The Impact of the COVID-19 Epidemic on the U.S. Senior Housing Market—Analysis of Changes in Brookdale's Market Capitalization Based on Smoothing Splines Regression

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Abstract. The U.S. population is aging, with a large portion of the population already entering retirement age. As a result, demand in the senior living industry continues to increase. This article explores the impact of the COVID-19 pandemic on the senior living industry, focusing on changes in market capitalization for industry leader Brookdale. Based on Brookdale's market cap data from 2005 to 2023, smoothing spline regression was used to analyze the impact of the pandemic on the company's market worth. Three different cross-validation methods including ordinary cross-validation (OCV), approximate cross-validation (ACV) and generalized approximate cross-validation (GACV) were tested for regression parameter selection. The study found that ACV provided the best model fit with an R-squared of 0.7181. The results show that Brookdale's market capitalization has experienced a significant decline during the COVID-19 outbreak, and the predicted values are consistent with the actual reduction in Brookdale's market capitalization. Factors contributing to the decline include lower occupancy rates in senior care facilities and the impact of the pandemic on the overall economy. This underscores the likelihood of challenges within the senior living industry during public health emergencies, warning both investors and operators to prepare for potential risks. The employment of the smoothing spline model in this study enhances the precision of market trend representation and facilitates rational decision-making among industry stakeholders.

Keywords: Senior living, Brookdale, smoothing spline, approximate cross-validation.

1. Introduction

As the aging population of American society continues to increase, the demand for elderly care services is bound to increase. According to the U.S. Census Bureau, all baby boomers will be over the age of 65 by 2030, bringing 1 in 5 residents to retirement age [1]. At the same time, net international migration nationwide has continued to decline since 2016 [2], making it impossible for the population structure to be improved through the external environment. At the same time, according to the Centers for Disease Control and Prevention, the average life expectancy in the United States in 2022 is 76.4 years. Due to advances in medical technology and the prevention and control of chronic diseases, it is expected to increase to 85.6 years by 2060 [3]. Therefore, the market for senior living has become increasingly popular in recent years. In 2022, the size of the U.S. senior living market will be US$92.6 billion and is expected to continue to increase at a compound annual growth rate of greater than 5% from 2023 to 2028 [3].

There are three main categories of senior living facilities. First, independent living apartments provide a collective living place for the elderly who do not need medical care and daily care, and arrange community activities, field trips, and shopping excursions. Its main purpose is to provide the elderly with a pleasant and quality life experience. Second, assisted living programs provide daily care services to seniors who do not require full-time care. Services include housing, meals, personal health management, and skilled nursing care. Third, skilled nursing facilities provide 24-hour care for those who can no longer live independently. Specially trained staff assist residents with daily activities from cleaning to eating [4]. As the largest senior living operator and supplier in the United States, Brookdale owns more than 670 senior living communities in 41 states, covering all types of senior living facilities in the industry [5]. Therefore, analyzing Brookdale's market situation can provide guidance for industry trends and future development.

Due to the weak physical fitness of the elderly over 60 years old and the accumulation of past medical conditions, they are naturally more susceptible to infection and severe reactions to epidemic diseases. During the COVID-19 outbreak, people aged 60 and over showed significantly higher infection and mortality rates, while the mortality rate of coronavirus for people over 80 years old reached 14.8% [6]. Places where seniors gather, such as senior living facilities, are more vulnerable to large-scale public health emergencies. Therefore, this article will explore the impact of the outbreak of COVID-19 on the senior living industry by analyzing the market capitalization changes of Brookdale, an industry leader. The impact of public health emergencies on elderly life studied in this article will also be used as a reference factor for the future development of the industry to reasonably adjust growth expectations. At the same time, by analyzing the impact of the pandemic on the company's market value, companies and investors can reasonably allocate assets to avoid related potential financial risks.

2. Data Description

The main data used in this article is Brookdale's market capitalization from 2005 to 2023 from public information on the Internet [7]. The annual market capitalization is calculated based on December 30 of that year. Since it has not yet ended in 2023, the data on June 30 will be used as the market value of that year. Using year-end data to represent the market capitalization for the entire year can avoid large fluctuations in stock prices caused by accidental events in certain months. After a full year of changes in internal and external factors, the stock price can make a reasonable correction and truly reflect the development trend. The formula for calculating market capitalization is the price per share multiplied by the number of shares outstanding. Since market capitalization has a significant positive correlation with investors' decisions, companies with high market capitalization are often able to obtain more financing and gain development advantages [8]. For companies with industry-leading positions such as Brookdale, their market value changes are a benchmark for the overall industry.

3. Methods

Since there are large changes between specific years in the data, to reduce the noise in the data, this study uses smoothing splines to regress market capitalization. The parameters tested for the regression are ordinary cross-validation (OCV), approximate cross-validation (ACV), and generalized approximate cross-validation (GACV).

3.1. Ordinary Cross-Validation

Ordinary Cross-Validation is a basic tool for smoothing data. It divides the data into a certain number of folds and then processes each fold as a data point. The formula for OCV is

$$OCV(\lambda) = \frac{1}{n}\sum_{i=1}^{n}[-y_i\,\eta_\lambda^{(-i)}(x_i) + b(\eta_\lambda(x_i))] \tag{1}$$

Where $\eta_\lambda^{(-i)}$ is the minimizer of $-\sum_{i=1}^{n} l\big(y_i, \eta(x_i)\big) + \frac{\eta\lambda}{2}J(\eta)$ [9]. However, to avoid the huge amount of calculation caused by $\eta_\lambda^{(-i)}$, the OCV formula can be approximated as below [9].

$$OCV(\lambda) \approx L(\lambda) + \frac{1}{n}\sum_{i=1}^{n} \frac{y_i(y_i-\mu_\lambda(x_i))}{\frac{y_i-\mu_\lambda^{(-i)}(x_i)}{\eta_\lambda(x_i)-\mu_\lambda^{(-i)}(x_i)} - b''(\eta_\lambda(x_i))} \tag{2}$$

3.2. Approximate Cross-Validation

To further reduce the computational cost of cross-validation while completing accurate estimation of OCV, approximate cross-validation (ACV) is introduced. To further simplify the complex terms in formula 2, formula 3 is used for replacement [9].

$$\frac{\eta_\lambda(x_i)-\mu_\lambda^{(-i)}(x_i)}{y_i-\mu_\lambda^{(-i)}(x_i)} \simeq h_{ii} \tag{3}$$

Combining formulas 2 and 3, the formula of approximate cross-validation is shown below [9].

$$ACV(\lambda) = \frac{1}{n}\sum_{i=1}^{n}(-y_i\,\eta_\lambda(x_i) + b(\eta_\lambda(x_i))) + \frac{1}{n}\sum_{i=1}^{n}\frac{h_{ii}y_i(y_i-\mu_\lambda(x_i))}{1-h_{ii}b''(\eta_\lambda(x_i))} \tag{4}$$

3.3. Generalized Approximate Cross-Validation

Based on formula 4, generalized approximate cross-validation is obtained by converting h_{ii} into $\frac{tr(H)}{n}$ and replacing $h_{ii}b''(\eta_\lambda(x_i))$ by $tr\left(w^{\frac{1}{2}}Hw^{\frac{1}{2}}\right)/n$ [9]. The formula of GACV is shown below [9].

$$GACV(\lambda) = \frac{1}{n}\sum_{i=1}^{n}(-y_i\,\eta_\lambda(x_i) + b(\eta_\lambda(x_i))) + \frac{tr(H)}{n}\frac{\sum_{i=1}^{n}(y_i-\mu_\lambda(x_i))}{n-tr(w^{1/2}Hw^{1/2})} \tag{5}$$

3.4. Comparison between parameters

By comparing the R-Squared of the models generated by three parameters, this study found that the model using ACV has the highest R-squared of 0.7181, which is significantly higher than the other two parameters' R-squared which are 0.5366 and 0.6201. Therefore, this study chooses ACV as the parameter of the smooth spline because it has the best fit.

Table 1. Comparison between predicted and original data

	OCV	ACV	GACV
R-Squared	0.5366	0.7181	0.6201

4. Results

4.1. Smoothing Spine Results

Figure 1 is the visualization of Brookdale's trend of development based on Brookdale's historical market capitalization data. Figure 1 shows that the company suffered severe market capitalization declines in 2008 and 2015, as well as in 2020. Affected by the economic crisis in 2008, the U.S. stock market plummeted. Referring to the S&P 500's 48% decline in six months [10], Brookdale's decline in market value is in line with the overall market trend and is also caused by the impact of the economic crisis. The continued downward trend after 2015 is due to the company's excessive operating costs after spending $2.6 billion to complete the merger with Emeritus Corporation, another senior living operator, but its revenue has stagnated [11]. The resulting financial pressure caused investors and the market to lower their expectations for Brookdale and reduce investment [12]. The third major decline occurred in 2020, which coincided with the year when COVID-19 began. Therefore, approximate cross-validation was used to perform smoothing spline regression on historical market capitalization data to explore the impact of the outbreak of the pandemic in early 2020 on Brookdale's market capitalization.

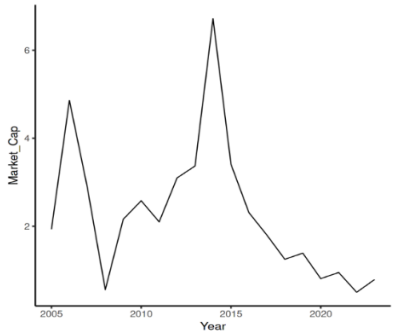

Figure 1. 2005-2023 Brookdale market cap

The R2 of this smooth spline regression is 0.7181, which means that 71.81% of the prediction results can be explained by this regression model, which represents a good model-fitting outcome. Compared with the changes in the original data shown in Fig. 1, the changes in market capitalization in Fig. 2 are more gradual. In particular, the two market capitalization shocks that occurred in 2008 and 2015 became flatter in the predictions of the model but were still in line with the changing trends of the market at that time. The decline in market value in 2020 is still significantly reflected after smoothing spline regression.

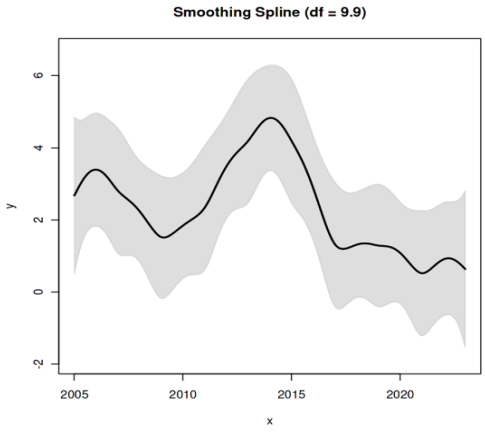

Figure 2. 2005-2023 Brookdale market cap after smoothing spline regression

By comparing the predicted values generated by the regression model with actual data, this study found that in 2019, when the pandemic was about to break out, the original market value of 1.39 billion was slightly higher than the predicted data of 1.29 billion. Since this study uses market capitalization data on December 30th, 2019, and the World Health Organization officially named the novel coronavirus on January 7th [13], this means that Brookdale's market capitalization did not significantly increase before the pandemic spread widely. Signs of decline. When the public health emergency occurred in the United States due to COVID-19 in 2020, the original market value shrank to 0.81 billion, which was far lower than the predicted value of 1.08 billion. In the model predictions for the next three years, the market value was always lower than the 1.39 billion before the outbreak, showing the company's continued sluggish value in the stock market.

Table 2. Comparison between predicted and original data

Year	Market Cap Predicted (Billion Dollar)	Market Cap Original (Billion Dollar)
2023	0.64	0.79
2022	0.91	0.5
2021	0.52	0.95
2020	1.08	0.81
2019	1.29	1.39

4.2. Factors contributing to the decline of Brookdale's market capitalization

First, the decline in senior living facility occupancy rates caused by COVID-19 has severely dampened the overall development of the industry. In the first quarter of 2020, the overall occupancy rate of the industry reached the highest level during the epidemic period at 87.7% [14], but by the second quarter of 2021, it dropped to the lowest point of 77.8% [15]. Brookdale's occupancy rate of 83.5 in the first quarter of 2020 also dropped to 71.2% in the second quarter of 2021 [16, 17]. This shows that the overall decline in facility occupancy rates close to 10% is common in the industry. Since the main income of senior living operators comes from monthly rent and service fees, the significant reduction in occupancy rates has increased their revenue pressure and discouraged outside investment.

Secondly, the slowdown in economic growth and overall stock market decline caused by COVID-19 have also impacted senior living operators such as Brookdale. Global stock markets fell by more

than 10% in response to the EU travel restrictions announced by the United States on March 12, 2020. By March 18, global stock markets had dropped 30% from their peak [18]. According to data predictions in July 2020, the GDP growth of the United States will drop by 6% in the same year and by 2% in 2021 [18]. Due to the outbreak of COVID-19, the stock market and economic development in the United States and around the world have been seriously damaged, causing the senior living industry to be affected by the general environment.

5. Conclusion

This article studies the changes in the market value of Brookdale during the COVID-19 outbreak. By performing smooth spline regression using the ACV formula, this study found that Brookdale's actual capitalization was significantly lower than the model's predicted capitalization in 2020 when COVID-19 broke out, and both the subsequent predicted and actual values were lower than before the outbreak. Therefore, it can be concluded that the outbreak of COVID-19 has caused Brookdale's capitalization to shrink significantly, and the negative impact will persist for a long time.

The smooth spline model used in this article has greatly improved the accuracy of model prediction values. Due to the extreme market value changes in the original data in 2008 and 2015, the ordinary model cannot be accurately fitted. However, after smoothing splines, the changing trend of market capitalization becomes softer because it avoids extreme values and extreme changes, and more accurately reflects the changes in the value of companies in the stock market. According to the trend shown in this model, Brookdale's market value is relatively stable when it does not encounter force majeure factors (economic crisis, public health emergency) and wrong business decisions (merger). This means that the senior living industry has operational and revenue stability. At the same time, this also provides operators and investors with a reference that the industry is relatively vulnerable when encountering public health emergencies. Therefore, it is important to consider these potential risk factors when investing in and operating senior living facilities and to minimize potential risks in advance.

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