xi = \frac{\Delta(\text{GINI})/\text{GINI}}{\Delta\text{POVHCR}/\text{POVHCR}} = \frac{d\ln(\text{GINI})}{d\ln(\text{POVHCR})}, \tag{6}$$

$$\text{Total poverty elasticity (TPE)}: \ \delta = \eta + \zeta, \tag{7}$$

$$\text{PPG Index: } \varphi = \frac{\delta}{\eta}. \tag{8}$$

The study further assessed the pro-poorness of social expenditures and evaluates its impact to observe changes in IHR. The study shows the following mathematical illustrations that is extended from the scholarly work of Zaman and Khilji (2014); Kakwani and Pernia (2000) and Kakwani and Son (2004) i.e.,

$$\eta_\alpha = \frac{\partial P_\alpha}{\partial \text{SOCIALEXP}} \frac{\text{SOCIALEXP}}{P_\alpha} = -\frac{\alpha[P_{\alpha-1} - P_\alpha]}{P_\alpha} \tag{9}$$

where $\alpha = 0$, 1 and 2 indicate POVHCR, poverty gap and squared poverty gap, respectively, 'P' indicates FGT poverty measures, and 'SOCIALEXP' indicates social expenditures. Differentiating η_α in Eq. (9) with respect to social expenditures gives more elaborated form of GEP, i.e.,

$$\frac{\partial \eta_\alpha}{\partial \text{SOCIALEXP}} = -\frac{\alpha P_{\alpha-1}}{\text{SOCIALEXP}(P_\alpha)}[\eta_{\alpha-1} - \eta_\alpha]. \tag{10}$$

The elasticity of entire class of poverty measures P_α with respect to Gini index is given by

$$\begin{aligned} \xi_\alpha &= \frac{(\text{SOCIALEXP} - z)f(z)/F(z)}{F(z)} \text{ when } \alpha = 0 \\ &= \frac{\alpha}{zP_\alpha}[(\text{SOCIALEXP} - z)P_{\alpha-1} + zP_\alpha], \alpha \geq 1 \end{aligned} \tag{11}$$

which will be always positive only when $SOCIALEXPE > z$.Equations (10) and (11) are combined together to form TPE for all FGT poverty measures, i.e.,

$$\frac{dP_\alpha}{P_\alpha} = \eta_\alpha \frac{d\text{SOCIALEXP}}{\text{SOCIALEXP}} + \xi_\alpha \frac{d\text{GINI}}{\text{GINI}}$$
$$\text{or} \tag{12}$$
$$\delta_\alpha = \eta_\alpha + \xi_\alpha$$

or $\delta_\alpha = \eta_\alpha + \xi_\alpha$. Finally, pro-poorness of social expenditures estimated based on the following equation, i.e.,

$$\varphi_\alpha = \frac{\delta_\alpha}{\eta_\alpha}. \tag{13}$$

Kakwani and Son (2004) presented the following bench mark applications to assess the pro-poor and/or anti-poor policies, i.e., the following value judgments regarding the PPG index (φ) are as follows, i.e.,

If
$\varphi < 0$, growth is pro-rich or anti-poor,
$0 < \varphi \leq 0.33$, the process of PPG is considerable low,
$0.33 < \theta \leq 0.66$, the process of PPG is moderate,
$0.66 < \varphi < 1.0$, the process of EG considered as pro-poor, and
$\varphi \geq 1.0$, the process of EG is highly pro-poor.
The study utilized the PPG model for ready reference in this study.

3 Results

This section presented the descriptive statistics in Table 1, correlation matrix in Table 2, dynamic system GMM estimates in Table 3, IRF estimates in Table 4, VDA estimates in Table 5, while finally Table 6 shows the estimates for PPG in a panel of selected countries. Table 1 shows that GDPPC has a minimum value of US$ 199.350 and the maximum value of US$ 11257.600, with a mean and standard deviation (STD) value of US$ 4340.777 and US$ 2490.554, respectively. GINI has a minimum value of 25% and the maximum value of 64.790%, having an STD value of 8.580% with an average value of 45.095%. The minimum value of EDUEXP is about 0.998% of GDP and the maximum value of 7.657% of GDP, with an average value of 4.051% of GDP. The average value of HEXP per capita is about US$ 321.249 and a maximum value of US$ 1431.154, with an

Table 1 Descriptive statistics

Variables	Mean	Std. dev.	Minimum	Maximum
GDPPC	4340.777	2490.554	199.350	11257.600
GINI	45.095	8.580	25.000	64.790
EDUEXP	4.051	1.464	0.998	7.657
HEXP	321.249	292.802	9.736	1431.154
POVHCR	12.394	16.591	0.010	69.000
TOP	62.391	39.384	13.753	220.407
UNEMP	8.890	6.010	0.700	27.200
CRIME	11.664	16.539	0.439	71.786

Table 2 Correlation matrix

Variables	GDPPC	GINI	EDUEXP	HEXP	POVHCR	TOP	UNEMP	CRIME
GDPPC	1.000							
GINI	0.264	1.000						
EDUEXP	0.243	0.205	1.000					
HEXP	0.730	0.233	0.146	1.000				
POVHCR	−0.599	−0.058	−0.385	−0.438	1.000			
TOP	0.061	−0.164	0.389	−0.169	−0.316	1.000		
UNEMP	0.152	0.263	0.393	0.135	−0.128	−0.212	1.000	
CRIME	0.031	0.671	0.188	0.041	0.164	−0.301	0.417	1.000

Table 3 Dynamic panel data estimates, two-step system GMM

Variables	CRIME	POVHCR	GINI	GDPPC
GDPPC	−0.002	−0.010[a]	0.004[a]	–
$GDPPC^2$	−2.07e−07	8.62e−07[a]	−3.83e−07[a]	–
GINI	0.818[b]	0.179	–	37.289
EDUEXP	1.427	−0.985	0.359	−101.523
HEXP	0.007	−0.008[a]	0.001	5.690[a]
POVHCR	0.253	–	0.081	−31.323[b]
TOP	−0.047[c]	−0.076	−0.009	11.022[c]
UNEMP	0.425[b]	−0.017	−0.010	23.808
CRIME	–	0.304	0.223[a]	0.679
Constant	−41.627[a]	38.180[b]	29.531[a]	695.364
Statistical tests				
F-statistics	13.87[a]	4.00[a]	30.40[a]	49.64
Sargan-Hansen Test	0.413	0.102	0.756	0.848
AR(1)	0.284	0.059[c]	0.651	0.164
AR(2)	0.132	0.032[b]	0.100	0.153

[a,b,c] indicates 1%, 5%, and 10% significance level

STD value of US$ 292.802. The maximum value of POVHCR is about 69% at US$1.90 a day with an average value of 12.394% at US$1.90 a day. The minimum value of trade is 13.753% of GDP and the maximum value of 220.407% of GDP, with an average value of 62.391% of GDP. The mean value for UNEMP is about 8.890% of total labor force with STD value of 6.010%. Finally, the minimum value of crime rate is about 0.439 per 100,000 inhabitants and the maximum value of 71.786 per 100,000 inhabitants, with an average value of 11.664 per 100,000 peoples. This exercise would be helpful to understand the basic descriptions of the studied variables in a panel of countries.

Figure 3 in Appendix shows the plots of the studied variables and found the stationary movement in the variables at their first difference. Table 2 presents the estimates of correlation matrix and found that GINI (i.e., $r=0.264$), EDUEXP ($r=0.243$), HEXP ($r=0.730$), TOP ($r=0.061$), UNEMP (0.152) and CRIME ($r=0.031$) have a positive correlation with the GDPPC, while POVHCR ($r=-0.599$) significantly decreases GDPPC.

The results further reveal that GINI is affected by EDUEXP, HEXP, UNEMP and CRIME, while it considerably decreases by trade liberalization policies. EDUEXP, HEXP, PCI, TOP and UNEMP significantly decrease POVHCR, while crime rate has

Table 4 IRF estimates

Response of DLOG (CRIME):

Period	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	0.108	0	0	0	0	0	0	0
2016	−0.0006	−0.009	−0.0004	−0.0005	−0.001	0.003	0.0005	−0.009
2017	−0.006	0.024	−0.005	−0.002	0.005	0.007	−0.009	0.006
2018	4.74E−05	−0.003	0.001	0.003	0.003	−0.0004	0.002	−0.001
2019	6.05E−05	−0.003	−0.0004	−0.001	−0.001	−0.0009	0.0007	7.27E−05
2020	−0.0002	0.0005	4.42E−05	0.0001	−8.24E−05	0.0004	−0.0007	0.000647
2021	4.38E−05	0.0003	−2.17E−05	−3.35E−05	9.11E−06	−9.41E−05	0.0003	2.36E−05
2022	−1.40E−05	−0.0001	1.67E−05	−9.26E−05	−5.92E−05	4.49E−05	5.62E−05	0.000140
2023	3.04E−05	4.81E−05	4.41E−05	9.98E−05	−1.33E−05	1.75E−06	−6.97E−05	1.03E−05
2024	2.78E−06	1.05E−05	1.23E−05	−3.85E−05	−3.00E−06	−2.48E−05	2.19E−05	5.90E−06

Response of DLOG (POVHCR):

Period	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	−0.089	0.448	0	0	0	0	0	0
2016	0.039	−0.058	0.047	0.060	0.032	−0.023	−0.011	−0.026
2017	0.023	−0.038	0.009	0.014	−0.006	−0.029	−0.020	−0.042
2018	−0.004	0.010	−0.004	−0.013	0.005	0.002	−0.011	−0.001
2019	−0.001	0.004	−0.004	0.004	0.006	0.004	0.0008	−0.002
2020	−0.000	−0.003	−0.001	−0.0008	0.0005	−0.001	0.003	−0.002
2021	−0.000410	−0.001	−0.0003	−0.0003	−0.0006	0.0004	−0.001	−0.000
2022	5.08E−05	0.0002	−0.0001	0.0003	2.83E−05	−0.0001	−1.53E−05	−0.0005
2023	−9.16E−05	−0.0001	−0.0002	−0.0003	−4.76E−05	−4.20E−05	0.0002	−0.0001
2024	2.74E−06	−1.19E−05	−4.83E−05	0.0001	−1.01E−06	7.74E−05	−8.97E−05	−8.10E−05

Response of DLOG(GINI):

Period	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	−0.0002	0.006	0.022	0	0	0	0	0
2016	−0.0006	−0.0007	0.001	0.002	−0.001	9.12E−05	−0.0004	−0.0004
2017	−0.001	0.001	0.001	0.0006	0.001	−3.32E−05	−0.0002	5.86E−05
2018	−0.0001	7.10E−05	0.0002	−0.0002	8.98E−05	0.0001	−3.04E−05	0.0001
2019	−1.41E−05	−0.0004	0.0001	0.0002	0.0001	2.06E−06	−8.90E−05	0.0001
2020	−6.37E−05	6.40E−05	−1.32E−05	−9.40E−05	−2.29E−05	−2.04E−05	6.65E−05	5.88E−05
2021	−2.52E−05	2.25E−05	1.71E−05	−2.51E−05	3.23E−06	5.03E−05	3.23E−07	0.0001
2022	9.23E−06	−2.43E−06	1.77E−05	3.09E−05	−6.18E−06	−4.49E−06	1.31E−05	1.67E−05
2023	−7.45E−07	−8.83E−08	8.92E−06	−1.71E−05	−8.24E−06	−4.67E−06	4.76E−06	1.96E−05
2024	6.68E−07	6.45E−06	5.20E−06	5.13E−06	−7.18E−07	5.17E−06	−6.70E−06	1.19E−05

Response of DLOG (GDPPC):

Period	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	−0.005	−0.004	0.002	−0.009	−0.003	0.014	0.002	0.028
2016	−0.002	0.001	1.48E−06	0.002	−0.0002	0.004	0.001	0.008
2017	−0.001	0.001	0.001	−0.003	−0.001	0.0001	0.003	0.006
2018	−6.20E−05	0.0002	0.001	0.0006	−0.001	0.0009	−0.0002	0.003
2019	0.0003	0.0006	0.0009	0.0001	−0.0003	−0.0003	0.0002	0.001
2020	3.85E−05	0.0002	0.0004	−0.0002	−0.0001	8.60E−05	−3.97E−05	0.0009
2021	8.49E−05	0.0002	0.0002	0.0001	1.96E−05	7.14E−05	−0.0001	0.0004

Table 4 (continued)

Response of DLOG (GDPPC):								
Period	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2022	2.36E−05	6.57E−05	0.0001	−4.36E−05	−2.77E−06	−3.43E−05	5.19E−05	0.0002
2023	1.00E−06	3.23E−05	5.74E−05	−5.90E−06	−5.82E−06	3.49E−05	−3.36E−05	0.0001
2024	9.15E−06	2.64E−05	3.56E−05	1.83E−05	2.83E−06	2.43E−07	−3.59E−07	6.50E−05

'D' shows first difference, while 'LOG' represents natural logarithm

a positive correlation with the POVHCR. Finally, GINI have a greater magnitude, i.e., $r = 0.671$, to influence CRIME, followed by UNEMP ($r = 0.417$), EDUEXP ($r = 0.188$), and POVHCR ($r = 0.164$) while trade liberalization policies support to decrease crime rates in a panel of countries. The study now proceeds to estimate the two-step system GMM for analyzing the functional relationship between socio-economic factors and crime rate. The results are presented in Table 3.

The results of panel GMM show that GINI and UNEMP both have a significant and direct relationship with the CRIME, while TOP have an indirect relationship with CRIME in a panel of countries. The results imply that GINI and UNEMP are the main factors that increase CRIME, while trade liberalization policies have a supportive role to decrease crime rates across countries. Thorbecke and Charumilind (2002) evaluated the impact of income inequality on health, education, political conflict, and crime, and surveyed the different casual mechanism in between income inequality and its socio-economic impact across the globe. The policies have devised while reaching the conclusive relationships between them. Kennedy et al. (1998) concluded that social capital and income inequality are the powerful predictors of intentional homicides rate and violent crime in the US states. Altindag (2012) explored the long-run relationship between unemployment and crime rates in a country-specific panel dataset of Europe and found that unemployment significantly increases crime rates, while unemployment has a power predictor of exchange rate movements and industrial accident across the Europe. Menezes et al. (2013) confirmed the positive association between income inequality and criminality, as rational income distribution tends to decrease neighborhood homicides rate while it implies an increase in the intentional homicides rate in the surrounding neighborhoods.

In a second regression panel, the results confirmed the U-shaped relationship between POVHCR and GDPPC, as at initial level of EG, POV significantly declines, while at the later stages, this result is evaporated, as EG subsequently increases POVHCR that shows pro-rich federal policies across countries. The HEXP, however, significantly decreases POVHCR during the study time period. Dercon et al. (2012) investigated the relationship between chronic POV and rural EG in Ethiopia and argued that chronic POV is associated with the lack of education, physical assets and remoteness, while EG in terms of provide better roads and extension services may trickle down to the poor in a same way that the non-chronically poor benefited. Solinger and Hu (2012) examined the relationship between health, wealth and POV in urban China and found that wealthier cities prefer to allocate their considerable portion of savings for social assistance funds, while poorer places save the city money

Table 5 VDA estimates. Source: authors' estimation

VDA of DLOG(CRIME):

Period	S.E.	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	0.108	100	0	0	0	0	0	0	0
2016	0.109	98.336	0.747	0.001	0.002	0.019	0.105	0.002	0.784
2017	0.113	91.843	5.308	0.203	0.061	0.248	0.554	0.673	1.107
2018	0.113	91.554	5.382	0.211	0.131	0.331	0.553	0.720	1.113
2019	0.113	91.436	5.463	0.213	0.148	0.343	0.559	0.723	1.112
2020	0.113	91.425	5.464	0.213	0.148	0.343	0.561	0.727	1.115
2021	0.113	91.423	5.465	0.213	0.148	0.343	0.561	0.729	1.115
2022	0.113	91.422	5.465	0.213	0.148	0.343	0.561	0.729	1.115
2023	0.113	91.422	5.465	0.213	0.148	0.343	0.561	0.729	1.115
2024	0.113	91.422	5.465	0.213	0.148	0.343	0.561	0.729	1.115

VDA of DLOG(POVHCR):

Period	S.E.	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	0.457	3.818	96.181	0	0	0	0	0	0
2016	0.471	4.308	91.952	1.009	1.619	0.474	0.253	0.060	0.321
2017	0.477	4.453	90.385	1.025	1.669	0.481	0.629	0.237	1.116
2018	0.477	4.452	90.233	1.034	1.743	0.496	0.630	0.294	1.115
2019	0.477	4.450	90.192	1.042	1.751	0.512	0.638	0.294	1.117
2020	0.478	4.450	90.184	1.043	1.751	0.512	0.639	0.298	1.120
2021	0.478	4.450	90.184	1.043	1.751	0.512	0.639	0.299	1.120
2022	0.478	4.450	90.183	1.043	1.751	0.512	0.639	0.299	1.120
2023	0.478	4.450	90.183	1.043	1.751	0.512	0.639	0.299	1.120
2024	0.478	4.450	90.183	1.043	1.751	0.512	0.639	0.299	1.120

VDA of DLOG(GINI):

Period	S.E.	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	0.023	0.010	7.598	92.391	0	0	0	0	0
2016	0.023	0.086	7.557	90.966	1.020	0.292	0.001	0.041	0.033
2017	0.023	0.308	7.649	89.897	1.089	0.963	0.001	0.056	0.033
2018	0.023	0.311	7.648	89.879	1.098	0.964	0.003	0.056	0.037
2019	0.023	0.311	7.680	89.833	1.105	0.965	0.003	0.057	0.041
2020	0.023	0.312	7.681	89.829	1.107	0.96	0.003	0.058	0.041
2021	0.023	0.312	7.680	89.826	1.107	0.965	0.004	0.058	0.044
2022	0.023	0.312	7.680	89.826	1.107	0.965	0.004	0.058	0.044
2023	0.023	0.312	7.680	89.826	1.107	0.965	0.004	0.058	0.044
2024	0.023	0.312	7.680	89.826	1.107	0.965	0.004	0.058	0.044

VDA of DLOG (UNEMP):

Period	S.E.	DLOG (CRIME)	DLOG (POVHCR)	DLOG (GINI)	DLOG (UNEMP)	DLOG (EDUEXP)	DLOG (HEXP)	DLOG (TOP)	DLOG (GDPPC)
2015	0.242	0.016	2.218	0.101	97.663	0	0	0	0
2017	0.261	0.584	2.024	0.178	92.177	0.218	1.956	1.917	0.942
2018	0.261	0.584	2.035	0.212	91.805	0.266	1.988	2.138	0.968
2019	0.262	0.604	2.031	0.218	91.695	0.267	1.996	2.148	1.036
2020	0.262	0.605	2.030	0.222	91.678	0.267	1.998	2.157	1.038
2021	0.262	0.605	2.030	0.223	91.670	0.267	2.002	2.161	1.038

Table 5 (continued)

VDA of DLOG (UNEMP):									
Period	**S.E.**	**DLOG (CRIME)**	**DLOG (POVHCR)**	**DLOG (GINI)**	**DLOG (UNEMP)**	**DLOG (EDUEXP)**	**DLOG (HEXP)**	**DLOG (TOP)**	**DLOG (GDPPC)**
2022	0.262	0.606	2.030	0.223	91.666	0.267	2.003	2.161	1.040
2023	0.262	0.606	2.030	0.223	91.666	0.267	2.003	2.161	1.040
2024	0.262	0.606	2.030	0.223	91.666	0.267	2.003	2.161	1.040
VDA of DLOG(GDPPC):									
Period	**S.E.**	**DLOG (CRIME)**	**DLOG (POVHCR)**	**DLOG (GINI)**	**DLOG (UNEMP)**	**DLOG (EDUEXP)**	**DLOG (HEXP)**	**DLOG (TOP)**	**DLOG (GDPPC)**
2015	0.034	2.255	2.080	0.723	7.336	1.314	18.038	0.441	67.808
2016	0.036	2.418	2.198	0.660	7.015	1.205	17.927	0.633	67.940
2017	0.037	2.424	2.182	0.858	7.475	1.373	16.925	1.364	67.396
2018	0.037	2.396	2.160	0.974	7.419	1.430	16.782	1.352	67.484
2019	0.037	2.399	2.183	1.040	7.403	1.435	16.751	1.354	67.431
2020	0.037	2.397	2.185	1.051	7.402	1.436	16.737	1.353	67.434
2021	0.037	2.397	2.189	1.055	7.403	1.436	16.733	1.354	67.430
2022	0.037	2.397	2.189	1.056	7.403	1.436	16.732	1.354	67.430
2023	0.037	2.397	2.189	1.056	7.403	1.436	16.732	1.354	67.430
2024	0.037	2.397	2.189	1.056	7.403	1.436	16.732	1.354	67.430

Table 6 PPG, education, healthcare assessment and crime rates in five different growth phases

PPG assessment and crime rate						
Years	**IEP**	**GEP**	**TPE**	**PPG index**	**PPG decision**	**Crime elasticity of poverty (CEP)**
1990–1994	− 0.630	− 0.023	− 0.629	27.347	Pro-poor	0.081
1995–1999	0.517	− 0.187	0.330	− 1.764	Anti-poor	0.051
2000–2004	0.292	− 0.056	0.236	− 4.714	Anti-poor	− 0.008
2005–2009	0.520	− 0.205	0.315	− 1.536	Anti-poor	0.022
2010–2014	0.177	− 0.019	0.158	− 8.315	Anti-poor	− 0.029
Pro-poor education (PPE) assessment and crime rate						
Years	**IEP**	**Education elasticity of Poverty (EEP)**	**TPE**	**PPE index**	**PPE decision**	**CEP**
1990—1994	− 0.734	0.064	− 0.670	− 10.468	Anti-poor	0.077
1995—1999	0.362	− 0.278	0.084	− 0.302	Anti-poor	0.058
2000—2004	0.160	− 0.057	0.103	− 1.807	Anti-poor	− 0.005
2005—2009	− 0.259	− 0.132	− 0.391	2.962	Pro-poor	0.075
2010— 2014	0.057	0.148	0.205	1.385	Pro-poor	− 0.037
Pro-poor health (PPH) assessment and crime rate						
Years	**IEP**	**Health Elasticity of Poverty (HEP)**	**TPE**	**PPH Index**	**PPH Decision**	**CEP**
1990— 1994	− 0.585	− 0.036	− 0.621	17.25	Pro-poor	0.087
1995— 1999	0.625	− 0.192	0.433	− 2.255	Anti-poor	0.088
2000— 2004	− 0.045	0.040	− 0.005	− 0.125	Anti-poor	− 3.60E−05
2005— 2009	0.303	− 0.145	0.158	− 1.089	Anti-poor	0.057
2010— 2014	0.065	0.018	0.083	4.611	Pro— poor	− 0.028

and work outside in a hope that the peoples would be better able to support themselves. Fosu (2015) examined the relationship between GIP triangle in sub-Saharan African countries and found that as a whole, South African countries lag behind the BICR (Brazil, India, China and Russia) group of countries; however, many of them in sub-Saharan African countries have outperformed India. The results further specified that PCI is the main predictor to reduce POV in sub-Saharan African countries; however, rational income distribution is a crucial challenge to reduce POV reduction through substantial growth reforms in a region. Kalichman et al. (2015) concluded that food poverty is associated with the multifaceted problems of health-related outcomes across the globe.

In a third regression panel, the results confirm an inverted U-shaped relationship between GDPPC and GINI that verified an inequality-induced KC in a panel of countries. The results imply that at initial level of economic development, GINI first increases and then decreases with the increased GDPPC across countries. CRIME, however, it is associated with the higher GINI during the studied time period. Kuznets (1955), Ahluwalia (1976), Deininger and Squire (1998), and others confirmed an inverted U-shaped relationship between INC_INEQ and PCI in different economic settings. Mo (2000) suggested different channelss to examine the possible impact of INC_INEQ on EG and found that 'transfer channel' exert the most important channel, while 'human capital' is the least important channel that negatively affects the rate of EG via INC_INEQ. Popa (2012) argued that health and education both are important predictors for EG, while POV and unemployment negatively correlated with the EG in Romania. Herzer and Vollmer (2012) confirmed the negative relationship between INC_INEQ and EG within the sample of developing countries, developed countries, democracies, non-democracies, and sample as a whole. In a similar line, Malinen (2012) confirmed the long-run equilibrium relationship between PCI and INC_INEQ and found that income inequality negatively affected the growth of developed countries.

The final regression shows that HEXP and TOP both significantly increase GDPPC, while POVHCR decreases the pace of EG, which merely be shown pro-rich federal policies in a panel of countries. Ranis et al. (2000) found that both the health and education expenditures lead to increased EG, while investment improves human development in a cross-country regression. Bloom et al. (2004) confirmed the positive connection between health and EG across the globe. Gyimah-Brempong and Wilson (2004) examined the possible effect of healthy human capital on PCI of sub-Saharan African and OECD countries and found the positive association between them in a panel of countries.

The statistical tests of the system GMM estimator confirmed the stability of the model by F-statistics, as empirically model is stable at 1% level of confidence interval. Sargan–Hansen test confirmed the instrumental validity at conventional levels for all cases estimated. Autocorrelations tests imply that except POVHCR model, the remaining three models including CRIME, GINI and GDPPC model confirmed the absence of first- and second-order serial correlation, and as a consequence, we verified our instruments are valid. As far as POVHCR model, we believed the results of Sargan–Hansen test of over identifying restrictions and AR(1) that is insignificant at 5% level, and confirmed the validity of instruments and absence of autocorrelation at first-order serial correlation.

Table 4 shows the estimate of IRF for the next 10-year period starting from a year of 2015 to 2024.

The results show that the socio-economic factors have a mix result with the rate of crime, as POVHCR slightly increases with decreasing rate with the crime data, i.e., in the next coming years from 2016, 2018, 2019, and 2022, POVHCR exhibits a negative sign, while in the remaining years in between from 2015 to 2024, POVHCR increases crime rate. GINI will considerably increase crime rate from 2022 to 2024. UNEMP has a mixed result to either increase crime rate in one period while in the very next upcoming periods, it declines crime rate. Similar types of results been found with EDUEXP, HEXP and with the TOP; however, GDPPC will constantly increase the rate of crime in a panel of countries. In an inter-temporal relationship between POVHCR and other predictors, the results show that GDPPC would significantly decrease POVHCR for the next 10-year period; however, UNEMP, HEXP, and crime rate would considerably increase POVHCR. EDUEXP and TOP would support to reduce GINI for the next upcoming years, while remaining variables including crime rate, POV, UNEMP, HEXP, and GDPPC associated with an increased GINI across countries. The GDPPC will be influenced by crime rate, POVHCR, GINI, UNEMP, HEXP, and EDUEXP, while TOP would considerably to support GDPPC for the next 10-year time period. Figure 4 in Appendix shows the IRF estimates for the ready reference.

Table 5 shows the estimates of VDA and found that POVHCR will exert the largest share to influence crime rates, followed by GDPPC, TOP, HEXP, EDUEXP, GINI, and UNEMP. POVHCR would be affected by crime rate (i.e., 4.450%), UNEMP (1.751%), GDPPC (1.120%), GINI (1.043%), HEXP (0.639%), and EDUEXP (0.512%), and TOP (0.299%), respectively.

The results further reveal that GINI will affected by POVHCR, as it is explained by 7.680% variations to influence GINI for the next 10-year period. UNEMP, EDUEXP, and crime rate will subsequently influenced GDPPC about to 1.107%, 0.965%, and 0.312% respectively. The largest variance to explain UNEMP will be TOP, while the lowest variance to influence UNEMP will be GINI for the next 10-year period. Finally, GDPPC would largely influenced by HEXP, followed by UNEMP, CRIME, POVHCR, EDUEXP, TOP, and GINI for the period of 2015 to 2024. Figure 5 in Appendix shows the plots of the VDA for ready reference.

Finally, Table 6 presents the changes in crime rate by five different growth phases, i.e., phase 1: 1990–1994, phase 2: 1995–1999, phase 3: 2000–2004, phase 4: 2005–2009, and phase 5: 2010–2014. The results show that in the years 1990–1994, 1% increase in EG and INC_INEQ decrease POVHCR by −0.023% and −0.630%, which reduces TPE by −0.629 percentage points. The PPG index surpassed the bench mark value of unity and confirmed the trickledown effect that facilitates the poor as compared to the non-poor. However, there is an overwhelming increase in the crime rate beside that the pro-poorness of EG, which indicate the need for substantial safety nets' protection to the poor that escape out from this acute activities (Wang et al. 2017). In a second phase from 1995 to 1999, although EG decreases POVHCR by −0.187; however, GINI has a greater share to increase POVHCR by 0.517% that ultimately increases TPE by 0.330%. This increase in the TPE turns to decrease PPG as 1.764, which shows anti-poor/pro-rich federal policies and low reforms for the

poor that accompanied with the higher rates of crime in a panel of countries. The rest of the growth phases from 2000 to 2014 show anti-poor growth accompanied with the higher INC_INEQ and lower EG; however, crime rate decreases in the year 2000–2004 and 2010–2014 besides that the growth process is anti-poor across countries. The policies should be formulated in a way to aligned crime rate with the PPG reforms across countries (Vellala et al. 2018).

The results of PPE index confirmed an anti-poor growth from 1990 to 2004, while at the subsequent years from 2005 to 2014, education growth rate subsequently benefited the poor as compared to the non-poor, i.e., PPE index exceeds the bench mark value of unity. Crime rate is increasing from 1990 to 1999, and from 2005 to 2009, while it decreases the crime rate for the years 2000–2004 and 2010–2014. The good sign of recovery has been visible for the years 2010–2014 where the PPE growth supports to decrease crime rate in a panel of selected countries. Finally, the PPH index confirmed two PPG phases, i.e., from 1990 to 1994, and 2010 to 2014 in which crime rate increases for the former years and decreases in the later years. The remaining health phases from 1995 to 2009 show anti-poor health index, while crime rate is still increasing during the years from 1995 to 1999 and 2005 to 2009, and decreasing for the period 2000–2004. The results emphasized the need to integrate PPG index with the crime rate, as PPG reforms are helpful to reduce humans' costs by increasing EG and social expenditures, and providing judicious income distribution to escape out from POV and vulnerability across the globe (Musavengane et al. 2019).

From the overall results, we come to the conclusion that social spending on education and health is imperative to reduce crime incidence, while it further translated a positive impact on POV and inequality reduction across countries (Hinton 2016). EG is a vital factor to reduce POV; however, it is not a sufficient condition under higher INC_INEQ (Dudzevičiūtė and Prakapienė 2018). INC_INEQ and unemployment rate both are negatively correlated with crime rates; however, it may be reduced by judicious income distribution and increases social spending across countries (Costantini et al. 2018). Trade liberalization policies reduce incidence of crime rates and improve country's PCI, which enforce the need to capitalize domestic exports by expanding local industries. Thus, the United Nations SDGs would be achieved by its implication in the countries perspectives (Dix-Carneiro et al. 2018). The study achieved the research objectives by its theoretical and empirical contribution, which seems challenge for the developmental experts to devise policies toward more pro-growth and PPG.

4 Conclusions and policy recommendations

This study investigated the dynamic relationship between socio-economic factors and crime rate to assess PPG reforms for reducing crime rate in a panel of 16 diversified countries, using a time series data from 1990–2014. The study used PCI and square PCI in relation with crime rate, POVHCR, and GINI to evaluate crime-induced KC, poverty-induced KC and inequality-induced KC, while PPG index assesses the federal growth reforms regarding healthcare provision, education and wealth to escape out from POV and violence. The results show that GINI and UNEMP are the main predictors that have a devastating impact to increase crime rate. Trade liberalization

policies are helpful to reduce crime rate and increase PCI. Healthcare expenditures decrease POVHCR and amplify EG. The EG is affected by POVHCR, which requires strong policy framework to devise PPG approach in a panel of selected countries. The study failed to establish crime-induced KC and poverty-induced KC, while the study confirmed an inequality-induced KC. The results of IRF reveal that PCI would considerably increase crime rate, while crime rate influenced GINI and PCI for the next 10-year period. The estimates of VDA show that POVHCR explained the greater share to influence crime rates, while reverse is true in case of POVHCR. The study divided the studied time period into five growth phases 1990–1994, 1995–1999, 2000–2004, 2005–2009, and 2010–2014 to assess PPG, PPH, and PPE reforms and observe the changes in crime rates. The results show that there is an only period from 1990 to 1994 that shows PPG, while crime rate is still increasing in that period; however, in the years 2000–2004, and 2010–2014, crime rate decreases without favoring the growth to the poor. PPE and PPH assessment confirmed the reduction in the crime rates for the years 2010–2014. The overall results confirmed the strong correlation between socio-economic factors and crime rates to purse the pro-poorness of government policies across countries. The overall results emphasized the need of strong policy framework to aligned PPG policies with the reduction in crime rate across the globe. The study proposed the following policy recommendations, i.e.,

(i) Education, health and wealth are the strong predictors of reducing crime rates and achieving PPG, thus it should be aligned with inclusive trade policies to reduce human cost in terms of decreasing chronic poverty and violence/crime.
(ii) The policies should be formulated to strengthen the pro-poorness of social expenditures that would be helpful to reduce an overwhelming impact of crime rate in a panel of countries.
(iii) GIP triangle is mostly viewed as a pro-poor package to reduce the vicious cycle of poverty; however, there is a strong need to include some other social factors including unemployment, violence, crime, etc., which is mostly charged due to increase in poverty and unequal distribution of income across the globe. The policies should devise to observe the positive change in lessen the crime rate by PPG reforms in a panel of selected countries.
(iv) The significant implication of the Kuznets' work should be extended to the some other unexplored factors especially for crime rate that would be traced out by the pro-poor agenda and pro-growth reforms.
(v) There is a need to align the positivity of judicious income distribution with the broad-based economic growth that would be helpful to reduce poverty and crime rate across countries.
(vi) The result although not supported the 'parabola' relationship between income and crime rates; however, it confirmed the U-shaped relationship between income and poverty. The economic implication is that income is not the sole contributor to increase crime rates while poverty exacerbates violent crimes across countries. There is a high need to develop a mechanism through which poverty incidence can be reduced, which would ultimately lead to decreased crime rates. The improvement in the labor market structure, judicious income distribution, and providing

social safety nets are the desirable strategies to reduce crime rates and poverty incidence across countries, and

(vii) The results supported parabola relationship between economic growth and inequality, which gives a clear indication to improve income distribution channel for reducing poverty and crime rates at global scale.

(viii) These seven policies would give strong alignment to improve social infrastructure for managing crime through equitable justice and PPG process.

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Authors' contributions
The collection, processing and analysis of the data were carried out by the authors. All authors read and approved the final manuscript

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Availability of data and materials
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Competing interests
The authors declare that they have no conflict of interest.

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Appendix

See Table 7, Figs. 2, 3, 4 and 5.

Table 7 List of countries

Countries	Region	Countries	Region	Countries	Region
Argentina	South America	Malaysia	South East Asia	Tunisia	North Africa
Brazil	South America	Mexico	North America	Turkey	Eastern Europe and Western Asia
Chile	South America	Morocco	North Africa	Uganda	East Africa
China	East Asia	Poland	Europe	Uruguay	South America
Colombia	South America	South Africa	Southern Africa	Total: 16 countries	
Indonesia	South East Asia	Thailand	South East Asia		

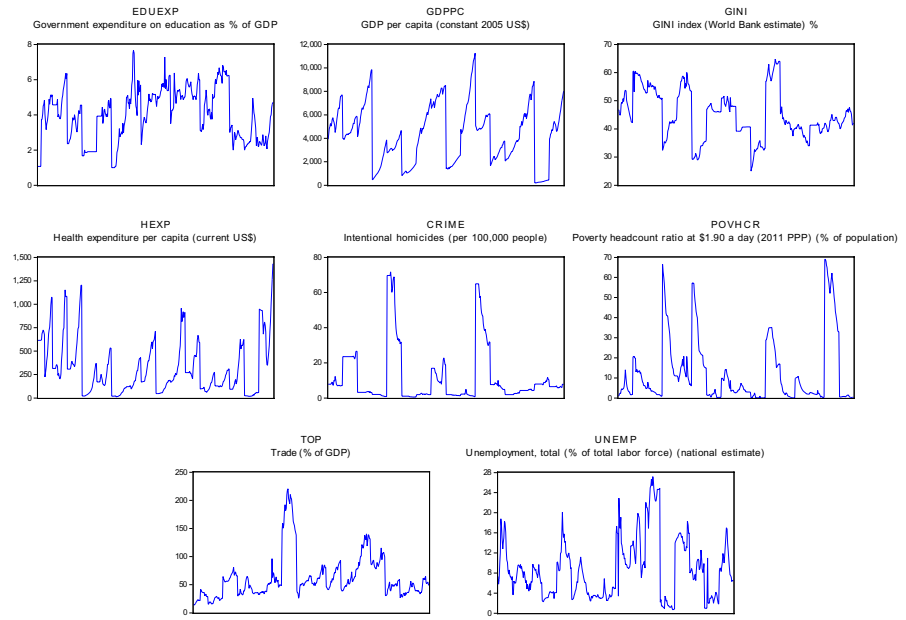

Fig. 2 Data trend at level. Source: World Bank (2015)

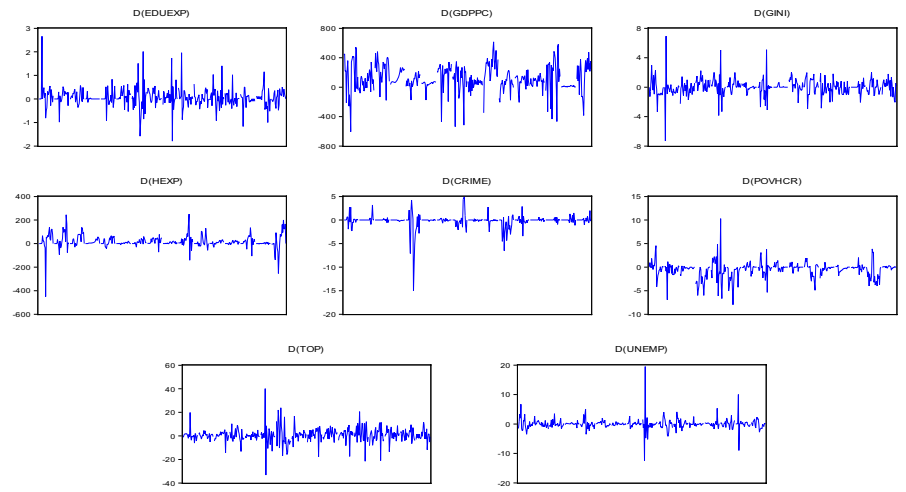

Fig. 3 Data trend at first differenced Source: World Bank (2015). 'D' indicates first difference

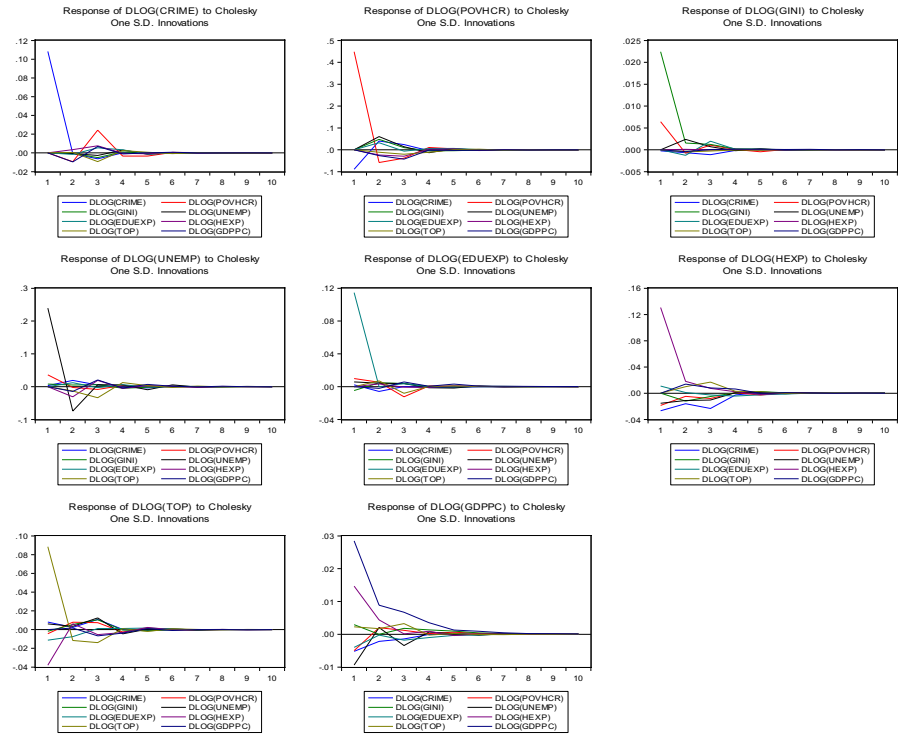

Fig. 4 Plots of IRF. Source: authors' estimation. Note: 'D' shows first difference, while 'LOG' represents natural logarithm

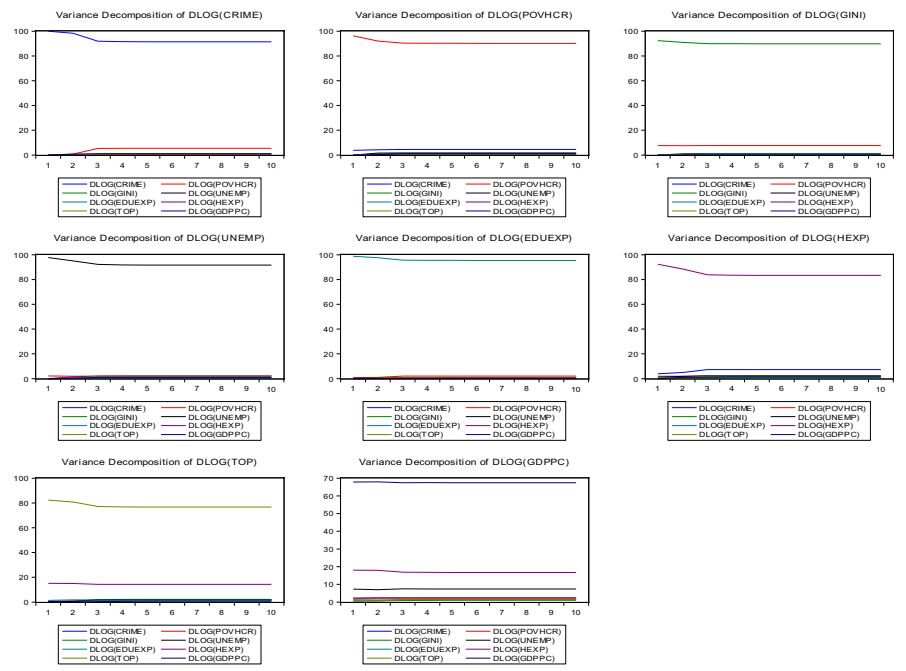

Fig. 5 VDA Estimates. Source: authors' estimation. Note: 'D' shows first difference, while 'LOG' represents natural logarithm

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