Managing crime through quality education: A model of justice

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ABSTRACT

The study examines the role of quality education in access to justice, using a panel data of 21 diversified countries for the period of 1990–2015. The findings show that there is a positive relationship between the presence of scientific and technical journals (STJ) articles and crime rates. The R&D expenditures does not substantially reduce crime rate while per capita income, trademark applications, and technical cooperation grants significantly reduce crime rates across countries. The panel fixed effect (FE) model confirmed the inverted U-shaped relationship between per capita income (GDPpc) and crime rate in the presence of STJ, while this result is changed in the case of GMM estimator. The results of panel causality confirmed the unidirectional causality running from crime rate to STJ and R&D expenditures, while there is bidirectional causality between i) GDPpc and technical cooperation grants, and between ii) energy efficiency and refugee population by country. The variance decomposition analysis (VDA) shows that R&D expenditures have a greater share to influence crime rate, while technical cooperation grants will affect STJ for the next 10 years time. This finding bolsters the conversation on the relationship between education and a reduction in crime rates.

1. Introduction

The United Nations Sustainable Development Goals (SDGs) largely emphasized for quality education (SDG-4) and access to justice (SDG-16) that is imperative for broad-based growth. The SDG-4 demonstrates that achieving a quality education is the fundamental factor that provides the basis of sustainable development across countries. Inclusive education not only improves the quality of life of the general people while it equips the population with innovative ideas and solutions to solve the world's macroeconomic problems. The global statistics show that > 265 million children are away from school among them 22% is out of school from primary school age. The inadequate teachers training, deprived schools condition and gender issues in the rural children are the key reasons to be deficient of quality education. The SDG-16 emphasized the need of global peace, justice and strong institution to minimize the risks of international crime, violence, and human trafficking that is pivotal for the development of inclusive societies for long-term sustained growth. In a way of managing the global

peace, the provision of justice and strong institutions are needed at all levels. The current global statistics show that developing countries bear the cost of some US$1.26 trillion per year in the form of corruption, theft and tax evasion, while this amount could be used to uplift the poor population that spend their lives on less than US$1.25a day. Nearly half of the world's children experienced violence every year. The global policies are needed in order to restrain social evils by strong rule of law [42].

According to UN-OHCHR [43] report, access to the quality education is well deserve to all children and it plays a crucial role for enabling social skills, mental and physical development, and understanding their role in country's social participation, with further enhancing the abilities to live with peace, tolerance, friendship and equality. Legal Rights Forum [29] discussed the right to education to all children whose age is fall under 5 to 16 years, while state should determine to provide free and compulsory education that would helpful to break the vicious cycle of poverty and empower human transformation at all levels. World Justice Project [44] highly worked on revitalizing the justice to all

project and promotes SDG-16, yet 5 billion global people have unmet justice in different social domains that is the study area to provide justice them without any racial discrimination. The project further emphasized the need to provide fairly justice to all vulnerable peoples who have less exposure of voice and/or who are extremely vulnerable and unable to access the justice, thus, the need of publicizing the information among the masses required the re-union of the experts to design effective policies for giving equity base justice.

On the basis of significant discussion, the study assessed the role of education in crime diminution in a diversified panel of countries. The sample countries include the following, namely, Algeria, Brazil, Chile, China, Colombia, Egypt, Indonesia, Jordan, Kenya, Malaysia, Mexico, Morocco, Mozambique, Namibia, Poland, Russian Federation, South Africa, Thailand, Tunisia, Turkey, and Uruguay. The rationale to select these countries is stated below:

 i) Overwhelming increase in crime rates across countries,
 ii) An increase in number of scientific and technical journal articles,
 iii) To utilize energy efficiency for strong academic base,
 iv) Considerable share of R&D expenditures relative to their GDP,
 v) Balanced economic growth,
 vi) Irresistible movement of refugee by country or territory of origin etc.

This study is different from the earlier studies in three main perspectives; first, the study brings scientific and technical journals as an indicator of education, while the earlier studies largely brings educational expenditures and different levels of education as a proxy variable for education [16,28,30,31]. Secondly, the study used R&D expenditures, technical cooperation grants, and trademark applications as institutional factors that would better be able to explain the reduction of crime rate counts across countries. Finally, the study used international homicide rates as a proxy variable for crime rate, while refugee population and energy efficiency served as a control variable in this study to overcome the bias issue in the human cost modeling. These features make this study more policy oriented and would be able to draw sound policy inferences for reduction of crime rates through quality education.

The above discussion confirmed the strong relationship between educational indicators and crime rates across the globe. The study evaluated different educational and technical indicators in terms of STJ articles, trademark applications, technical cooperation grants, and R&D expenditures on possible reduction in the crime rates in a panel of 21 selected diversified countries, for the period of 1990–2015. The more specific objectives are:

 i) To examine the relationship between STJ and crime rates coupled with the socio-economic factors across countries.
 ii) To validate the inverted U-shaped relationship between economic growth and crime rates.
 iii) To investigate the causality relationship between STJ and crime rates, and
 iv) To explore the inter-temporal relationship between STJ and crime rates in forecasting framework.

These objectives would be empirically assessed by panel fixed effect (FE) model and Generalized Method of Moments (GMM) estimator in a panel of selected countries.

2. Literature review

The relationship between education and reduction in crime rates are widely discussed area in the scholarly literature (Lochner and Moretti 2003, [21,33]). Thus, the present study investigated education-crime nexus by including number of educational and technical factors (including STJ articles, trademark applications, technical cooperation

grants, and R&D expenditures); growth factors (including GDPpc, energy efficiency, and refugee population by country); and crime rates in a panel of 21 diversified countries for the period of 1990–2015. There are number of studies that provoke the distinct socio-economic variables to analyze the possibilities of reduction in crime rates across the globe i.e., McCall et al. [32] evaluated different socio-economic factors to analyze crime rates in a cross-sectional pooled data and found that poverty, urbanization and the weak association of family & social structure are the strong predictors that increases crime rates. Sun et al. [39] examined the relationship between economic deprivation and crime rate in a longitudinal data set of 52 countries for a period of 1995–1999 and found that economic deprivation model including GDPpc and income inequality affects social structure that leads to variation in crime rates. The social change variables including urbanization and population growth found direct interlinkages with the theft rates and crime rates across countries. Chon [10] found different factors that influenced crime rates including poverty level, inadequate educational opportunities, gap between rich and poor, and level of alcohol consumption. These socio-economic variables have a considerable impact to increase crime rate in Latin America. Sohnen [38] emphasized the need for more work done on crime-development nexus by different transmission channels that would helpful for the policymakers to formulate human costs modeling to secure pervasive violence and crime. Kumar [25] investigated the impact of higher crime rates on India's economic growth and found that higher crime rate decreases country's per capita income. It has been noticed that Indian states that have a high income level substantially less affected with the crime rates as compared to the low income states.

Teixeira and Soeiro [40] surveyed the 1122 students' willingness to pay for crime reduction and found that younger and female students are more willing to pay to reduce violent crime among a specific group of society. Detotto and Pulina [11] investigated the long-run relationship between crime rates and economic activities in Italy for a period of 1970–2004 and found that lack of deterrence increases crime rates and thefts, while all forms of crime typologies have a negative impact on employment rate and legal economic progress. Crime typologies including crime rates, extortions, robbery and kidnapping that have a crowding-out effect in Italy's economic growth. Awan et al. [3] discussed the viability of civic education in environmental sustainability agenda and demonstrate that environmental knowledge is imperative to improve human life and it is a way to overcome sustainability challenges efficiently through creating civic awareness and civic participation among the masses. Romano [36] examined the exposure of crime and its devastating impact on educational outcomes in Mexico and found that crime rates have a negative impact on average standardized scores test and higher rates of grade failure both in primary and secondary schools' students, however, secondary schools' students largely affected as compared to the primary schools' students. Niño et al. [34] examined the potential linkages between crime rates in Ciudad Juárez and its resulting impact on El Paso economic conditions and found that crime homicides have a negative impact on economic activities of E1 Paso at different time lags. Torres-Preciado et al. [41] investigated the relationship between crime rates and economic growth of Mexican states and found that crime homicides and robbery negatively influenced regional Mexican growth. Foote [18] investigated the possible effects of crime rate on migration rates for counties in U.S. metropolitan areas and found that higher rates of crime forced to migrate households approximately 10 times largely white households as compared for black households. Rivera [35] empirically investigated the different factors that have a considerable impact on crime rates in Latin America, by using the consistent data series taken from 1980 to 2010. The results found three main predictors of crime rates including female labor force, youth dominance, and post conflicts states, all three factors have a positive association with the social violence. The study argued that sound judicial system and increase school attendance may give harmony and peace in the region. Heckman et al. [23] identified

Table 1
Current literature review on education and crime rates.

Authors	Crime types	Educational factors/level	Study setting	Results	Policy implications
Cano-Urbina and Lochner [8]	Violent, property crime, and white collar crimes	Compulsory schooling laws / schools quality	American women / female crime rates	Increase the level of education substantially reduces violent and property crime but not white collar crimes.	Education lead to empower women to get better job opportunities and find better matches for marriage and family formation.
Garcia et al. [19]	Violent, property, and drug crimes	Early childhood education	Randomized controlled trial	Mother's childhood education significantly reduces the different violent commitments	Deprived male more associated with costly crimes as compared to their counterpart, thus, both gender needed strong policy intervention to reduce violent commitments through increase education.
Young and Date [46]	Violent crimes	High school graduates	North Carolina state	Race, poverty, and other social factors lead to violent crime in the state.	Reducing dropout school children rate, increasing social budgets, and overcome racial issues would helpful to decrease crime rates.
Laurito et al. [26]	Violent crimes	Middle school students	New York city department	Violent crimes in the neighborhood decrease the test scores of middle school students in English language arts exam.	Provide safe school environment and reducing violent crimes are needed to improve goods exam grades.
Chan [9]	Intolerance	College education	Google search data	College education may helpful to reduce intolerance among the students.	Increase social spending on education and other possible determinants would helpful to reduce hateful attitudes and behaviors among the student.
Fisher et al. [17]	School crime and violence	School survey	National longitudinal study	Security cameras located inside the schools may reduce school crime and violence.	Racial tension, bullying, gang activity and other social disturbances would be handled by severe punishment and educational counseling to reduce pressure among the students.
Burdick-Will et al. [7]	School education	Violent crime in the neighborhood	Route to incident crime level data	Violent crime in the streets and route transit buses are the main factors to increase absenteeism in school children.	Exposure to danger likely to increase fear among the students that needed secure and safe routes.

the number of non-market benefits that could attain by education and ability, including self esteem, trust, welfare gain, mental health, etc. The study concludes with the favor of positive educational outcomes in different socio-economic and psychological traits that are necessary for healthy gain. Aslund et al. [2] concluded that educational attainment significantly decreases property crime while this positive impact disappears in violent crime. In a nutshell, it is evident that educational attainment helpful to reduce commit to crime that is positive outcome gain by higher education. Ahonen [1] found that sportsmanship and other physical activities substantially decreases criminal activity, which is further translated into higher education gain, however, the low social spending on education and health leads to increase commit to crime in a current generation. Thus, the parental investment should be made on education and health, which would be helpful to gain in sound health and mental improvement that able to reduce criminal activities in the society. Table 1 shows the recent literature on education and crime rate across countries.

The current literature widely discussed the types of violent crime, educational factors, study setting, results and possible remedies. The most of the literature is based upon documented survey while none of the study, as authors believe, used a time series data to analyze the quality education and access to justice across countries. This study filled this gap and surveyed longitudinal data spanning 26 years for 21 diversified countries to analyze education and crime nexus, which gives sound policy inferences for actionable research.

3. Data source and methodology

The study selected the following key variables for robust inferences i.e., crime rates per 100,000 people, STJ articles in numbers, R&D expenditures relative to GDP, Technical cooperation grants in US$, number of trademark applications, GDP per capita in constant 2005 US $, refugee population by country, and GDP per unit of energy use as PPP $ per kg of oil equivalent. The longitudinal data covered a period of 26 years from 1990 to 2015 of 21 diversified countries. The study estimated the following non-linear relationship between crime rates and STJ articles in three specified studied models i.e.,

Model -1: STJ and crime rates

$$\ln(CRIME)_{i,t} = \beta_0 + \beta_1 \ln(STJURNL)_{i,t} + \beta_2 \ln(RESNDEV)_{i,t} + \beta_3 \ln(TCGRANT)_{i,t} + \beta_4 \ln(TMAPL)_{it} + \beta_5 \ln(GDPPC)_{i,t} + \beta_6 \ln(REFUGEE)_{i,t} + \varepsilon_{i,t} \tag{1}$$

Model -11: STJ and crime Kuznets curve

$$\ln(CRIME)_{i,t} = \beta_0 + \beta_1 \ln(STJURNL)_{i,t} + \beta_2 \ln(RESNDEV)_{i,t} + \beta_3 \ln(TCGRANT)_{i,t} + \beta_4 \ln(TMAPL)_{it} + \beta_5 \ln(GDPPC)_{i,t} + \beta_6 \ln(GDPPC)_{i,t}^2 + \beta_7 \ln REFUGEE_{i,t} + \varepsilon_{i,t} \tag{2}$$

Model -111: Energy efficiency, STJ and crime rates

$$\ln(STJURNL)_{i,t} = \beta_0 + \beta_1 \ln(CRIME)_{i,t} + \beta_2 \ln(ENRGEFC)_{i,t} + \beta_3 \ln(RESNDEV)_{i,t} + \beta_4 \ln(TCGRANT)_{i,t} + \beta_5 \ln(TMAPL)_{it} + \beta_6 \ln(GDPPC)_{i,t} + \beta_7 \ln(REFUGEE)_{i,t} + \varepsilon_{i,t} \tag{3}$$

Where, CRIME indicate crime rates, STJURNL indicates scientific and technical journal articles, RESNDEV indicates research and development expenditures, TCGRANT indicates technical cooperation grants, TMAPL indicates trademark applications. GDPPC indicates GDP per capita, REFUGEE indicates refugee population, ENRGEFC indicates GDP per unit of energy use, 'i' shows cross-section countries

($i = 1....0.21$ countries), 't' shows time period ($t = 1990$–2015, and 'ε' shows error term.

Eq. (1) shows the interrelationship between STJ articles and crime rates including set of specified variables i.e., R&D expenditures, trademark applications, technical cooperation grants, GDPpc, and refugee populations. These variables selected because of two main reasons, i.e., except GDPpc and refugee populations, the remaining variables directly associated with the academia and industry, while GDPpc and refugee population considered being affected crime rates at macroeconomic level. We assume that GDPpc decreases crime rates under the presence of academic factors, while refugee population would be one of the significant predicator that influence crime rates in a panel of selected countries. Academic variables should decrease crime rates due to higher R&D expenditures and technical cooperation grants for reducing humans' cost.

Eq. (2) is the extended version of eq. (1) by including square of GDPpc to evaluate 'crime Kuznets curve' i.e., the study assumed that under the presences of academic and technical variables, the second order coefficient of GDPpc would be negative with crime rates. Crime rates would initially increases with the GDPpc, while at the later stages of growth and academic contribution, crime rates would considerably decreases. The sign and magnitude matters to observe the relationship between GDPpc and crime rates i.e., i) if $\beta_5 > 0$ and $\beta_6 < 0$, we refer this situation as inverted U-shaped relationship, ii) if $\beta_5 < 0$ and $\beta_6 > 0$, we refer this situation as U-shaped relationship i.e., initially GDPpc decreases crime rates due to significant contribution of STJ articles, while at the later stages of economic development, this results is averted and it would increase crime rates due to policy lacuna in the government policies, finally iii) if $\beta_5 = 0$ and $\beta_6 = 0$, we conclude that both the variables have no/flat relationship between them.

Eq. (3) is reverse version of Eq. (1) in terms of changing the endogenous variable from crime rates to STJ articles and further included one of the potential regressor i.e., energy efficiency to understand the causal mechanism between the given nexus. These three equations would be evaluated by sophisticated panel econometric techniques including panel FE regression and panel GMM estimator. The appropriate panel regression technique is evaluated by Hausman test for model specification and presented the results in Table 2 and found that all three models (or equations) have a significant chi-square statistic which indicates FE model is appropriate for the studied models as compared to the random effect regression.

After confirming the Hausman test for right model specification, the study used panel FE model that controlled time invariant shocks in a panel of selected countries. The following equations would be analyzed by panel FE model i.e.,

$$\ln(CRIME)_{i,t}$$
$$= \beta_0 + \gamma_t + \beta_1 \ln(STJURNL)_{i,t} + \beta_2 \ln(RESNDEV)_{i,t} + \beta_3$$
$$\ln(TCGRANT)_{i,t}$$
$$+ \beta_4 \ln(TMAPL)_{it} + \beta_5 \ln(GDPPC)_{i,t} + \beta_6 \ln(REFUGEE)_{i,t} + \varepsilon_{i,t} \quad (4)$$

$$\ln(CRIME)_{i,t}$$
$$= \beta_0 + \gamma_t + \beta_1 \ln(STJURNL)_{i,t} + \beta_2 \ln(RESNDEV)_{i,t} + \beta_3$$
$$\ln(TCGRANT)_{i,t} + \beta_4 \ln(TMAPL)_{it}$$
$$+ \beta_5 \ln(GDPPC)_{i,t} + \beta_6 \ln(GDPPC)^2_{i,t} + \beta_7 \ln REFUGEE)_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$\ln(STJURNL)_{i,t}$$
$$= \beta_0 + \gamma_t + \beta_1 \ln(CRIME)_{i,t} + \beta_2 \ln(ENRGEFC)_{i,t} + \beta_3$$
$$\ln(RESNDEV)_{i,t} + \beta_4 \ln(TCGRANT)_{i,t}$$
$$+ \beta_5 \ln(TMAPL)_{it} + \beta_6 \ln(GDPPC)_{i,t} + \beta_7 \ln(REFUGEE)_{i,t} + \varepsilon_{i,t} \quad (6)$$

Where, γ indicates country's fixed effects.

The previous studies largely used panel FE model and GMM estimator in evaluating the relationship between education and crime nexus, for instance, Fajnzylber et al. [15], Edmark [12], Buonanno [4], Buonanno & Leonida [5,6], Kim and Clark [24], etc. The FE model incorporates country specific time invariant shocks in a given panel. The alternative but equivalent FE model is the least square dummy variable (LSDV). In first step, for each N unit, dummy variable is created, for instance;

$$D_{Nit} = \begin{cases} 1 & \text{if } N = i \\ 0 & \text{if } N \neq i \end{cases}$$

In the second step, OLS is performed on the given dummy variables and the potential regressors, for instance;

$$Y_{it} = \alpha_1 D_{1it} + \alpha_2 D_{2it} + ... + \alpha_n D_{Nit} + \beta_1 X_{it1} + \beta_2 X_{it2} + \varepsilon_{it}$$

This gives estimates of the LSDV with the slope parameters.

The FE estimator involves two steps. In the first step, original data should be transformed with the "time-demeaned data", while in the second step, simply run the OLS estimator, it would give the same LSDV estimates. The following are the properties of FE model, i.e.,

i) FE model produce unbiased estimates of intercept and slope parameters in small samples.
ii) The slope parameters are consistent with the fixed T as $N \rightarrow \infty$.
iii) The intercept estimates is not consistent with fixed T as $N \rightarrow \infty$, and.
iv) To resolve heteroskedasticity issue in the FE model, we may shift towards "weighted Least Squares FE estimator" for robust inferences.

Besides panel FE model, the study employed panel GMM estimator that addressed both the possibility of autocorrelation and endogeneity problem in the existing models/equation. The main features of GMM estimator is as follows:

i) GMM estimator is efficiently estimates both the linear and non-linear regression.
ii) Moments of probability distribution direct to estimates parameters with their sample analogues.
iii) The GMM estimator is asymptotically normal, and.
iv) The population orthogonality conditions are largely exists under GMM estimator.

The study included first lagged of the endogenous variable as a regressor and first lagged explanatory variables as an instrument for

Table 2
Hausman test for model specification.

Models	Chi-square Statistics	Probability value	Degree of freedom	Appropriate Estimation Technique
Model -1	12.487	0.051	6	$p < .090$
Model -11	12.913	0.074	7	$p < .090$
Model -111	52.718	0.000	7	$P < .010$

Note: $p < .090$ shows probability value is significant at 90% confidence interval. $p < .010$ shows probability value is significant at 99% confidence interval.

controlling the possibility of serial correlation and endogeneity problem in the stated models/equations i.e.,

$$\ln(CRIME)_{i,t}$$
$$= \beta_0 + \gamma_t + \beta_1 \ln(CRIME)_{i,t-1} + \beta_2 \ln(STJURNL)_{i,t} + \beta_3$$
$$\ln(RESNDEV)_{i,t} +$$
$$\beta_4 \ln(TCGRANT)_{i,t} + \beta_5 \ln(TMAPL)_{it} + \beta_6 \ln(GDPPC)_{i,t} + \beta_7$$
$$\ln(REFUGEE)_{i,t} + z_{i,t} + \varepsilon_{i,t} \qquad (7)$$

$$\ln(CRIME)_{i,t}$$
$$= \beta_0 + \gamma_t + \beta_1 \ln(HOMICIDES)_{i,t-1} + \beta_2 \ln(STJURNL)_{i,t} + \beta_3$$
$$\ln(RESNDEV)_{i,t} + \beta_4 \ln(TCGRANT)_{i,t}$$
$$+ \beta_5 \ln(TMAPL)_{i,t} + \beta_6 \ln(GDPPC)_{i,t} + \beta_7 \ln(GDPPC)_{i,t}^2 + \beta_8$$
$$\ln REFUGEE)_{i,t} + z_{i,t} + \varepsilon_{i,t} \qquad (8)$$

$$\ln(STJURNL)_{i,t}$$
$$= \beta_0 + \gamma_t + \beta_1 \ln(STJURNL)_{i,t-1} + \beta_2 \ln(CRIME)_{i,t} + \beta_3$$
$$\ln(ENRGEFC)_{i,t} + \beta_4 \ln(RESNDEV)_{i,t} +$$
$$\beta_5 \ln(TCGRANT)_{i,t} + \beta_6 \ln(TMAPL)_{it} + \beta_7 \ln(GDPPC)_{i,t} + \beta_8$$
$$\ln(REFUGEE)_{i,t} + z_{i,t} + \varepsilon_{i,t} \qquad (9)$$

where, 'z' indicates first lagged of the explanatory variables as an instrument. In Eq. (8), β_6 and β_7 used for analyzing the crime -Kuznets curve for the panel of selected countries.

The study further used panel non-Granger heterogeneous causality test for determining the causality between the variables while innovation accounting technique including impulse response function (IRF) and variance decomposition analysis (VDA) used for inter-temporal relationship between STJ articles and crime rates in a panel of selected countries.

4. Results

Table 3 shows the estimates of panel FE model and GMM estimator for robust inferences. The results show that STJ articles does not have any significant association with the crime rates in a FE model, while GMM estimator indicates that STJ articles have a positive and significant association with the crime rates. The results imply that along with increase in STJ articles, crime rates increases 0.017 percentage point. There are number of contrary studies available on the relationship between education and crime rates whom argued that high school graduation substantially decreases commit to crime (see, Lochner and Moretti, 2003); while it further helpful to reduce criminal activities in young adults [33]. Gonzalez [21] in a similar line emphasized on college graduation and considered education is one of the secret to crime reduction. Although, it is no doubt about the social spending on education reduce crime rates, however, when we used STJ articles as a proxy for education, the result of positivity between education and crime reduction is disappeared. The overall results indicate the academia's Achilles' hill need to be strong enough for creating the positive association between educational indicators and crime reduction all across the globe.

The R&D expenditures, technical grants and trademark applications are the associated members of cooperative align for STJ articles and found that along with increase in R&D expenditures it increases crime rates by 0.315 percentage points, while technical cooperation grants and trademark application significantly reduces crime rates by 0.031% and 0.010% respectively. The point of attention is that R&D expenditures have a greater share in terms of increasing crime rates as compared to reduce crime rates by technical cooperation grants and trade mark application in a panel of selected countries. The GDPpc significantly associated with the reduction in crime rates in both the FE

model and GMM estimator, however, the magnitude to reduce crime rates are far greater in FE model as compared to the GMM estimator.

The next regression apparatus confirm the negative sign of second order coefficient of GDPpc with crime rates under the presence of STJ articles that substantiate the 'crime Kuznets curve' in a panel of FE model, however, this result is evaporated in GMM estimator that indicates the flat/no relationship between GDPpc and crime rates. Goulas and Zervoyianni [22] confirmed the asymmetric relationship between crime and GDPpc and argued that if economic conditions are sustained and stable over a longer period of time, than crime rate does not affect the income of the countries. In a final reverted regression where STJ articles are the endogenous variable connected with the crime rates and other regressors reveal that there is no significant association between crime rates and STJ articles in both of the FE model and GMM estimator, while R&D expenditures, technical cooperation grants, trademark applications, GDPpc and refugee population tend to increase STJ articles in a panel of selected countries. Energy efficiency has a mixed impact on STJ articles, as FE model indicates that both of the variables have a positive correlation with each other, while GMM estimator shows the contrary results. The significant and positive value of lagged dependent variable in GMM estimation exhibits the inertia in the crime rates and in the STJ articles, while J-statistics confirm the validity of prescribed instruments for the given model. Table 4 shows the cause-effect relationship between crime rates and STJ articles coupled with the other regressors and found that there is one-way causality running from crime rates to STJ articles and R&D expenditures, but not vice versa.

The causality relationship shows that crime rates Granger cause STJ and R&D expenditures in a panel of countries. The other causality relationship show that there is one-way causality running from technical cooperation grants to crime rates, from STJ articles to technical cooperation grants, from trademark applications to STJ articles and R&D expenditures, from refugee to R&D expenditures, from R&D expenditures to energy efficiency, from technical cooperation grants to energy efficiency, from trademark applications to GDPpc, and from GDPpc to refugee population. The study confirms the feedback relationship between GDPpc and technical cooperation grants, and between energy efficiency and refugee population across countries. After analyzing the causality patterns between the studied variables, the study analyzed accounting innovation technique including IRF in Fig. 1, and VDA in Table 5 respectively.

Fig. 1 shows that the response to shocks of crime rates with the STJ articles are mixed, as in the forthcoming years 2016, 2020, 2022, 2025 the response of shocks to increase crime rates would be positive, while in between the years, the response of shocks would become negative with the STJ articles. The remaining variables including R&D expenditures, technical cooperation grants, GDPpc, refugee population, and energy efficiency have about negative response shocks at the end 2025 year on crime rates, while trademark application would significantly increase crime rates in the year 2025. The estimates further confirm the negative response shocks to the crime rates for next 10 years time period, while R&D expenditures, trademark applications, GDPpc, and refugee population would decrease STJ articles, while technical cooperation grants and energy efficiency would be positive for the next subsequent years from 2016 to 2025.

Table 5 shows the estimate of VDA and found that R&D expenditures have a greater share in terms of influencing the crime rates (i.e., 0.875%), followed by trademark applications (i.e., 0.404%), technical cooperation grants (i.e., 0.287%), STJ articles (i.e., 0.214%), GDPpc (i.e., 0.149%), energy efficiency (i.e., 0.113%), while refugee population (i.e., 0.038%) exert the least share to influence crime rates for the next 10 years time period.

The VDA estimates for STJ articles indicate that technical cooperation grants exerts the larger share to influence it followed by GDPpc, trademark applications, refugee population, crime rates, R&D expenditures, while energy efficiency have a least share in to order to

Table 3
Results of FE model and GMM estimator.

Variables	FE	GMM	FE Model: Evaluate crime Kuznets curve	GMM estimator: Evaluate crime Kuznets curve	FE Model	GMM
	$\ln(CRIME)_t$	$\ln(CRIME)_t$	$\ln(CRIME)_t$	$\ln(CRIME)_t$	$\ln(STJURNL)_t$	$\ln(STJURNL)_t$
Constant	6.725*	0.757**	1.592	0.368	−7.285*	−0.532
	(11.697)	(2.967)	(1.032)	(0.961)	(−5.741)	(−1.099)
$\ln(CRIME)_{t-1}$	–	0.996*	–	0.997*	–	–
		(200.340)		(199.993)		
$\ln(STJURNL)_{t-1}$	–	–	–	–	–	0.959*
						(75.403)
$\ln(CRIME)_t$	–	–	–	–	−0.039	−0.012
					(−0.601)	(−1.535)
$\ln(STJURNL)_t$	−0.016	0.017**	−0.011	0.018**	–	–
	(−0.526)	(2.280)	(−0.382)	(2.376)		
$\ln(RESNDEV)_t$	0.315*	−0.008	0.337*	−0.004	0.058	0.035**
	(8.172)	(−0.806)	(8.724)	(−0.458)	(0.950)	(1.967)
$\ln(TCGRANT)_t$	−0.042**	−0.031*	−0.039**	−0.035*	0.152*	0.0215
	(−2.488)	(−2.722)	(−2.368)	(−2.962)	(6.163)	(0.967)
$\ln(TMAPL)_t$	0.002	−0.010***	−0.027	−0.011***	0.211*	0.0211**
	(0.070)	(−1.713)	(−0.889)	(−1.867)	(4.905)	(2.080)
$\ln(GDPPC)_t$	−0.497*	−0.023***	0.901**	0.105	1.011*	0.041***
	(−6.826)	(−1.957)	(2.681)	(1.078)	(6.746)	(1.878)
$\ln(GDPPC)_t^2$	–	–	−0.090*	−0.008	–	–
			(−3.579)	(−1.328)		
$\ln(REFUGEE)_t$	−0.007	0.0009	−0.001	0.001	0.080*	0.005
	(−1.098)	(0.333)	(−0.209)	(0.639)	(8.216)	(1.173)
$\ln(ENRGEFC)_t$	–	–	–	–	0.252**	−0.035***
					(2.068)	(−1.937)
Statistical tests						
R^2	0.962	0.9902	0.963	0.9903	0.969	0.9906
Adjusted R^2	0.960	0.9901	0.961	0.9901	0.968	0.9905
F-statistics	492.862*	–	486.340*	–	591.176*	–
J-statistics	–	1.38E-27	–	1.661	–	5.97E-18
Instrumental Rank	–	9	–	11	–	9

Note: *, **, and *** indicates 1%, 5%, and 10% level of significance.

Table 4
Panel non-Granger heterogeneous causality test.

DH causality tests	W-Stat.	Zbar-Stat.	Prob.
STJURNL → CRIME	5.74578	6.27913	3.E-10
CRIME → STJURNL	3.36326	1.99965	0.0455
RESNDEV → CRIME	6.01377	6.76048	1.E-11
CRIME → RESNDEV	10.1296	14.1534	0.0000
TCGRANT → CRIME	3.79974	2.78364	0.0054
CRIME → TCGRANT	3.08705	1.50351	0.1327
TCGRANT → STJURNL	5.68182	6.16424	7.E-10
STJURNL → TCGRANT	3.86083	2.89338	0.0038
TMAPL → STJURNL	3.44665	2.14943	0.0316
STJURNL → TMAPL	5.97347	6.68810	2.E-11
TMAPL → RESNDEV	3.77959	2.74745	0.0060
RESNDEV → TMAPL	5.15037	5.20965	2.E-07
REFUGEE → RESNDEV	4.31366	3.70674	0.0002
RESNDEV → REFUGEE	6.14141	6.98975	3.E-12
ENRGEFC → RESNDEV	5.89803	6.55259	6.E-11
RESNDEV → ENRGEFC	3.49888	2.24324	0.0249
TCGRANT ↔ GDPPC	3.79250	2.77064	0.0056
	3.70056	2.60550	0.0092
ENRGEFC → TCGRANT	3.07031	1.47344	0.1406
TCGRANT → ENRGEFC	3.63829	2.49364	0.0126
GDPPC → TMAPL	6.19012	7.07725	1.E-12
TMAPL → GDPPC	3.35311	1.98140	0.0475
REFUGEE → GDPPC	2.53554	0.51288	0.6080
GDPPC → REFUGEE	8.22422	10.7309	0.0000
ENRGEFC ↔ REFUGEE	4.26588	3.62093	0.0003
	3.98053	3.10839	0.0019

Note: → shows unidirectional causality, while ↔ show bidirectional causality between the variables.

influence STJ articles for the next 10 years time period.

5. Discussion

The results of the study are interconnected with the earlier studies in different economic settings. The study results demonstrate that increase in the scientific and technical journal articles does not necessarily implies that the violent crime would be substantially decline, even though the countries more focused on publishing articles in the crime-education nexus, however, there is a largely needed to devise strong educational policies that trickle down to the lower masses, which commit to the crime. Ghauri et al. [20] emphasized the need of civic civilization for promoting sustainable education and enforced the need to create harmony between social, economic, and environmental sustainable factors through knowledge economy. Groot and Bring (2007) argued that investment in education and return to education is highly permissible for reducing committing crimes, thus the need of effective educational policies would developed civic sense among the masses that tend to improve permissive attitude about towards criminal behavior. Buonanno and Leonida [6] discussed the non-market channel through which educational factors reduces crime rate, i.e., a country that have a flair of opportunities to getting employment and have a considerable high wage rate could benefited greatly with the increase education that tend to reduce crime rates while reverse is hold for weak labor market opportunities. Thus, the policies to liberalize labor market and generating sufficient employment opportunities would better get a return to investment in education to decrease crime rates across countries. Lochner [47] concluded that enforcement policies are needed to reduce criminal behavior through promoting education, employees training, and wage subsidies. The human capital approach thus required for long-term sustained growth. Meghir et al. [48] suggested that family resources and better parenting would healthier intervene in the
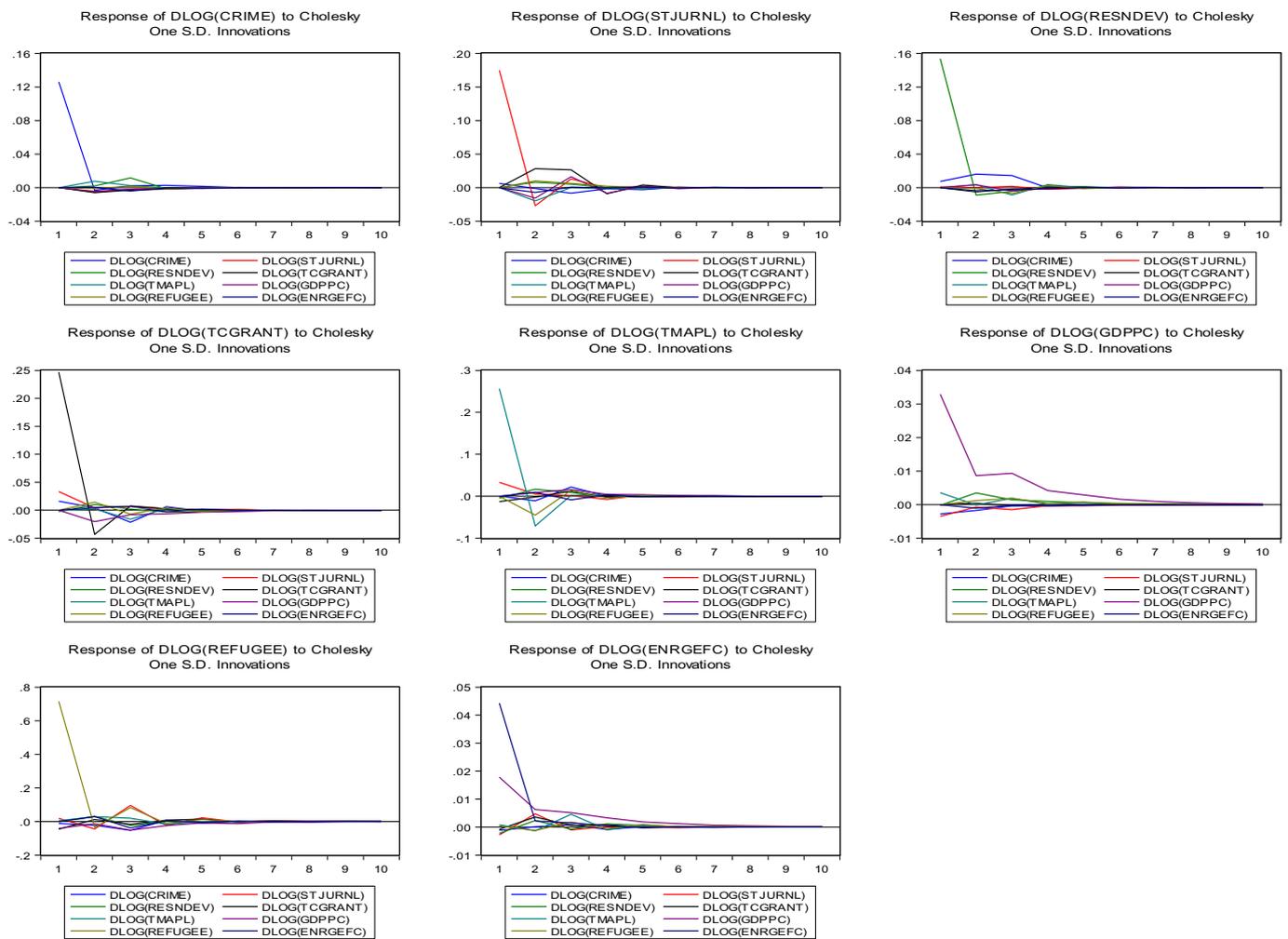
Fig. 1. Plots of impulse response function.
(Source: Author's estimation.)

Table 5
VDA Estimates.

VDA of Δln(CRIME):

Period	S.E.	Δln(CRIME)	Δln (STJURNL)	Δln (RESNDEV)	Δln (TCGRANT)	Δln G(TMAPL)	Δln G(GDPPC)	Δln (REFUGEE)	Δln (ENRGEFC)
2016	0.125	100	0	0	0	0	0	0	0
2017	0.126	99.078	0.187	0.025	0.216	0.368	0.113	0.007	0.001
2018	0.127	97.984	0.211	0.866	0.267	0.400	0.134	0.024	0.110
2019	0.127	97.938	0.213	0.875	0.285	0.400	0.139	0.037	0.110
2020	0.127	97.921	0.213	0.875	0.286	0.403	0.147	0.038	0.113
2021	0.127	97.917	0.214	0.875	0.286	0.404	0.148	0.038	0.113
2022	0.127	97.916	0.214	0.875	0.286	0.404	0.149	0.038	0.113
2023	0.127	97.916	0.214	0.875	0.287	0.404	0.149	0.038	0.113
2024	0.127	97.916	0.214	0.875	0.287	0.404	0.149	0.038	0.113
2025	0.127	97.916	0.214	0.875	0.287	0.404	0.149	0.038	0.113

VDA of Δln(STJURNL):

Period	S.E.	Δln(CRIME)	Δln (STJURNL)	Δln (RESNDEV)	Δln (TCGRANT)	Δln G(TMAPL)	Δln G(GDPPC)	Δln (REFUGEE)	Δln (ENRGEFC)
2016	0.174	0.129	99.870	0	0	0	0	0	0
2017	0.181	0.124	94.869	0.191	2.434	1.170	0.747	0.311	0.151
2018	0.185	0.324	91.819	0.259	4.408	1.126	1.496	0.416	0.147
2019	0.185	0.330	91.382	0.258	4.639	1.127	1.685	0.428	0.147
2020	0.185	0.359	91.292	0.262	4.676	1.133	1.698	0.428	0.149
2021	0.185	0.361	91.282	0.262	4.675	1.133	1.705	0.429	0.149
2022	0.185	0.362	91.280	0.262	4.675	1.133	1.705	0.429	0.150
2023	0.185	0.362	91.279	0.262	4.675	1.133	1.705	0.429	0.150
2024	0.185	0.362	91.279	0.262	4.675	1.133	1.705	0.429	0.150
2025	0.185	0.362	91.279	0.262	4.675	1.133	1.705	0.429	0.150

Note: VDA shows variance decomposition analysis.

crime-education nexus that helpful to reduce crime rates through intergenerational human capital formation.

The other results show that technical cooperation grants and trade mark application largely reduced crime rate and increases scientific and technical journal articles, which implies that institutional efficiency promotes educational infrastructure and decrease crime rates across countries. The country's per capita income and refuges promote educational indicators while there is an inverted U-shaped relationship between income and crime across countries. Soares [37] found that variation in the crime rates is strongly influenced by institutional stability, corruption, and increase police force. The institutional stability is the key to revitalize socio-economic policies in a way to undertake crime rates. Enamorado et al. [13] concluded that income inequality has a negative impact on high risk of crime incidence, as it increases more drug related homicides. The policies to restrain 'drug trafficking organizations' are largely needed for crime reduction. Lawson et al. [27] showed the importance of CCTV and street lights as a policy intervention in the reduction of crime rates and argued that CCTV is more cost effective than street lights, thus the local policies should be designed in a way to plug CCTV and street lights in the 'hotspot' areas where the risk of crime is possibly be happened.

6. Conclusions

The study investigated the long-run, causal and inter-temporal relationship between STJ articles and crime rates by incorporating R&D expenditures, trademark applications, technical cooperation grants, GDPpc, energy efficiency, and refugee population in a panel of 21 diversified countries, over a period of 1990–2015. The study employed panel FE model that address the country invariant shocks, while GMM estimator control for possible endogeneity and serial correlation in a studied models. The study further used panel causality test and innovation accounting technique for more conclusive finding in the domain of causality analysis and in forecasting framework. The study conclude the following empirical results i.e.,

i) While absorbing country invariant shocks, the result does not confine any significant relationship between STJ articles and crime rates, however, by controlling the possibility of endogeneity and serial correlation issues, the results show that STJ articles increases crime rates in a panel of selected countries.

ii) R&D expenditures increases crime rates, while trademark applications, technical cooperation grants, and GDPpc considerably decrease crime rates during the study time period.

iii) By using the estimates of FE model, the results confirm the crime Kuznets curve under the presence of STJ articles; however, this result is not consistent in case of GMM estimator.

iv) R&D expenditures, trademark applications, technical cooperation grants, GDPpc, and refugee population, all variables promote STJ articles, while energy efficiency have a mixed results with different panel estimators.

v) There is one-way causality running from crime rates to STJ articles and R&D expenditures; from STJ articles to technical cooperation grants; from trademark applications to STJ articles, R&D expenditures, and GDPpc; from refugee to R&D expenditures; and from R&D expenditures to energy efficiency.

vi) There is bidirectional causality running between GDPpc and technical cooperation grants, and between energy efficiency and refugee population across countries, and

vii) R&D expenditures and technical cooperation grants both have a greater share to influence crime rates and STJ articles.

7. Policy implications

The overall results come to the conclusion with sound policy implications that describe by short-term, medium-term, and long-term action plans i.e.,

- Short-term action plan: There is a substantial need to design and formulate academia's policy in a way to find a possible solution to reduce crime rates by increasing social expenditures on education and R&D expenditures that would helpful to minimize crime rates all across the globe. The macroeconomic policies should be consider while devising any significant policy for human cost modeling, which would be well connected with the certain technical cooperation grants and trademark applications that give aid to reduce crime rates across countries.

- Medium-term action plan: The balanced and momentous economic growth would strengthen labour market outcomes in a form of providing job opportunities that eventually aid to reduce crime rates across countries, and

- Long-term action plan: Industry –academia interlinkages would be helpful to reduce crime cost modeling, for instance, the industry 'call for paper' about to survey the importance of institutions, education, and other possible determinants of crime rates, while the reasonable number of scholars put their efforts to find a conclusive findings on the stated issue. Thus, we may re-built the safe and sound infrastructure and increase police force and other law protecting agencies in order to provide justice across countries.

Declaration of Competing Interest

We confirm that the work is original and it is neither published before nor submitted for publication elsewhere. We all authors have no potential conflict of interest between them.

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