



Optimal Control Strategies to Cope with Unemployment During the Covid-19 Pandemic

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Received: 14 September 2022 / Accepted: 3 March 2023
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Abstract

In the present paper, a mathematical model using the non-linear differential equations depicting the impact of Covid-19 on unemployment is discussed. The stability of the system is studied and model is reformulated as an optimal control problem. To assess the impact of unemployment on human population, two time-dependent controls are used. Providing education and training of job-oriented persons act as first control and campaigning about the awareness of coronavirus disease and self-employment business is the second control. Necessary conditions for optimal control are derived by Pontryagin's maximum principle. Further, the results are illustrated by numerical simulation.

Keywords Modified unemployment model · Covid-19 · Stability analysis · Control strategies · Numerical simulation

1 Introduction

Unemployment is the state of a person who is willing to work but is not able to get the job. Unemployment is a big problem across the globe and it affects the socio-economic condition of a region. It is vividly a matter of concern for government authorities as it holds a major role in taxation and budgets. Hence, providing adequate number of jobs to meet the challenge of unemployment is a major agenda for every government body in elections. Apparently, supporting education from the primary classes itself is an essential and elementary step towards the solution of a bigger problem. Unfortunately, covid crisis has impacted the condition of unemployment in a more worse manner. Many people have lost their jobs due to the Covid-19 pandemic and their economic, mental and social health have suffered a lot. Advances in technology adds to the development economically but the advancement should be made in a planned and controlled way like proper training, developing skills

etc. These factors often increase the employment. Also, entrepreneurship increases the employment in an efficient way (Yousefpour et al. 2020; Mallick and Biswas 2017). The rate of unemployment has increased dejectedly today than from the previous years due to the worldwide lockdown and curfews. According to research, India's unemployment rate has increased to 7.1% in 2020 from 5.2% in 2019. In 2021–2022, unemployment rate is almost the same as 2019–2020 (<https://www.businesstoday.in/jobs/story/india-unemployment-in-2020-at-worst-level-in-29-years-shows-study-297195-2021-05-28>). One of the significant study depicts the cost effective measures for the control of unemployment which is to embed the control strategies on temporary employees and regular employees while creating some temporary and regular vacancies (Munoli et al. 2017). In Munoli et al. (2017) and Munoli and Gani (2016), models include the schemes of retirement, unavoidable circumstances like death, termination from job etc. and control analysis is executed by adopting the Pontryagin's maximum principle. In Abu Arqub and Shawagfeh (2021), optimal control problem is solved by the method of reproducing kernel Hilbert space. Inverse problems are analyzed for diffusion equations with fractional Sturm–Liouville operator for space (Djennadi et al. 2021a) and fractional derivatives in time (Djennadi et al. 2021b). The class of fractional delay differential equations with Atangana–Baleanu fractional derivatives is discussed in Sweis et al. (2022). Effective measures like various policies to provide temporary or regular employ-

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