Modeling, Analysis, and Control of Student Loan Debt using Epidemiological Models

Kavya Ravishankar (UPenn), Dr. Padmanabhan Seshaiyer (GMU)

kavya24@wharton.upenn.edu

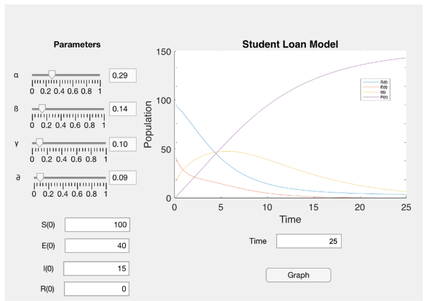
pseshaiy@gmu.edu

Abstract

Student loan debt is a debilitating problem that threatens a large subset of the American population. This research works to mathematically model the student loan debt situation from the lens of an **infectious disease contagion model**. The study describes a **belief proliferation model**. Specifically, the spread occurs through the unfounded external reassurance to students that the value of their college education will amount to a future job that will enable them to pay off their loans in full and on time. We additionally consider an enhanced model to study the potential effect of an **educational awareness program** and **the financial strain of the COVID-19 pandemic**.

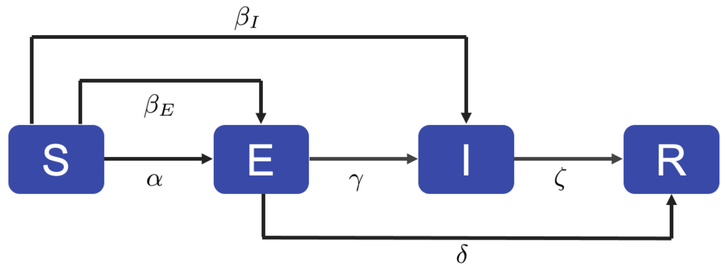
Motivation

Application



Studying the Student Loan Debt Problem from a unique perspective in order to better understand and address its effects

Compartmental Model of Epidemiology



S : Susceptible **I : Infected**

E : Exposed **R : Recovered**

Optimal Control Model

$$\begin{aligned}
\frac{dS}{dt} &= -\beta_E \frac{SE(1-\boxed{\epsilon_E})}{N} - \beta_I \frac{SI(1-\boxed{\epsilon_I})}{N} \\
&\quad -\alpha S \\
\frac{dE}{dt} &= \beta_E \frac{SE(1-\boxed{\epsilon_E})}{N} + \beta_I \frac{SI(1-\boxed{\epsilon_I})}{N} \\
&\quad +\alpha S - \gamma E - \delta E(1-\boxed{\sigma}) \\
\frac{dI}{dt} &= \gamma E - \zeta I(1-\boxed{\sigma}) \\
\frac{dR}{dt} &= \zeta I(1-\boxed{\sigma}) + \delta E(1-\boxed{\sigma})
\end{aligned}$$

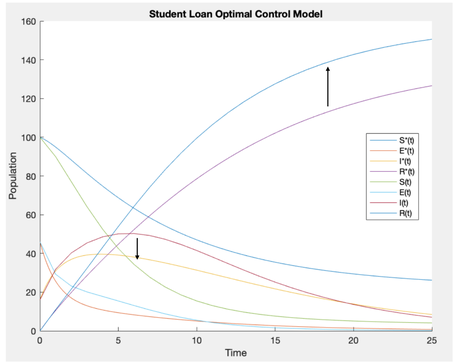
$$S(0) \geq 0, E(0) \geq 0, I(0) \geq 0, R(0) \geq 0$$

Basic Reproduction Number

$$\mathcal{R}_0 = \mathcal{R}_0^E + \mathcal{R}_0^I$$

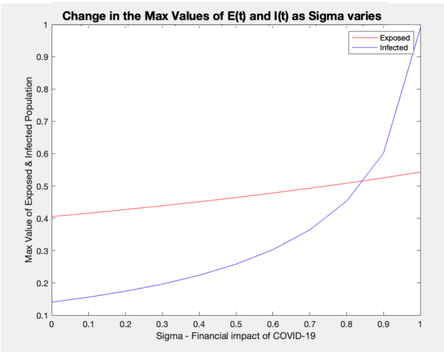
$$\begin{aligned}
\mathcal{R}_0^E &= \beta_E(1-\epsilon_E) \times \frac{1}{\gamma + \delta(1-\sigma)} \\
\mathcal{R}_0^I &= \beta_I(1-\epsilon_I) \times \frac{\gamma}{\gamma + \delta(1-\sigma)} \times \frac{1}{\zeta(1-\sigma)}
\end{aligned}$$

Computational Results



Inclusion of an Optimal Control Variable decreases the rate of Infection and increases the rate of Recovery

Escalating the Financial Impact of the COVID-19 pandemic reflects an increase in the Exposed and Infected populations



Future Work

- Evaluating the **Predictive Capability** of the model for available Data sets
- Engaging in further experimentation with available data sets to study changes in the model based on **geographical region, socioeconomic class, race, gender**, etc.
- Conducting **Parameter Estimation** on assigned variable values for each set of differential equations
- Implementing a **Computational Algorithm** for Optimal Control Analysis