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Modelling New Zealand COVID-19 Infection Rate, and the Efficacy of Social Distancing Policy

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Abstract

We fit the Gompertz curve to the New Zealand actual COVID 19 total infection cases from Feb 28, 2020 to Mar 27, 2020 then make projections under two scenarios. The first scenario is an effective lockdown of the country and a second scenario of a less effective lockdown scenario. The difference between the two scenarios is that the growth rate of infections is reduced faster and sooner under strict social distancing policy. We show that the Gompertz curve fits the data very well, and the projections of the two scenarios differ significantly. Social distancing by enforced lockdown reduces the infection rate significantly.

Keywords: Gompertz curve, COVID 19, Social Distancing, New Zealand

JEL Classification Number: C90

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1. Introduction

New Zealand reported the first case of a COVID 19 infection on Feb 28, 2020, which is more than a month after the pandemic started in China. The infection cases remained very low for a long time and only reached a double digit (11 cases) on Mar 17, 2020. From Mar 19, onwards New Zealand's infection rate trend began to accelerate. The government reported 20 cases. The infection cases increased to 39, 53, 66, 102, 189, 262, and 368 cases on Mar 27 at the time of writing this note. We expect the number for Mar 28 to be higher.

The objective of this note is to model the growth rate of COVID 19 cases in New Zealand, and to make a couple of projections. Gompertz (1825) used the Sigmoid function to model human mortality in the U.K.[1] We fit the actual New Zealand data of total COVID 19 infections from Feb 28 to Mar 27 to this curve. This function describes growth as being slowest at the start and end of a given time period; the curve approaches the future value asymptote of the function more gradually than the lower valued asymptote (in contrast to the simple logistic function in which the curve symmetrically approaches both sides). The Sigmoid function is a special case of the generalised logistic function.

Next, we present the model and the analysis. Section 3 is a summary.

2. The Model and Analysis

The Gompertz (1825) function is:

$$f(t) = a.e^{-be^{-gt}} \quad . \tag{1}$$

[1] The original paper is unavailable anywhere, but see Adler (1866), Olshansky and Carnes (1997) and Kirkwood (2015) about the Gompertz curve.

The parameter a is a constant since in the limit as times approaches infinity $a.e^{-be^{-gt}} = ae^0 = a$. The parameter b describes the displacement along the x-axis. The curve is highly sensitive to these parameters. The parameter e is the Euler's constant = 2.71828. The parameter g is the infection growth rate.

For New Zealand, we use data for total cases of COVID 19 infections from Feb 28, 2020, the date when the government announced the first number until March 27, 2020, to fit equation (1). We take the data from the World Health Organization Situation Report published daily on its website. We found that $= 0.1$; $b = 0.2$; and $g = 0.5$ to fit the curve best. Figure (1) plots the actual data and the fitted curve. The fit is near perfect. Next, we make projections under two different scenarios.

Scenario 1: No change in the parameters a, e, and b, however, we assume that the lockdown imposed on New Zealanders March 25 is effective in reducing the growth rate of infection as time goes by. Thus, the parameter g falls fast and soon.

Scenario 2: No change in the parameters a, e, and b, however, we assume that the lockdown imposed on New Zealanders March 25 is less effective in reducing the growth rate of infection as time goes by. Thus, the parameter g falls by less than it did in scenario 1, and began much later. The projections begin from Mar 28, 2020. Figure (2) plots the assumed growth rates of the total infection rate under the two scenarios above. As shown, under strict social distancing and effective lockdown, the growth rate falls faster and sooner than under the scenario of a looser lockdown.

Figures (3) and (4) plot the actual and projected infection under the two scenarios above, effective lockdown, and less effective lockdown. The curves resemble the Chinese curve, whereby the infection growth rate increases very fast, peaks, then tumbles quickly and remains flat. The difference between the two scenarios is significant. Under an effective lockdown scenario, New Zealand's peak infection reaches 2,630 cases on April 3. Then it dips because the growth rate begins to fall. Under the less effective lockdown scenario, the infection cases reach the peak of 78,203 cases on April 15. This is quite a significant increase in two weeks period, a staggering 75,573 more cases. It emphasizes the importance and effectiveness of the lockdown and strict social distancing, which seems to be crucial to defeat the virus. See Greenstone and Nigam (2020). In a rather more elaborate model, they project that moderate social distancing would save 1.7 million lives between March 1 and October 1.

Figure (1)

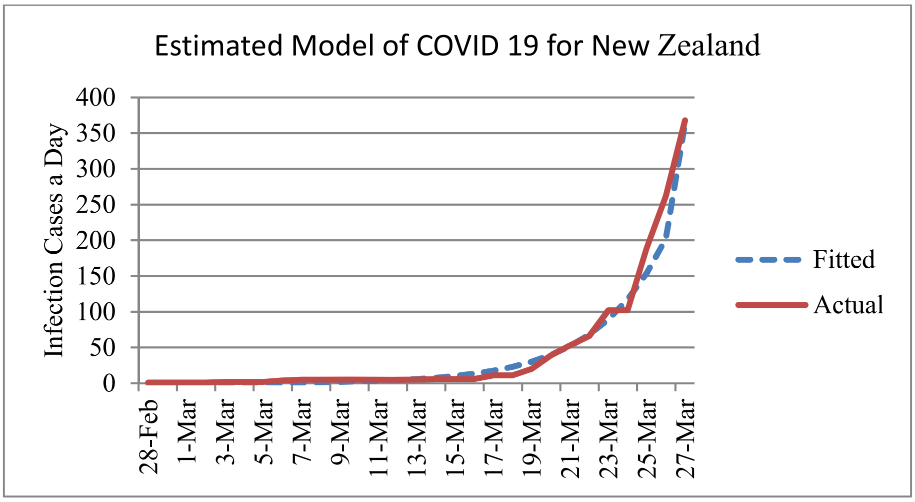


Figure (2)

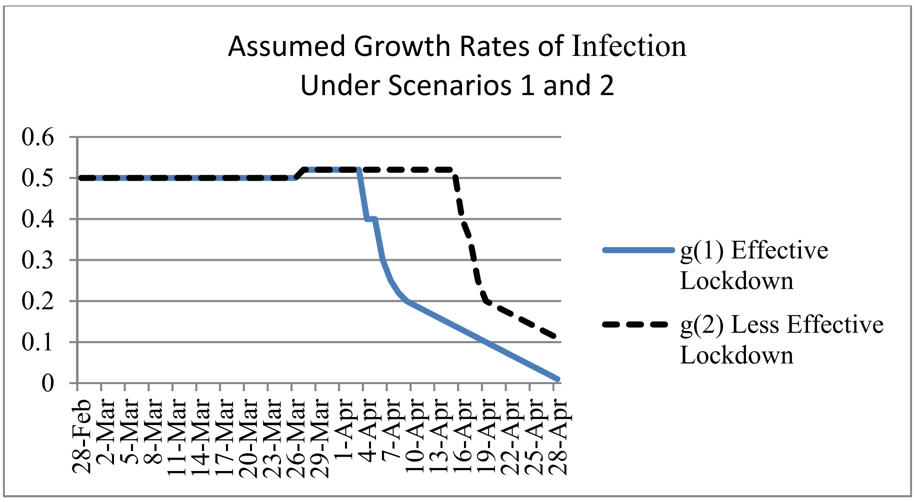


Figure (3)

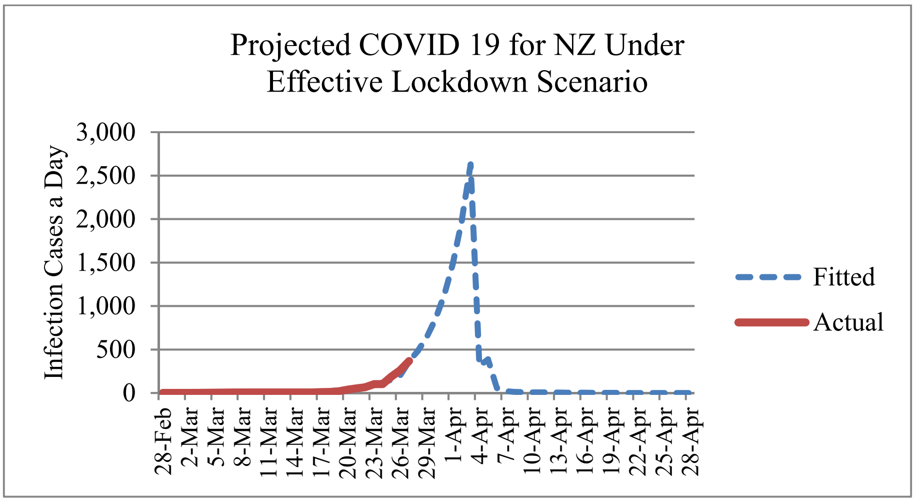
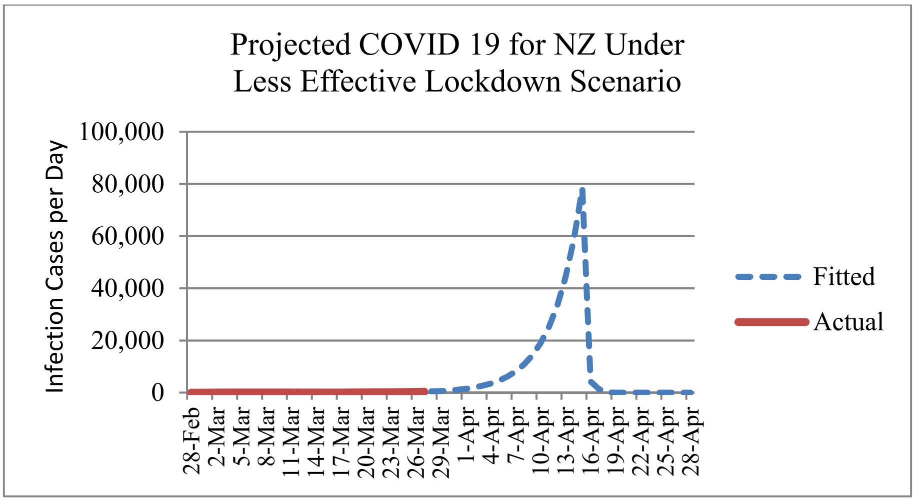


Figure (4)



3. Summary

We model New Zealand's actual COVID 19 infections data from Feb 28 to Mar 27, 2020 using the Sigmoid curve (Gompertz, 1825). We find that under certain parameters, the curve fits the data remarkably well. Then we made projections until the end of April, which is the government announced lockdown target data, under two scenarios. The first scenario is an effective social distancing involving a strict lockdown and the the other is a less effective social distancing regime. The effective lockdown scenario differs from the less effective regime only in that the growth rate of infection is reduced more, and earlier. We find that effective social distancing can reduce infection rates significantly from a peak of 78,203 infection cases to 2,630 cases within two weeks.

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