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Analysis of a Mathematical Model of Corruption as an Epidemic

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Abstract

Corruption is a societal challenge facing many governments and human institutions globally. This paper presents the analysis of a deterministic model of corruption taking into account honest/incorruptible individuals. We first proved that the model formulated is well-posed. We computed the corruption-free equilibrium state, the corruption basic reproduction number (R_0) and established that the corruption-free state is locally and globally stable whenever $R_0 < 1$ and unstable if $R_0 > 1$. We have also shown that the proposed model admits a unique and globally stable endemic equilibrium when $R_0 > 1$. Furthermore, we conducted numerical simulations to demonstrate the validity of the model.

Subject Areas

Mathematical Analysis

Keywords

Corruption, Mathematical Model, Stability Analysis, Numerical Simulations

1. Introduction

According to the World Bank and the International Monetary Fund (IMF), corruption is the abuse of public office for personal gain Tesfaye *et al.* [1]. It is a global societal challenge with more pronounced consequences in low-income countries Nwajeri *et al.* [2]. From an epidemiological point of view, corruption can be described as an endemic human disease with records of outbreaks spanning from the time of the first human on earth till date. It is a major cause of poverty globally, especially in Africa. Corruption is a major factor that slows down sustainable economic growth in many countries. It is one of the causes of social unrest around the world [1] [3]. Despite the efforts of some governments and anti-corruption agencies to fight corruption, this social ill still continues to evolve in our society [1] [4] [5]. Hence, the need for more research into the topic becomes crucial. Mathematical modelling has become a significant decision making toolbox especially in the absence of real data [6]. Despite, the existence of a vast literature on corruption, mathematical models on the analysis of corruption transmission dynamics are still limited [1] [6]. In what follows, we briefly discuss some mathematical models that have been formulated to study this evil phenomenon of corruption. Tesfaye *et al.* [1] formulated and analyzed a stochastic model of corruption dynamics in society. It was revealed from their analysis that there is a direct proportion between the number of corrupt individuals in a community and the interaction rate of corrupt individuals with the susceptible ones. Additionally, the study demonstrated that education or punishment could be an effective strategy for minimizing the number of corrupt individuals in the community. Researchers in [7] used a deterministic model to describe the transmission dynamics of corruption. These authors recommended that investing in public awareness and encouraging religious leaders to preach about the negative impact associated with corruption can help mitigate this evil act. Alemneh [8] formulated an optimal control problem of the corruption model using combinations of control measures such as educational campaigns and punishment including jail. The study revealed that an integrated control strategy is required to fight corruption. Ahmed *et al.* [9] also established that prevention and punishment are effective control measures for mitigating corruption. Rahmadi and Rahayu [10] used a mathematical modelling approach to explore alternative solutions for combating corruption in Indonesia. Their model took into account the intensity of enforcement against corrupt practices, public education/awareness and the effectiveness of the corruption control policy. It was shown from the study that the spread of corruption in Indonesia depends on the initial conditions. Gutema *et al.* [3] formulated an optimal control model for corruption dynamics in society. Their study revealed that combining public sensitization and law enforcement is the most effective control strategy for combating corruption in our society. Teklu [11] analyzed a fractional order optimal control problem of corruption dynamics using controls such as preventive measures and measures for checking moderate and high level corruption. The study's numerical results showed that a combination of these controls can drastically reduce the number of corrupt people in a community. Bonyah [6] also used a fractional optimal control model to investigate the best strategy to reduce the occurrence of corruption in society. The author recommended that simultaneous implementation of preventive measures, correctional measures, and motivational measures that will make people desist from corrupt practices is required to mitigate corruption in our society. Fantaye and Birhanu [12] analyzed an optimal control model of corruption taking into consideration the social influence of honest individuals in society. The study revealed that a combination of preventive and punitive measures is the most efficient control strategy for minimizing corruption.

2. Corruption Model Formulation

To construct a compartmental model for studying corruption dynamics, we adopt the model formulated in [6] to include honest individuals. Here, the total population at time t ($N(t)$) is stratified into seven sub-classes. Namely: $S(t)$, $H(t)$, $E(t)$ $C(t)$, $P(t)$, $F(t)$ and $R(t)$. Individuals are recruited into the susceptible class ($S(t)$) at rate ζ out of which, a small proportion (Λ) are honest/ incorruptible individuals. Some of these honest people lose their honesty and move to susceptible class at rate γ. A susceptible person can also move to honest class ($H(t)$) at rate θ. The susceptible individuals become exposed to corruption following interaction with the corrupted individuals at a force of influence $\beta(q_1C+q_2P+q_3F)$. Exposed individuals get involved into corrupt practices and move to corrupt class ($C(t)$) at rate ρ. These corrupt people either repent through self conviction and move to repented class ($R(t)$) at rate δ or get punished and move to punished class ($P(t)$) at rate η_1. In reality, it common to see some corrupt individuals going unpunished sometimes due to their political colors, social status or for other reasons. Hence, the model assumes that some corrupt individuals who are well known for engaging into corrupt practices get away with it or are forgiven. This category of corrupt people join the unpunished class ($F(t)$) at rate η_2. Corrupt individuals who go unpunished engage in corrupt activities again at rate ψ or repent at rate ϕ. Corrupt individuals who are punished either repent at rate π or join the susceptible class at rate ω. Individuals who repent from corrupt practices either move to susceptible class at rate υ or honest class at rate α. It is assumed in this model that individuals can die naturally from each compartment at a rate μ. The model also assumes a corrupt person can die from corruption related issues at rate ε. The variables and parameters used to describe the corruption model summarized by **Figure 1** are defined in **Table 1**.

$$
\begin{cases}
\frac{\mathrm{d}S}{\mathrm{d}t}=(1-\Lambda)\zeta+\gamma H+\omega P+\upsilon R-\beta(q_1C+q_2P+q_3F)S-(\theta+\mu)S\\
\frac{\mathrm{d}H}{\mathrm{d}t}=\Lambda\zeta+\theta S+\alpha R-(\gamma+\mu)H\\
\frac{\mathrm{d}E}{\mathrm{d}t}=\beta(q_1C+q_2P+q_3F)S-(\rho+\mu)E\\
\frac{\mathrm{d}C}{\mathrm{d}t}=\rho E+\psi F-[\tau\eta_1+(1-\tau)\eta_2+\delta+\varepsilon+\mu]C\\
\frac{\mathrm{d}P}{\mathrm{d}t}=\tau\eta_1C-(\pi+\omega+\mu)P\\
\frac{\mathrm{d}F}{\mathrm{d}t}=(1-\tau)\eta_2C-(\phi+\psi+\mu)F\\
\frac{\mathrm{d}R}{\mathrm{d}t}=\delta C+\pi P+\phi F-(\upsilon+\alpha+\mu)R
\end{cases}
\tag{1}
$$

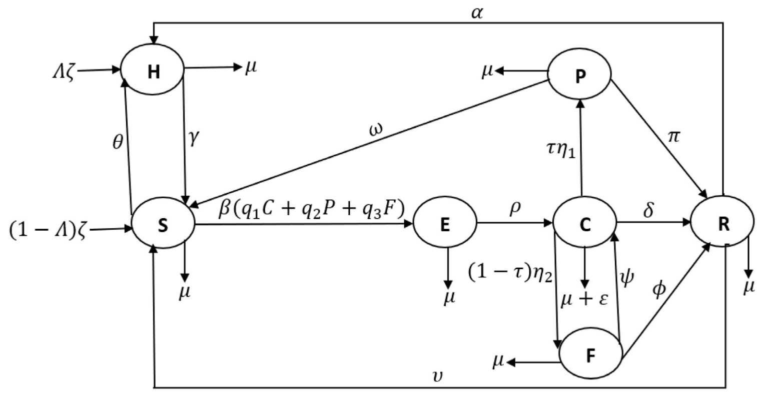

Figure 1. Corruption transmission flow chart.

Table 1. Corruption model parameters and initial conditions.

Parameter	Definition	Value	Source
ζ	Population recruitment rate	100	[2]
Λ	proportion of honest individuals	0.01	Assumed
μ	Population natural mortality rate	$\frac{1}{65}$	[2]
θ	Honesty rate of susceptible individuals	0.03	[3] [8]
β	Influence rate of corrupt individuals	0.0234	[3] [8]
γ	Rate at which honest people become susceptible	0.0021	[9] [13]
α	Honesty rate of repented people	0.035	[8]
ρ	Progression rate from exposed to corrupt class	0.06	[4] [8]
η_1	Punishment rate of corrupt people	0.1	[4]
η_2	Rate at which corrupt people go unpunished	0.18	Assumed
δ	Progression rate from corrupt to repented class	0.035	Assumed
ε	corruption related death rate	0.0005	Assumed
ψ	Progression rate from unpunished to corrupt class	0.0095	Assumed
ϕ	Progression rate from unpunished to repented class	0.114	Assumed
π	Progression rate from punished to repented class	0.000001	[7]
ω	Progression rate from punished to susceptible class	0.125	[5]
υ	Progression rate from repented to susceptible class	0.315	Assumed
τ	Probability of punishing a corrupt person	0.6	Assumed
$q_1 / q_2 / q_3$	Degree at which a corrupt/ punished/unpunished individual influences a susceptible person	0.036	[3] [8]
Initial Value			
$S(0)$	Initial susceptible population	300	Variable
$H(0)$	Initial honest population	50	Variable
$E(0)$	Initial exposed population	100	Variable
$C(0)$	Initial corrupt population	15	Variable
$P(0)$	Initial punished population	5	Variable
$F(0)$	Initial unpunished population	5	Variable
$R(0)$	Initial repented population	5	Variable

The following notation will be used in the rest of the study:

$g_1 = \theta + \mu,\ g_2 = (\gamma + \mu),\ g_3 = (\rho + \mu),\ g_4 = (\tau\eta_1 + (1-\tau)\eta_2 + \delta + \varepsilon + \mu),$
$g_5 = (\pi + \omega + \mu),\ g_6 = (\phi + \psi + \mu)$ and $g_7 = (\upsilon + \alpha + \mu)$

2.1. Well-Posedness of the Model

In this section, we establish that the system of differential equations representing model (1) admits only non-negative solutions. Furthermore, the set over which the model system of equations is meaningful is also determined. These results are summarized in the theorems below.

Theorem 1. *Given the initial value set:* $\{S(0), H(0), E(0), C(0), P(0), F(0), R(0)\} \ge 0$ *of system* (1), *it follows that the model solutions* $S(t), H(t), E(t), C(t), P(t), F(t)$ *and* $R(t)$ *are non-negative and bounded* $\forall\, t \ge 0$.

Proof. Consider the differential equation for the susceptible sub-class:

$$\frac{\mathrm{d}S}{\mathrm{d}t} = (1-\Lambda)\zeta + \gamma H + \omega P + \upsilon R - \beta(q_1C + q_2P + q_3F)S - (\theta + \mu)S$$

$$\Rightarrow \frac{\mathrm{d}S}{\mathrm{d}t} \ge -\lambda S - g_1 S,\ \lambda = \beta(q_1C + q_2P + q_3F)$$

$$\Rightarrow S(t) \ge S(0)\mathrm{e}^{-\left(g_1 t + \int_0^t \lambda(x)\mathrm{d}x\right)} \ge 0$$

Similarly, the following results can be obtained:

$$H(t) \ge H(0)\mathrm{e}^{-g_2 t} \ge 0,\ E(t) \ge E(0)\mathrm{e}^{-g_3 t} \ge 0,\ C(t) \ge I(0)\mathrm{e}^{-g_4 t} \ge 0,$$
$$P(t) \ge P(0)\mathrm{e}^{-g_5 t} \ge 0,\ F(t) \ge F(0)\mathrm{e}^{-g_6 t} \ge 0 \text{ and } R(t) \ge R(0)\mathrm{e}^{-g_7 t} \ge 0$$

Therefore, $\forall\, t \ge 0$, the state variables of the model have non-negative solutions.

Theorem 2. *The feasible positive invariant region in which the solution set of the model system of equations is considered meaningful is the set*:

$$\mathscr{D} = \left\{(S, H, E, C, P, F, R) \in \mathbb{R}_+^7 : S + H + E + C + P + F + R \le \frac{\zeta}{\mu}\right\} \tag{2}$$

Proof. The total population N at any given time t is:

$$N = S + H + E + C + P + F + R$$
$$\Rightarrow \frac{\mathrm{d}N}{\mathrm{d}t} = \zeta - \mu N - \varepsilon C \tag{3}$$
$$\Rightarrow N \le \frac{\zeta}{\mu} \text{ as } t \to +\infty$$

Hence, the set $\mathscr{D}$ in (2) is obtained.

2.2. Corruption-Free Equilibrium Point (CFEP)

Equating the individual equations of the system (1) to zero with $E = C = P = F = R = 0$, we obtain the CFEP χ^0 given by

$$\chi^0 = (S^0, H^0, E^0, C^0, P^0, F^0, R^0) = \left(\frac{[\gamma + \mu(1-\Lambda)]\zeta}{g_1 g_2 - \gamma\theta}, \frac{1}{g_2}(\Lambda\zeta + \theta S^0), 0, 0, 0, 0, 0\right)$$

The Basic Reproductive Number (R_0) for the Corruption Model

Borrowing the concept of basic reproductive number from epidemiology, the corruption reproductive number may be defined as the average number of secondary corrupt individuals that will be influenced by one corrupt individual when introduced into a wholly susceptible population. To compute the corruption reproductive number, we expressed the corrupt sub-system of (1) in the form $\frac{\mathrm{d}X}{\mathrm{d}t}=(\mathscr{K}-\mathscr{V})X^{\mathrm{T}}$. Here, $X=(E,C,P,F)$, $\mathscr{K}$ and $\mathscr{V}$ are the source of new corrupt individuals and transfer rates respectively. Now, considering the corrupt system of (1) that is:

$$\begin{cases}\frac{\mathrm{d}E}{\mathrm{d}t}=\beta(q_1C+q_2P+q_3F)S-g_3E\\ \frac{\mathrm{d}C}{\mathrm{d}t}=\rho E+\psi F-g_4C\\ \frac{\mathrm{d}P}{\mathrm{d}t}=\tau\eta_1C-g_5P\\ \frac{\mathrm{d}F}{\mathrm{d}t}=(1-\tau)\eta_2C-g_6F\end{cases} \tag{4}$$

we obtain:

$$\mathscr{K}=\begin{pmatrix}\beta(q_1C+q_2P+q_3F)S\\0\\0\\0\end{pmatrix} \text{ and } \mathscr{V}=\begin{pmatrix}g_3E\\-\rho E+g_4C-\psi F\\-\tau\eta_1C+g_5P\\(1-\tau)\eta_2C+g_6F?\end{pmatrix} \tag{5}$$

Consequently, we obtain the matrices K and V of $\mathscr{K}$ and $\mathscr{V}$ as:

$$K=\begin{pmatrix}0&\beta q_1S^0&\beta q_2S^0&\beta q_3S^0\\0&0&0&0\\0&0&0&0\\0&0&0&0\end{pmatrix} \text{ and } V=\begin{pmatrix}g_3&0&0&0\\-\rho&g_4&0&-\psi\\0&-\tau\eta_1&g_5&0\\0&-(1-\tau)\eta_2&0&g_6\end{pmatrix} \tag{6}$$

From V above, we obtain V^{-1} as follows:

$$V^{-1}=\begin{pmatrix}\frac{1}{g_3}&0&0&0\\ \frac{\rho g_6}{g_3(g_4g_6-\psi(1-\tau)\eta_2)}&\frac{g_6}{(g_4g_6-\psi(1-\tau)\eta_2)}&0&\frac{\psi}{(g_4g_6-\psi(1-\tau)\eta_2)}\\ \frac{\rho\tau\eta_1g_6}{g_3g_5(g_4g_6-\psi(1-\tau)\eta_2)}&\frac{\tau\eta_1g_6}{g_5(g_4g_6-\psi(1-\tau)\eta_2)}&\frac{1}{g_5}&\frac{\psi\tau\eta_1}{g_5(g_4g_6-\psi(1-\tau)\eta_2}\\ \frac{\rho(1-\tau)\eta_2}{g_3(g_4g_6-\psi(1-\tau)\eta_2)}&\frac{(1-\tau)\eta_2}{(g_4g_6-\psi(1-\tau)\eta_2)}&0&\frac{g_4}{(g_4g_6-\psi(1-\tau)\eta_2)}\end{pmatrix} \tag{7}$$

Using K and V^{-1} from (6) and (7), we obtain R_0 as the spectral radius of KV^{-1} given by:

$$R_0=\frac{\beta\rho S^0\left[g_6(q_1g_5+\tau\eta_1q_2)+q_3g_5(1-\tau)\eta_2\right]}{g_3g_5(g_4g_6-\psi(1-\tau)\eta_2)} \tag{8}$$

2.3. Stability Analysis of CFEP

2.3.1. Local Stability

To study the local stability of the CFEP, we adopt the linearization approach.

Theorem 3. *The corruption-free equilibrium point,*

$\chi^0 = \left(\frac{\left[\gamma + \mu(1-\Lambda)\right]\zeta}{g_1 g_2 - \gamma\theta}, \frac{1}{g_2}\left(\Lambda\zeta + \theta S^0\right), 0, 0, 0, 0, 0 \right)$ *admits a local asymptotic stability* (*LAS*) *whenever* $R_0 < 1$ *and is unstable if* $R_0 > 1$.

Proof. Let J_0 be the Jacobian matrix of system (1) evaluated at χ^0, that is:

$$J_0 = \begin{pmatrix} -g_1 & \gamma & 0 & -\beta q_1 S^0 & \omega - \beta q_2 S^0 & -\beta q_3 S^0 & \upsilon \\ \theta & -g_2 & 0 & 0 & 0 & 0 & \alpha \\ 0 & 0 & -g_3 & \beta q_1 S^0 & \beta q_2 S^0 & \beta q_3 S^0 & 0 \\ 0 & 0 & \rho & -g_4 & 0 & \psi & 0 \\ 0 & 0 & 0 & \tau\eta_1 & -g_5 & 0 & 0 \\ 0 & 0 & 0 & (1-\tau)\eta_2 & 0 & -g_6 & 0 \\ 0 & 0 & 0 & \delta & \pi & \phi & -g_7 \end{pmatrix} \tag{9}$$

Clearly, the matrix in (9) admits three negative real eigenvalues, namely $\lambda_1 = -g_2$, $\lambda_2 = -g_1$, $\lambda_3 = -g_7$. Other eigenvalues of matrix J_0 can be obtained from the sub-matrix J_1 below:

$$J_1 = \begin{pmatrix} -g_3 & \beta q_1 S^0 & \beta q_2 S^0 & \beta q_3 S^0 \\ \rho & -g_4 & 0 & \psi \\ 0 & \tau\eta_1 & -g_5 & 0 \\ 0 & (1-\tau)\eta_2 & 0 & -g_6 \end{pmatrix} \tag{10}$$

The matrix in (10) will be stable if its trace and determinant are negative and positive, respectively [14]. Now

$$\text{Trace}(J_1) = -(g_3 + g_4 + g_5 + g_6) < 0 \tag{11}$$

and

$$\det(J_1) = g_3 g_5 \left(g_4 g_6 - (1-\tau)\eta_2\psi\right)(1-R_0) > 0 \text{ if } R_0 < 1 \tag{12}$$

Thus, the CFEP is locally asymptotically stable whenever $R_0 < 1$.

Next, we examine the global stability of CFEP.

2.3.2. Global Stability of CFEP

To determine the global stability status of the CFEP, we proceed as in [15]-[17]. Thus, model (1) is first expressed as:

$$\begin{cases} \frac{dY_s}{dt} = B_1\left(Y_s - Y_{sCFEP}\right) + B_{12} Y_i \\ \frac{dY_i}{dt} = B_2 Y_i \end{cases} \tag{13}$$

where Y_s and Y_i denote the non-corrupted and corrupted compartments, respectively. Here, $Y_s = (S, H, R)^{\mathrm{T}}$, $Y_i = (E, C, P, F)^{\mathrm{T}}$, $Y_{sCFEP} = \left(S^0, H^0, R^0\right)$,

$$B_1 = \frac{\partial Y_s}{\partial(S,H,R)}, \quad B_{12} = \frac{\partial Y_s}{\partial(E,C,P,F)} \quad \text{and} \quad B_2 = \frac{\partial Y_i}{\partial(E,C,P,F)}$$

Using model (1), we get:

$$B_1 = \begin{pmatrix} -g_1 & \gamma & \upsilon \\ \theta & -g_2 & \alpha \\ 0 & 0 & -g_7 \end{pmatrix} \tag{14}$$

$$B_{12} = \begin{pmatrix} 0 & -\beta q_1 S^0 & \omega - \beta q_2 S^0 & -\beta q_3 S^0 \\ 0 & 0 & 0 & 0 \\ 0 & \delta & \pi & \phi \end{pmatrix} \tag{15}$$

$$B_2 = \begin{pmatrix} -g_3 & q_1 S^0 & \beta q_2 S^0 & \beta q_3 S^0 \\ \rho & -g_4 & 0 & \psi \\ 0 & \tau\eta_1 & -g_5 & 0 \\ 0 & (1-\tau)\eta_2 & 0 & -g_6 \end{pmatrix} \tag{16}$$

From the above we formulate the theorem as follows.

Theorem 4. *The system* $\frac{\mathrm{d}Y_s}{\mathrm{d}t} = B_1(Y_s - Y_{sCFEP}) + B_{12}Y_i$ *admits a global asymptotic stability* (*GAS*) at the CFEP if matrix B_1 has negative eigenvalues and matrix B_2 is Metzler stable.

Proof. It is not hard to see that $\lambda_1 = -g_2, \lambda_2 = -g_0, \lambda_3 = -g_7$ are the eigenvalues of matrix B_1. Also, matrix B_2 is clearly Metzler stable. Hence, the CFEP admits a global asymptotic stability if $R_0 < 1$.

2.4. Existence of Corruption Endemic Equilibrium Point (CEEP)

Solving system (1) for the state variables at the CEEP, we obtain:

$$\begin{cases} S^* = \dfrac{g_2 g_5 \zeta G_1(1-G_3)[\gamma + \mu(1-\Lambda)] + [\tau\eta_1\omega g_2 + (\alpha\gamma + \upsilon g_2) g_5 G_0](g_1 g_2 - \gamma\theta)(R_0 - 1)}{g_2 g_5 G_1(1-G_3)(g_1 g_2 - \gamma\theta)(R_0 - G_3)} \\ H^* = \dfrac{1}{g_2^2 G_1(1-G_3)}\left[\gamma g_2 G_1(1-G_3)(\Lambda\zeta + \theta S^*) + \alpha\gamma G_0(g_1 g_2 - \gamma\theta)(R_0 - 1)\right] \\ E^* = \dfrac{1}{g_2 g_3(1-G_3)}(g_1 g_2 - \gamma\theta)(R_0 - 1) S^* \\ C^* = \dfrac{(g_1 g_2 - \gamma\theta)(R_0 - 1)}{g_2 G_1(1-G_3)} \\ P^* = \dfrac{\tau\eta_1(g_1 g_2 - \gamma\theta)(R_0 - 1)}{g_2 g_5 G_1(1-G_3)} \\ F^* = \dfrac{(1-\tau)\eta_2(g_1 g_2 - \gamma\theta)(R_0 - 1)}{g_2 g_6 G_1(1-G_3)} \\ R^* = \dfrac{G_0(g_1 g_2 - \gamma\theta)(R_0 - 1)}{g_2 G_1(1-G_3)} \end{cases} \tag{17}$$

where

$$G_0 = \frac{1}{g_5 g_6 g_7}\left[g_5\left(\delta g_6 + (1-\tau)\eta_2\phi\right) + \tau\eta_1\pi g_6\right],$$

$$G_1 = \frac{\beta}{g_5 g_6}\left[g_6\left(g_5 q_1 + \tau\eta_1 q_2\right) + (1-\tau)\eta_2 g_5 q_3\right],$$

$$G_3 = \frac{\rho g_6\left[\tau\eta_1\omega g_2 + \left(\alpha\gamma + \upsilon g_2\right)g_5 G_0\right]}{g_2 g_3 g_5\left(g_4 g_6 - \psi(1-\tau)\eta_2\right)}$$

It is clear from (17), that C^* exist if and only if $G_3 < 1$ and $R_0 > 1$.

Global Stability of CEEP

Theorem 5. *The unique CEEP* (χ^*) *of system* (1) *admits a global asymptotic stability whenever* $R_0 > 1$.

Proof. As in [3] [18], we consider a positive definite function $\mathscr{L}$ defined by:

$$\mathscr{L}(x) = \sum_{i=1}^{n}\frac{1}{2}\left(x_i - x_i^*\right)^2 \quad i = i^{th} \text{ model compartment}$$

Now,

$$\mathscr{L}\left(\chi^*\right) = \frac{1}{2}\Big[\left(S-S^*\right)+\left(H-H^*\right)+\left(E-E^*\right)+\left(C-C^*\right) + \left(P-P^*\right)+\left(F-F^*\right)+\left(R-R^*\right)\Big]^2 \tag{18}$$

$$\begin{aligned}\frac{\mathrm{d}\mathscr{L}\left(\chi^*\right)}{\mathrm{d}t} &= \left(N-N^*\right)\frac{\mathrm{d}N}{\mathrm{d}t}\\ &= \left(N-N^*\right)(\zeta - \mu N - \varepsilon I)\\ &\le \left(N-N^*\right)(\zeta - \mu N)\\ &\le -\mu\left(N-N^*\right)\left(N - \frac{\zeta}{\mu}\right)\\ &\le -\mu\left(N-N^*\right)^2\end{aligned} \tag{19}$$

Clearly, $\frac{\mathrm{d}\mathscr{L}\left(\chi^*\right)}{\mathrm{d}t} \le 0$ with equality holding if and only if $N = N^*$, hence, according to [3] [11] [14] [18] [19], the corruption endemic equilibrium point (CEEP) admits a global asymptotic stability whenever it exists ($R_0 > 1$).

3. Numerical Simulations

To validate our model, we carried out some numerical simulations using Matlab ode45 solver. System (1) was solved numerically and the simulation graphs are shown from **Figures 2-20**. Additionally, we plotted R_0 against some key model parameters to determine the kind of relationship that exists between these parameters and R_0.

4. Discussion, Conclusion and Future Work

Figures 3-9 describe the effect of varying the influence rate on the population sub-classes. **Figures 10-16** depict the evolution of the population sub-classes as the honesty rate is varied. **Figures 17-20** show the time evolution of corrupt

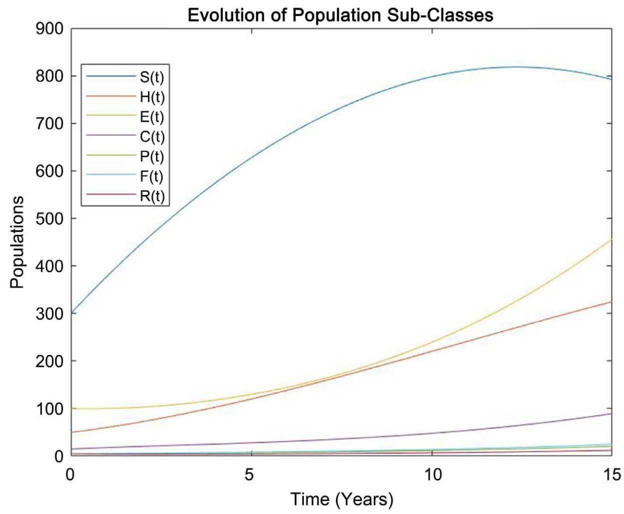

Figure 2. Plot of all population classes.

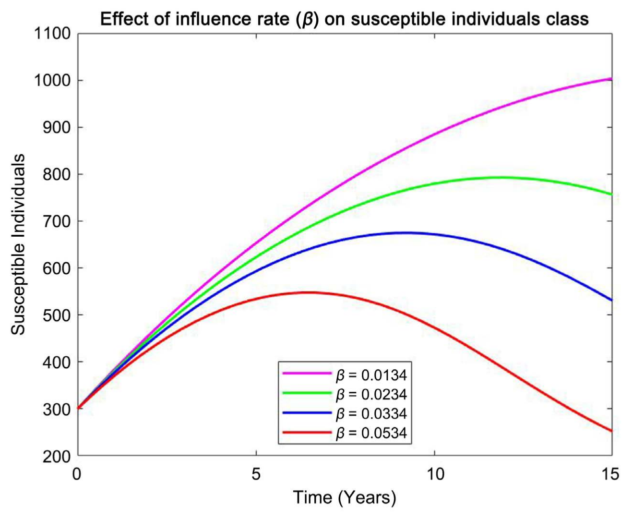

Figure 3. Plot of susceptible class against influence rate.

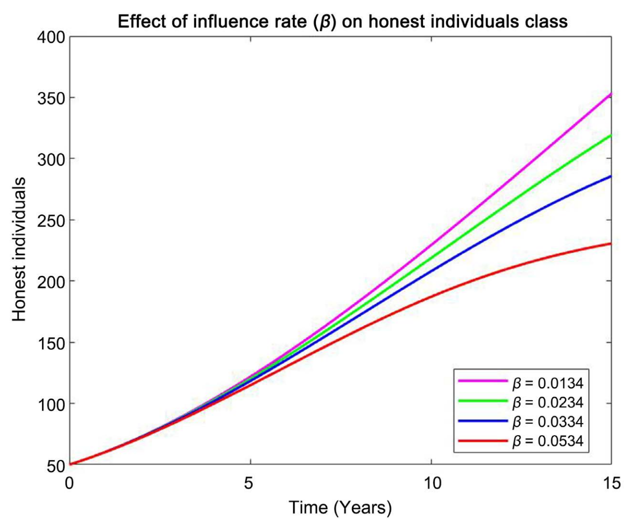

Figure 4. Plot of honest class against influence rate.

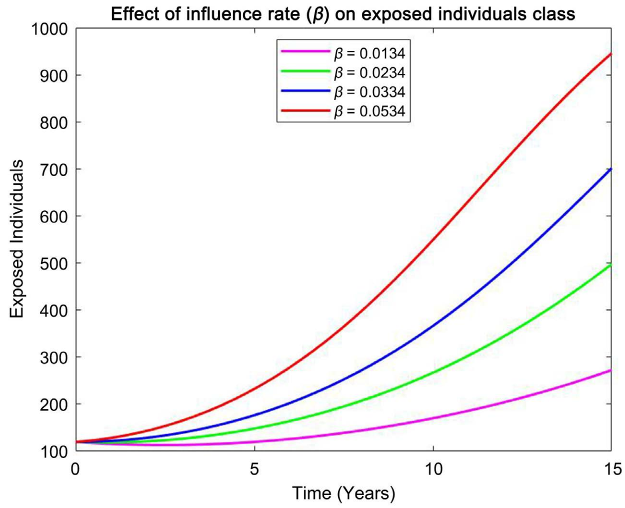

Figure 5. Plot of exposed class against influence rate.

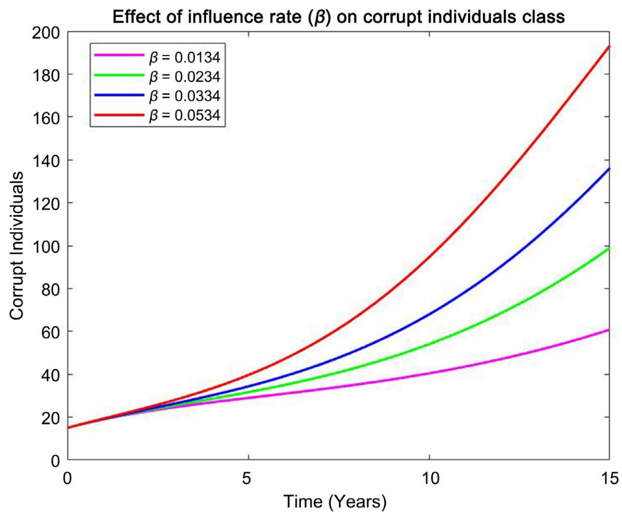

Figure 6. Plot of corrupt class against influence rate.

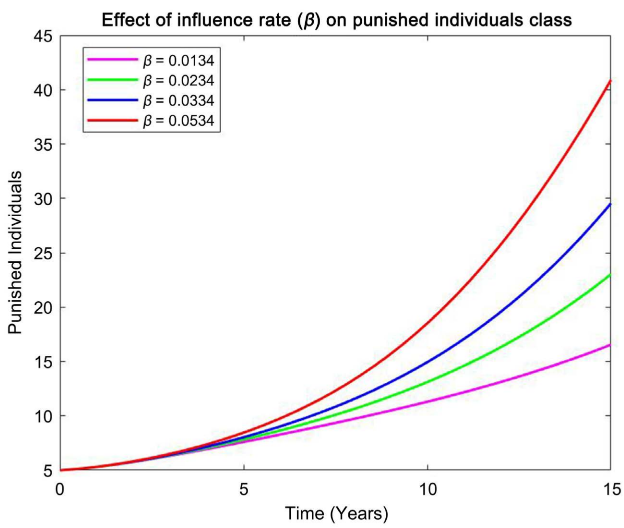

Figure 7. Plot of punished class against influence rate.

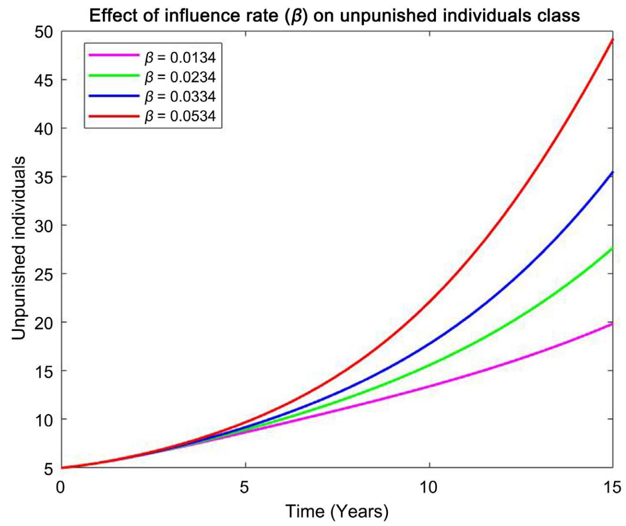

Figure 8. Plot of unpunished class against influence rate.

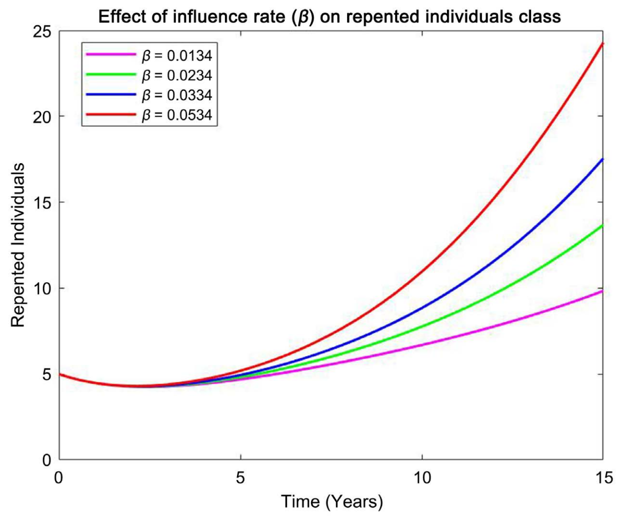

Figure 9. Plot of repented class against influence rate.

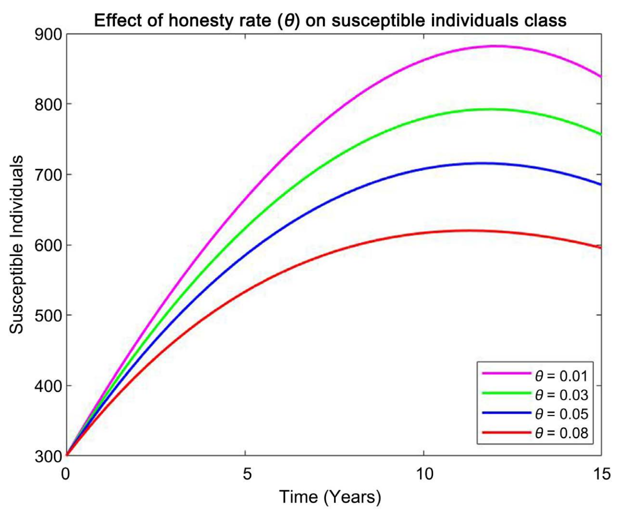

Figure 10. Plot of susceptible class against honesty rate.

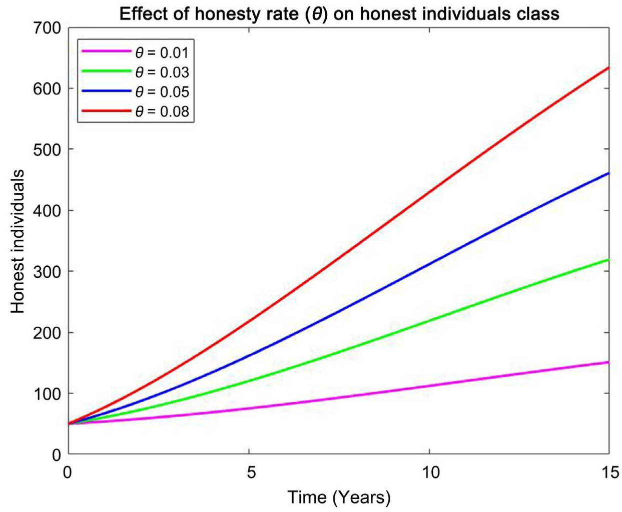

Figure 11. Plot of honest class against honesty rate.

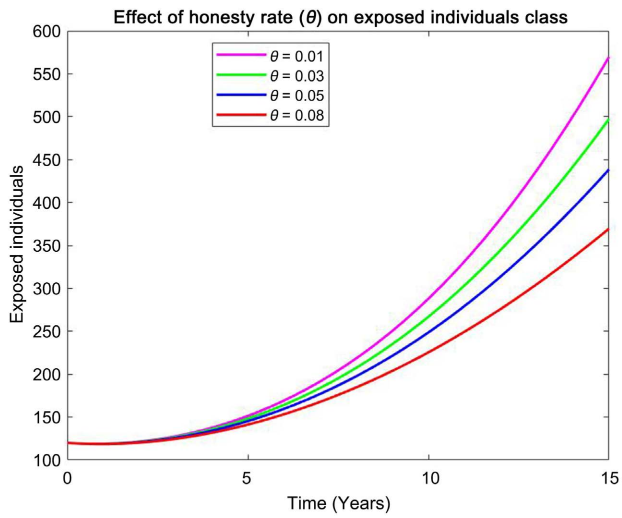

Figure 12. Plot of exposed class against honesty rate.

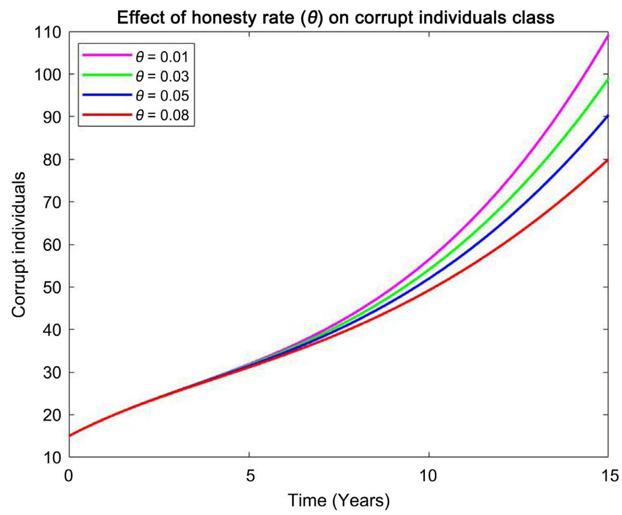

Figure 13. Plot of corrupt class against honesty rate.

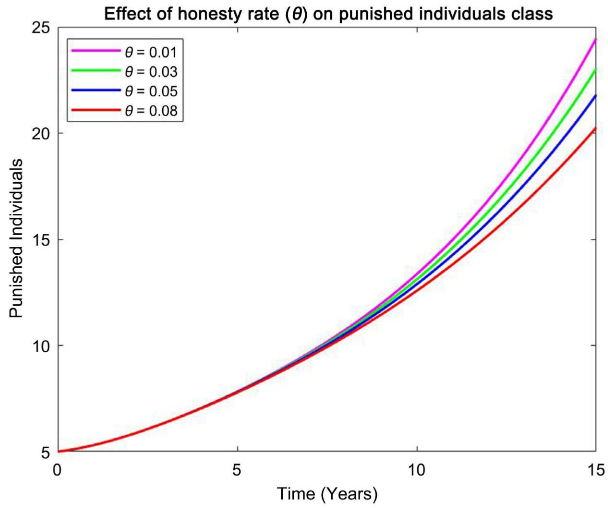

Figure 14. Plot of punished class against honesty rate.

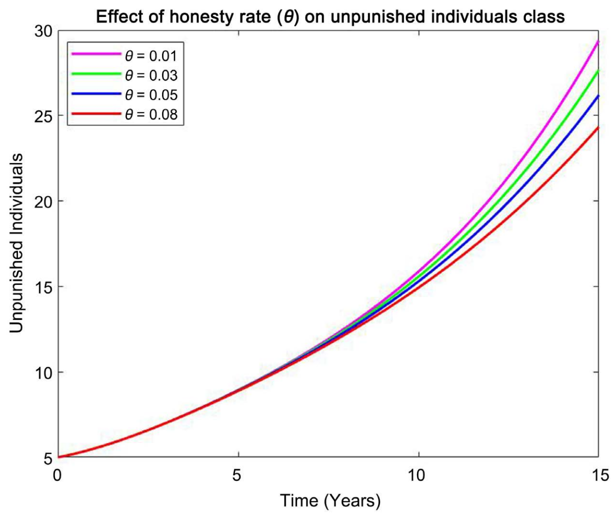

Figure 15. Plot of unpunished class against honesty rate.

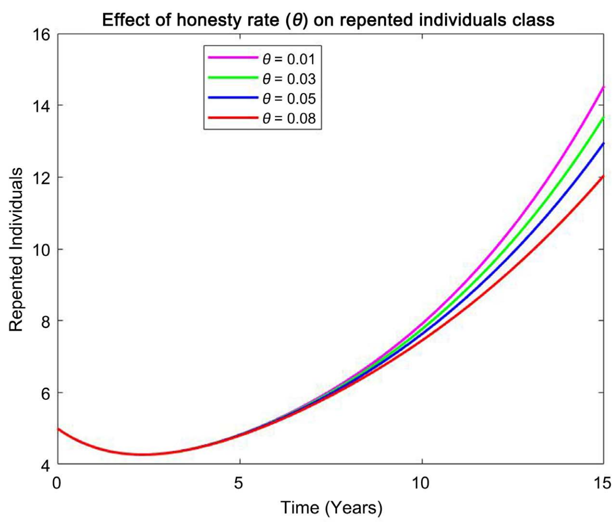

Figure 16. Plot of repented class against honesty rate.

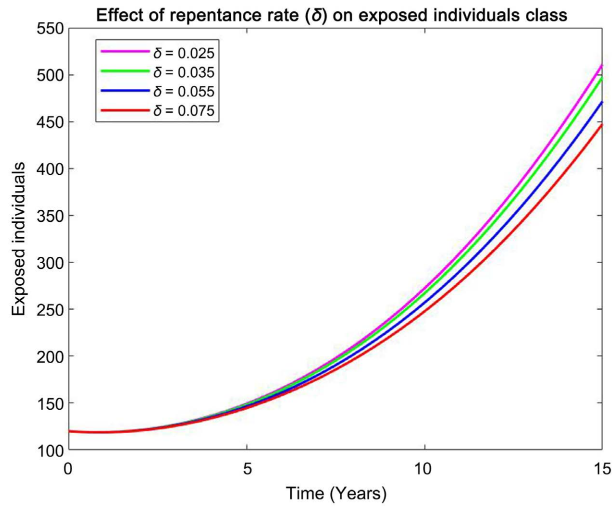

Figure 17. Plot of exposed class against repentance rate.

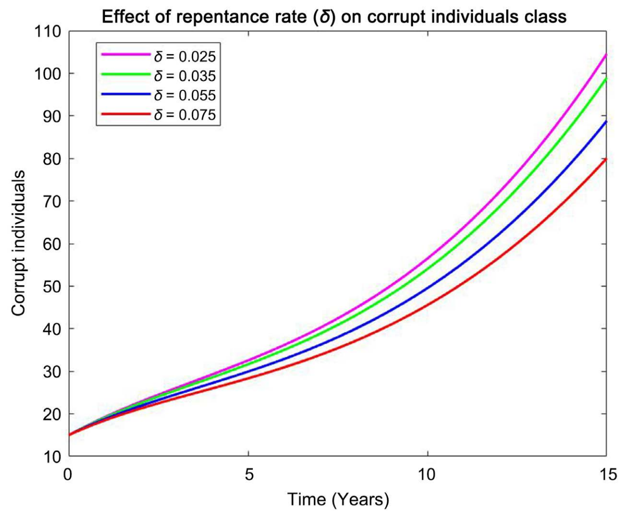

Figure 18. Plot of corrupt class against repentance rate.

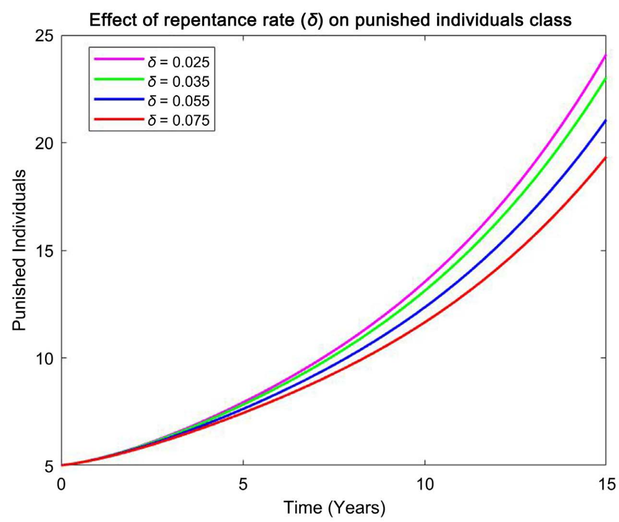

Figure 19. Plot of punished class against repentance rate.

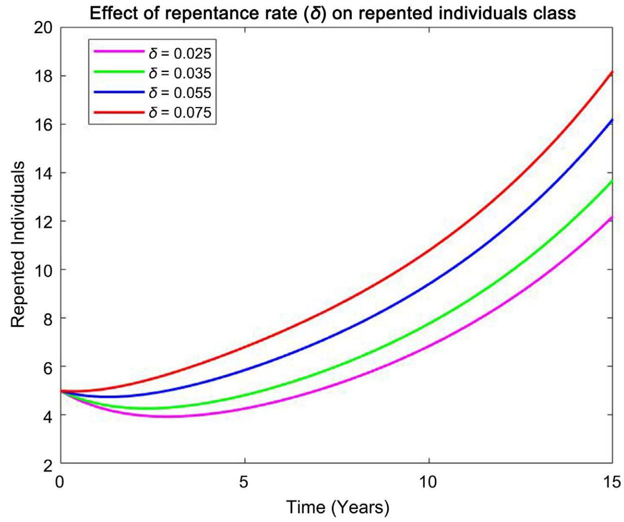

Figure 20. Plot of repented class against repentance rate.

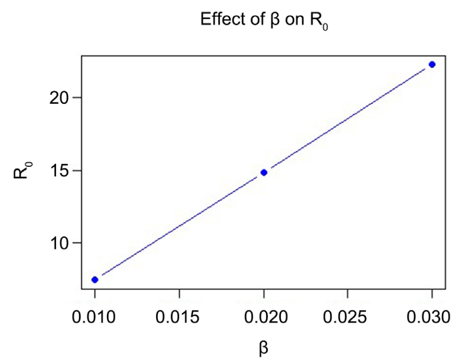

Figure 21. R_0 against β.

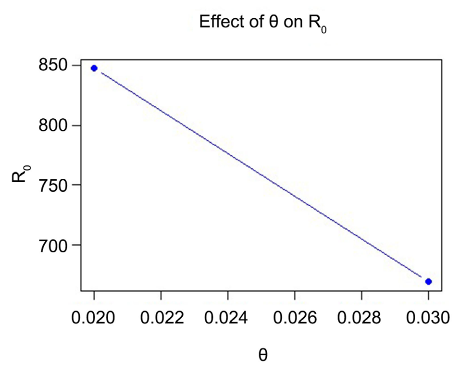

Figure 22. R_0 against θ.

classes as the repentance rate is varied. It can be seen from the simulation graphs that as the influence rate increases, the number of people in the corrupt classes also increases. This therefore suggests that if corruption is to be minimized in society, proper mechanisms to identify corrupt individuals and subject them to punitive measures could serve as a deterrent. Furthermore, it can be noted that increasing the honesty rate of susceptible people leads to minimizing the number of people in the corrupt classes. This implies that an effective sensitization campaign against corruption related practices in a community can help mitigate this demonic act. This sensitization program should be championed by the incorruptible political or religious leaders and other personalities of good moral standing from the community. Figure 21 and Figure 22 demonstrate the impact of influence and honesty rates on the spread of corruption. These Plots show that β (corruption influence rate) correlates positively with R_0 while θ (honesty rate) has an inverse correlation with R_0. In reality corruption is best transmitted among: peers, people belonging to the same tradition or political party, or officers with interrelated duty schedules, and so on. In some cases, corruption practices are influenced by external individuals. Thus, incorporating these factors into this model could improve its validity for future research. Furthermore, real data on corruption can be used to fit the model and perform other analyzes for future research.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Tesfaye, A.W. and Alemneh, H.T. (2023) Analysis of a Stochastic Model of Corruption Transmission Dynamics with Temporary Immunity. *Heliyon*, **9**, e12752. https://doi.org/10.1016/j.heliyon.2022.e12752

[2] Nwajeri, U.K., Asamoah, J.K.K., Ugochukwu, N.R., Omame, A. and Jin, Z. (2023) A Mathematical Model of Corruption Dynamics Endowed with Fractal-Fractional Derivative. *Results in Physics*, **52**, Article 106894. https://doi.org/10.1016/j.rinp.2023.106894

[3] Gutema, T.W., Wedajo, A.G. and Koya, P.R. (2024) A Mathematical Analysis of the Corruption Dynamics Model with Optimal Control Strategy. *Frontiers in Applied Mathematics and Statistics*, **10**, Article 1387147. https://doi.org/10.3389/fams.2024.1387147

[4] Shah, N.H., Yeolekar, B.M. and Patel, Z.A. (2017) Epidemics of Corruption Using Incidence Function. *Economic Computation & Economic Cybernetics Studies & Research*, **2**.

[5] Danford, O., Kimathi, M. and Mirau, S. (2020) Mathematical Modelling and Analysis of Corruption Dynamics with Control Measures in Tanzania. *Journal of Mathematics and Informatics*, **19**, 57-79. https://doi.org/10.22457/jmi.v19a07179

[6] Bonyah, E. (2020) Fractional Optimal Control for a Corruption Model. *Journal of Prime Research in Mathematics*, **16**, 11-29.

[7] Aga, B.Z., Tasisa, H.G., Keno, T.D., Geleta, A.G., Dinsa, D.W. and Geletu, A.R. (2024) Corruption Dynamics: A Mathematical Model and Analysis. *Frontiers in Applied Mathematics and Statistics*, **10**, Article 1323479. https://doi.org/10.3389/fams.2024.1323479

[8] Alemneh, H.T. (2020) Mathematical Modeling, Analysis, and Optimal Control of Corruption Dynamics. *Journal of Applied Mathematics*, **2020**, 1-13. https://doi.org/10.1155/2020/5109841

[9] Ahmed, M., Kamal, M. and Hossain, M.A. (2025) A Mathematical Model of Corruption Dynamics and Optimal Control. *Franklin Open*, **10**, Article 100216.

https://doi.org/10.1016/j.fraope.2025.100216

[10] Rahmadi, D. and Rahayu, P.P. (2024) Alternative Strategies to Eradicate Corruption in Indonesia with Numerical Simulation of 4th Order Runge Kutta Method on Mathematical Models. *Mathematical Journal of Modelling and Forecasting*, **2**, 37-45. https://doi.org/10.24036/mjmf.v2i2.31

[11] Teklu, S.W. (2024) Insight into the Optimal Control Strategies on Corruption Dynamics Using Fractional Order Derivatives. *Scientific African*, **23**, e02069. https://doi.org/10.1016/j.sciaf.2024.e02069

[12] Fantaye, A.K. and Birhanu, Z.K. (2022) Mathematical Model and Analysis of Corruption Dynamics with Optimal Control. *Journal of Applied Mathematics*, **2022**, 1-16. https://doi.org/10.1155/2022/8073877

[13] Akanni, J.O., Akinpelu, F.O., Olaniyi, S., Oladipo, A.T. and Ogunsola, A.W. (2020) Modelling Financial Crime Population Dynamics: Optimal Control and Cost-Effectiveness Analysis. *International Journal of Dynamics and Control*, **8**, 531-544. https://doi.org/10.1007/s40435-019-00572-3

[14] Konlan, M. and Chuaya, R.G. (2025) Stability Analysis of a Mathematical Model for Examination Malpractice Dynamics. *European Journal of Mathematical Analysis*, **5**, Article 16. https://doi.org/10.28924/ada/ma.5.16

[15] Msuya, R., Mirau, S., Nyerere, N. and Mbalawata, I. (2024) Modeling the Impact of Short-Term Displacement of Domestic Animals on the Transmission Dynamics of Brucellosis. *Heliyon*, **10**, e40255. https://doi.org/10.1016/j.heliyon.2024.e40255

[16] Konlan, M., Abassawah Danquah, B., Okyere, E., Osman, S., Amenyo Kessie, J. and Kobina Donkoh, E. (2024) Global Stability Analysis and Modelling Onchocerciasis Transmission Dynamics with Control Measures. *Infection Ecology & Epidemiology*, **14**, Article 2347941. https://doi.org/10.1080/20008686.2024.2347941

[17] Konlan, M. (2024) Modeling the Inflow of Exposed and Infected Migrants on the Dynamics of Malaria. *European Journal of Mathematical Analysis*, **4**, Article 7. https://doi.org/10.28924/ada/ma.4.7

[18] Goswami, N.K., Olaniyi, S., Abimbade, S.F. and Chuma, F.M. (2024) A Mathematical Model for Investigating the Effect of Media Awareness Programs on the Spread of COVID-19 with Optimal Control. *Healthcare Analytics*, **5**, Article 100300. https://doi.org/10.1016/j.health.2024.100300

[19] La Salle, J.P. (1976) The Stability of Dynamical Systems. Society for Industrial and Applied Mathematics. https://doi.org/10.1137/1.9781611970432