CEO Age, Firm Exit, and Zombification amidst the COVID-19 Pandemic*

Kongphop Wongkaew[a,*], Yukiko Umeno Saito[a,b]

[a] *Faculty of Political Science and Economics, Waseda University, 1-104 Totsukamachi, Shinjuku-ku, Tokyo, 169-8050, Japan*
[b] *Research Institute of Economy, Trade and Industry, 1-3-1, Kasumigaseki Chiyoda-ku, Tokyo, 100-8901, Japan*

Abstract

This study investigates the impact of the COVID-19 pandemic on zombification, firm exit, and chief executive officer (CEO) succession, and examines how CEO age moderates these effects. Using the firm-level data of Japanese firms from 2013 to 2021, we discover that the prevalence of zombification increased during the COVID-19 pandemic, as firm performance deteriorated and financial leverage increased. However, the pandemic had a limited impact on firm exit. We also find that the impact of the pandemic on firms varied depending on the age of their CEOs. Firms led by younger CEOs were more likely to increase their long-term borrowing and less likely to exit the market. Conversely, firms led by older CEOs were more likely to exit voluntarily or experience CEO turnover, especially family-owned firms and those in peripheral

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*Corresponding author
Email address: wo.kongphop@toki.waseda.jp (Kongphop Wongkaew)

prefectures.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic has evolved from a public health issue into a major global economic crisis, posing a significant threat to firms' financial positions and business continuity. Using alternative indicators, such as paycheck issuance and phone-tracking data, Crane, Decker, Flaaen, Hamins-Puertolas and Kurz (2022) find that business closures in the U.S. increased in some industries during the first year of the pandemic, especially among small businesses and businesses that were most affected by social distancing measures such as those in the hospitality sector. Muzi, Jolevski, Ueda and Viganola (2023) provide cross-country evidence of the impact of the COVID-19 pandemic on firm survival, using firm-level data collected for 34 economies during the first 18 months of the crisis, and find that less productive firms were more likely to exit.

The COVID-19 pandemic also threatened the global economy through heightened uncertainty. Baker, Bloom, Davis and Terry (2020) develop indicators based on stock market volatility, newspapers, and the survey of business expectations to quantify economic uncertainty in the U.S. economy. They estimate that uncertainty contributed to half of the U.S. economic contraction in the fourth quarter of 2020. Using a Business Plans and Expectations Survey conducted by the Research Institute of Economy, Trade and Industry (RIETI) and the Basic Survey of Japanese Business Structure and Activities conducted by the Ministry of Economy, Trade and Industry (METI), Chen, Senga and Zhang (2021) discover that firms' subjective uncertainty rose substantially following the onset of the COVID-19 pandemic between January and February 2020.

In addition to its adverse effects on firms' financial positions and business continuity, the challenging business environment created by the COVID-19 pandemic

could also influence chief executive officer (CEO) turnover. Although research on the specific impact of the COVID-19 pandemic on CEO turnover is lacking, a large body of the literature shows that the business environment has both direct and indirect effects on the likelihood of CEO turnover. For direct effects, Fee and Hadlock (2004) and Zhang and Rajagopalan (2004) find that challenging and unstable business conditions were associated with a higher probability of external CEO turnover in U.S. firms during the 1990s. For indirect effects, a challenging business environment affects CEO turnover through firm performance. Parrino (1997) and Huson, Parrino and Starks (2001) find a negative correlation between poor performance and forced CEO turnover in large public U.S. firms during the 1970s and 1980s.

Surprisingly, on the other hand, Hong, Ito, Nguyen and Saito (2022) find that firm exit rates declined during this period. They observe that firms with weaker balance sheets were less likely to exit, suggesting that the cleansing mechanism has weakened. On the other hand, they find that firms increased their leverage. These findings highlight the roles of economic and health policies in shaping a firm's financial position and firm dynamics. Hoshi, Kawaguchi and Ueda (2023) document that the Japanese government allocated 3% of its gross domestic product (GDP) to concessional loan programs, while financial institutions provided COVID-19 loans equivalent to 10% of the country's GDP in 2020. The authors find that distressed firms are more likely to receive concessional loans from private sector banks, which are backed by government guarantees, compared to standard loans from the same banks. This suggests that liquidity support measures during the pandemic may have favored non-viable businesses, thereby contributing to zombification.

The COVID-19 pandemic broke out against demographic changes, which influenced business dynamism in Japan. Hong, Ito, Nguyen and Saito (2020) examine the firm-level dataset of Japanese firms between 2007 and 2017 before the pandemic

and find that firms voluntarily exited more in the latest periods shown in the data. Importantly, they find that voluntary exit rates were strongly correlated with CEO age. Their findings are consistent with those of the survey conducted by Small and Medium Enterprises Agency in 2017 that medium-size Japanese firms cite aging and difficulty finding business successors as key reasons for considering business closure. As demographic change is prone to escalate, while the unprecedented health-related economic crises could recur in the near future, it is important to understand how zombification and firm exit decisions change during the health-related economic crisis, depending on the CEO's age profile.

This study investigates the impact of the COVID-19 pandemic on zombification, firm exit, and CEO turnover and appraises how CEO age moderates these effects. We use firm-level data on firm exit, balance sheets, and income statements from 2013 to 2021, including the years of the pandemic.

There is an extensive body of literature examining how firm performance and firm decision-making depend on CEO age. Among others, corporate risk-taking behavior influences firm performance during economic crises. The previous literature posits that CEO age is associated with corporate risk-taking behavior. However, the theoretical literature proposes mixed predictions: Hirshleifer and Thakor (1992) and Holmström (1999) posit that CEO age is positively associated with the degree of risk-taking behavior. Older CEOs have diminished career concerns; Consequently, they are less averse to risk and are more likely to adopt a more proactive approach in making key strategic decisions. However, Hambrick and Mason (1984), Prendergast and Stole (1996), and Malhotra and Harrison (2022) theorize that CEO age is negatively associated with risk-taking behavior. This line of the literature posits that older CEOs have a limited cognitive capacity to deal with uncertainty. Consequently, they are prone to adopting a more cautious approach in key decision-making. The re-

cent empirical literature supports the latter line of the theoretical literature. Serfling (2014) utilises a panel dataset of the S&P 1500 firms from 1992 to 2010 and finds a negative relationship between CEO age and stock return volatility. Furthermore, older CEOs invest in less risky projects, less in research and development, manage firms with diversified operations, and maintain lower leverage. Li, Low and Makhija (2017) analyze the plant-level data from the U.S. Census Bureau and discovered that younger CEOs are more likely to invest in new lines of businesses and divert from existing ones, leading to significant fluctuations in firm size. As the COVID-19 pandemic is likely to adversely affect firm performances and indirectly contribute to uncertainty in business conditions, firm decision-making during the pandemic is likely to depend on CEO age.

Our findings can be summarized as follows: First, we find that the prevalence of zombification increased during the pandemic as firm performance deteriorated and financial leverage increased. However, the pandemic had a limited impact on firm exit. Second, we discover that the impact of the pandemic on firms vary depending on CEO age. Firms led by younger CEOs were more likely to increase long-term borrowing and less likely to exit, possibly due to government liquidity support. In contrast, firms led by older CEOs were more likely to exit voluntarily or experience CEO turnover, especially family-owned firms and those in peripheral prefectures.

Our study directly contributes to two strands of the literature. The first strand focuses on literature the impact of the COVID-19 pandemic on firm zombification and firm exit (e.g., Crane et al. (2022), Kozeniauskas et al. (2022), and Hong et al. (2020)), as well as CEO turnover (e.g., Parrino (1997) and Fee and Hadlock (2004) among others). The second strand of the literature deals with the association between CEO age and firm performance, (e.g. Serfling (2014); Li et al. (2017)).

The remainder of this paper is organized as follows: Section 2 describes the

study's data and measurements. Section 3 explains our empirical strategy. Section 4 presents our regression results, which are divided into four parts: Section 4.1 presents stylized facts, Section 4.2 presents our main findings from the full-sample analysis, Section 4.3 explains the different regression results between core and peripheral prefectures, and Section 4.4 distinguishes the results between family-owned and non-family-owned firms. Finally, Section 5 concludes the paper and discusses the results, as well as the limitations and future research avenues.

2. Data

2.1. Data Description and Measurement

Tokyo Shoko Research (TSR) is a private credit reporting agency that gathers data from listed and unlisted Japanese firms that apply for credit assessments of their own or their potential trading partners. The data enumerate firm identifiers, four-digit JSIC industry, geographic location, and information on firm characteristics. The coverage is the near universe of firms registered in Japan between 2007 and 2021. Despite not encompassing all firms in Japan, the TSR dataset duly represents the Economic Census for Business Activity undertaken by the Statistics Bureau of Japan in terms of the number of employment and geographic location.[1] The TSR data also have strong coverage of small and medium-sized enterprises (SMEs), making up 91% of all firms in the 2017 dataset.[2]

[1]Please refer to Carvalho et al. (2020) for a detailed comparison of the distribution of firm size and geographical location between the TSR dataset and the Economic Census for Business Activity in 2016. The study finds that the largest difference between the TSR and the Economic Census datasets is between micro-enterprises, where the number of employees per firm is less than five.

[2]The METI establishes the distinct criteria for defining SMEs in each industry based on capital value and number of employees. Owing to data availability, we adopt the criteria based on the number of employees. For wholesale and service firms, an SME is one that hires less than 100 employees. For retail firms, an SME hires fewer than 50 persons. For firms in other industries, such

TSR's raw database contains information on approximately one million Japanese firms from all sectors and regions. We restrict our sample to the subset of firms for which we can obtain exit and zombification data, which requires financial statement information. This results in a baseline sample of 2,980,836 observations, or an average of 229,295 firms per year.

The TSR dataset provides monthly information on whether a firm is set to exit. The TSR dataset also reports the mode of exit, namely, bankruptcy (*tosan*), temporary business suspension (*kyugyo*), business closure (*haigyo*), firm dissolution (*kaisan*) and mergers (*gappei*). Given the data availability constraints, we group temporary business suspensions, business closures, and firm dissolution as voluntary exits.

Notably, the TSR dataset provides information on the annual balance sheet and income statement. This dataset contains a detailed breakdown of assets, liabilities, equity, revenue, expense, and profit. We use this information to classify zombie firms. There are at least two zombie classifications that are widely accepted in the literature on the zombification of Japanese firms. First, Caballero, Hoshi and Kashyap (2008) identify zombie firms (zombies henceforth) as firms that receive subsidized credit. Caballero et al. (2008) define firms that receive subsidized credit as the actual interest payment is lower than the minimum required interest payment $I^*_{i,t}$ which is defined as

$$I^*_{i,t} = r^{short}_{t-1} B^{short}_{i,t-1} + \left(\frac{1}{5} \sum_{j=1}^{5} r^{long}_{t-j} \right) B^{long}_{i,t-1} + \min \left(r^{cb}_{t-5}, \cdots, r^{cb}_{t-1} \right) Bonds_{i,t-1}$$

where r^{short}_t and r^{long}_t are the mean value of the short-term prime rate and the long-

as manufacturing, construction, and transportation, an SME hires fewer than 300 persons.

term prime rate over the course of year t. Prime rates were retrieved from the Bank of Japan web-site. $\min\left(r^{cb}_{t-5}, \ldots, r^{cb}_{t-1}\right)$ is the minimum coupon rate observed on any convertible corporate bond issued in the last five years before year t. $B^{short}_{i,t}$, $B^{long}_{i,t}$, and $Bonds_{i,t}$ denote short-term borrowing from banks, long-term borrowing from banks, and total issued amount of corporate bonds of firm i at the end of year t, respectively. Second, Fukuda and Nakamura (2011) extend the approach proposed by Caballero et al. (2008) by adding two conditions regarding profitability and evergreen lending.

Specifically, Fukuda and Nakamura (2011) classify a firm as a zombie if its earnings before interest and tax (EBIT) fall short of the minimum required interest payment, that is, $EBIT_{i,t} < I^{*}_{i,t}$ *and* the firm meets *at least* one of the following financial support criteria: (1) interest payments fall short of the minimum required interest payment, as in Caballero et al. (2008); (2) the firm receives evergreen lending, which is defined as when firms borrow more than last year *and* the total debt at the beginning of the year, $B_{i,t} > B_{i,t-1}$ (the end of last year), is larger than a fifth of total asset at the beginning of the year. The definition posited by Caballero et al. (2008) aptly facilitates the discussion on bank non-performing loan issues and forbearance lending practices in the 1990s but overlooks firm profitability. We adopt the more complete definition proposed by Fukuda and Nakamura (2011) as our primary definition of a zombie firm.[3]

We also utilize other information on firm characteristics. We use the number of employees as a proxy for firm size. We also calculate labor productivity from

[3]Imai (2016) posits an alternative definition for zombie firms. He extends Fukuda and Nakamura (2011) approach to consider a firm's profitability over a longer period of time. His approach helps prevent misclassification owing to temporary fluctuations in a firm's profitability but heavily limits the sample. Given data availability, we exclude the definition of Imai (2016) from our study

the ratio of sales to number of employees. We use the year of establishment to calculate the firm age. Moreover, TSR informs about CEO characteristics, including the CEO's full name and birthday. We use information on the CEO's birthday to calculate the CEO's age. Furthermore, we utilize the CEO's full name and birthday to identify CEO turnover. Specifically, we construct CEO turnover as a dummy variable that takes the value of 1 when the CEO's full name and age are different from the previous period. The TSR dataset covers months during the outbreak of the COVID-19 pandemic. Thus, we can use these data to investigate the evolution of firm performances, firm borrowing, and firm exit during the pandemic.

Table 1 compares the size distribution of the sample in 2016 to the census and full TSR counterparts. Our sample gives lighter weight to small firms with 0-4 employees and distributes weights to medium and large firms, reflecting limited access to the financial statements of small firms. We construct our sample at an annual frequency. The information of year t accounts for the activity between October of year t and September of year $t+1$, or at the end of the period. As the data on firm exit are at a monthly frequency, we define that a firm exit in year t if it exits between October of year t and September of year $t+1$.

	Number of employees									
	0-4	5-9	10-19	20-29	30-49	50-99	100-299	300-999	1000-1999	2000
Census	56.2	17.5	11.8	4.7	3.9	3.0	2.0	0.6	0.1	0.1
Full TSR	49.3	21.6	13.3	4.9	4.2	3.3	2.4	0.8	0.1	0.1
Sample	27.5	22.8	16.5	7.1	6.6	5.9	4.8	1.8	0.3	6.5

Table 1: Comparison of firm size distribution: Economic Census for Business Activity versus the TSR data versus the primary sample

3. Methodology

Our empirical strategy links the outcome variables that measure zombification, firm exit, and CEO turnover, and contrasts the association between outcome variables and CEO age before and during the COVID-19 pandemic. Our regression sample comprises the data from 2013 to 2021. First, we apply a probit model to estimate the following equation:

$$y_{i,t} = G(\beta_1 ceoage_{i,t} + \beta_2 ceoage_{i,t} \times covid_t + \mathbf{x}'_{i,t}\gamma + \alpha_{ind(i)} + \alpha_{pref(i)} + \alpha_{year(t)}) + \varepsilon_{i,t} \quad (1)$$

where i denotes a firm and t is a time index, while $y_{i,t}$ denotes the outcome variable that measures changes in firm performances from t to $t+1$.

We are mainly interested in three groups of variables: zombification, firm exit, and CEO turnover. The first group measures zombification and the criteria variables that classify firms as zombies. It encompasses $zombie_{i,t}$, a dummy for whether a firm i is classified as a zombie in period t; $profitable_{i,t}$, a dummy for whether the EBIT of firm i at time t is positive; $debtrises_{i,t}$, a dummy for whether overall debt increases from the previous period and $intbelowmin_{i,t}$, a dummy for whether firm i in period t pays interest expense lower than the minimum required interest expenses. We go beyond a dummy for an increase in aggregate debt by categorizing debt into short- and long-term loans and construct two dummies: *stloanrises*, a dummy for whether the short-term loans of firm i at period t increase from the previous period, and *ltloanrises*, a dummy for whether the long-term loans of firm i at period t increase from the previous period. The second group measures the indicator of firm exit. It contains $totalexit_{i,t}$, a dummy for whether a firm i exits in period t; $bankruptcy_{i,t}$, a dummy for whether a firm i goes bankrupt in period t, and $voluntaryexit_{i,t}$, a dummy for whether a firm i voluntarily exits in period t. Lastly, we are also interested

in CEO turnover during the COVID-19 pandemic. We measure CEO turnover, $CEOturnover_{i,t}$ as a dummy for whether the name and age of the CEOs of firm i change from the previous period.

On the right-hand side of the equation, $G(\cdot)$ is a cumulative distribution function that satisfies $G(z) \equiv \Phi(z) \equiv \int_{\infty}^{z} \phi(v)dv$, where $\phi(v)$ is the standard normal density; $ceoage_{i,t}$ is the logarithm of CEO age; $covid_t$ is a dummy that takes value 1 for 2019 and 2020, and 0 otherwise; And $\mathbf{x}'_{i,t}$ is a vector of control variables for baseline (log number of employment, labor productivity measured as log of sales per worker, log firm age measured by log of the year of establishment, current ratio measured by the ratio between current assets and current liability, and a dummy for whether a firm reported CEO turnover). We include, in our baseline equation, a set of fixed effects, including two-digit industry fixed effects, $\alpha_{ind(i)}$; prefecture fixed effects, $\alpha_{pref(i)}$; and year fixed effects, $\alpha_{year(i)}$. Lastly, $\varepsilon_{i,t}$ is an error term that is robust against heteroskedasticity.

From Equation 1, we are interested in the partial effects of $ceoage_{i,t}$ on the response probability:

$$\frac{\partial \mathrm{P}(y_{i,t} = 1|ceoage_{i,t}, covid_t, \mathbf{x}'_{i,t})}{\partial ceoage_{i,t}} = g(ceoage_{i,t}, covid_t, \mathbf{x}'_{i,t})(\beta_1 + \beta_2 covid_t).$$

where $g(z) \equiv \frac{\mathrm{d}G}{\mathrm{d}z}(z)$. We evaluate function $g(\cdot)$ at the average values of the independent variables in the sample. β_1 captures the relationship between CEO age and the outcome variables before the COVID-19 outbreak, while $\beta_1 + \beta_2$ captures the relationship between CEO age and outcome variables during the COVID-19 pandemic. The estimated values of $0.01 \times \beta_1$ and $0.01 \times (\beta_1 + \beta_2)$ are the change in the response probability associated with a 1% difference in CEO age before and during the COVID-19 pandemic, respectively.

4. Results

4.1. Stylized Facts

4.1.1. Aggregate Dynamics of Zombification, Firm Exit, and CEO Turnover

We begin with the summary statistics. The first column of Table 2 suggests that the prevalence of zombie firms has increased during the COVID-19 pandemic. The share of zombie firms in our sample trended down from around 27.63% at the end of the Global Financial Crisis (GFC) to a trough of 15.50% in 2018. Nonetheless, the share increased considerably since 2020. The increase in zombie firms was driven by a reduction in profitability and greater financial leverage. On the one hand, Column 2 illustrates that the share of profitable firms fell from 70.95% in 2019 to 60.96% in 2020. On the other hand, Column 3 illustrates that the share of firms seeing greater debt than the previous year increased from 30.73% in 2019 to 39.89% in 2021. The increase in share of firms with greater debt during the COVID-19 pandemic mainly reflects an increase in long-term borrowing. Column 5 suggested that the share of firms showing an increase in long-term borrowing relative to the preceding year rose significantly from 24.24% in 2019 to 38.35% in 2021, as opposed to a falling share of firms showing an increase in short-term borrowing, as reported in Column 4. Column 5 also presents the share of firms paying interest less than the minimum required interest payment, which increased from 26.85% in 2019 to 30.73% in 2021. Our observation might reflect government policy support during the pandemic. Hoshi et al. (2023) reported at least 25 special lending programs in 2020 and estimated that acquired loans would add up to 10% of the GDP. As concessional loans typically last for more than a year, they are classified as long-term borrowing under our criteria.

	(1) $zombie_{i,t}$	(2) $profitable_{i,t}$	(3) $debtrises_{i,t}$	(4) $stloanrises_{i,t}$	(5) $ltloanrises_{i,t}$	(6) $intbelowmin_{i,t}$	(7) $totalexit_{i,t}$	(8) $bankruptcy_{i,t}$	(9) $voluntaryexit_{i,t}$	(10) $CEOturnover_{i,t}$
2009	27.63	59.89	43.23	28.02	39.84	23.82	0.992	0.576	0.181	6.07
2010	26.89	62.20	36.28	26.40	32.19	30.17	0.809	0.405	0.199	5.49
2011	25.86	64.08	35.49	25.47	30.71	32.27	0.649	0.326	0.163	4.95
2012	22.97	67.90	32.04	23.86	27.26	34.68	0.558	0.248	0.163	4.63
2013	21.22	69.62	31.09	23.41	25.86	34.84	0.468	0.188	0.147	4.55
2014	17.03	73.53	30.09	22.08	25.25	31.56	0.407	0.134	0.149	4.24
2015	17.36	70.91	30.25	21.44	25.50	28.60	0.359	0.103	0.140	4.25
2016	16.40	71.15	30.54	21.34	25.48	26.88	0.399	0.105	0.174	4.60
2017	15.66	71.20	29.52	20.85	24.07	26.81	0.377	0.095	0.154	4.54
2018	15.50	70.93	30.14	21.73	23.82	26.49	0.456	0.081	0.219	4.51
2019	15.54	70.95	30.73	21.85	24.24	26.85	0.529	0.092	0.247	4.39
2020	19.87	64.48	35.64	19.08	31.40	26.58	0.535	0.074	0.268	5.03
2021	23.94	60.96	39.89	15.03	38.35	30.73	0.484	0.037	0.263	4.80
Average	20.45	67.52	33.46	22.35	28.77	29.25	0.54	0.19	0.19	4.77

Table 2: Summary statistics

While the prevalence of zombie firms has increased, firm exit rate has been broadly stabilized during the COVID-19 pandemic. Column 7 demonstrates the evolution of the firm exit rate. To keep the definition consistent with that of zombie firms, in this section, we define the firm exit rate in period t as the ratio of the number of firms that exit in period t to the number of firms that exist in period $t-1$. The overall firm exit rate is below 1%. The exit rate declined from 0.99% in 2009 to 0.38% in 2017 but increased slightly to 0.46% in 2018. The decline in firm exit rates from 2009 to 2017 is mainly attributable to the bankruptcy rate, decreasing from 0.58% in 2009 to 0.09% in 2017 (Column 8). On the other hand, voluntary exit, the situation in which owners decide to discontinue their businesses even when they are not forced to to do so for financial reasons, contributed to the upward trend from 2017 to 2019. Column 9 suggests that voluntary exit rates increased from 0.15% in 2017 to 0.25% in 2019. Importantly, despite the decline in profitability, we do not observe that either bankruptcy or voluntary exit rates rose in 2020 and 2021. While the exit rate stabilized, Column 10 illustrated that the CEO turnover rate slightly increased from 4.39% in 2019 to 4.80% in 2021.

4.1.2. CEO Age

In the recent population projection published by The Japan Center for Economic Research, the share of the Japanese population aged 65 years and above is expected to increase from 28.6% in 2020, to 35.8% in 2043[4]. As the population ages, the average CEO age increases. Table 3 reports the full-sample summary statistics for CEO age by year. We winsorized all continuous variables at their 1st and 99th%iles.

[4]Please refer to https://www.jcer.or.jp/english/new-population-projection-how-does-it-differ-from-the-old-one

The average CEO age increased from 58.0 in 2008 to 59.9 in 2020.[5]

We compare the age profiles of CEOs across multiple dimensions to identify any patterns or trends. We discover that CEO age profiles vary according to location and ownership structure. First, we divide the firms into two groups based on their location in the core or peripheral prefectures. Based on the demographic and economic characteristics, we define Saitama, Chiba, Tokyo, Kanagawa, Aichi, Kyoto, Osaka, and Hyogo prefectures as core prefectures. The remaining prefectures are considered peripheral. The average age of CEOs has increased in both core and peripheral prefectures, but CEOs in peripheral prefectures have aged faster. From 2008 to 2020, the average CEO age in the peripheral prefectures increased from 57.9 years to 60.3 years, while the average CEO age in core prefectures increased from 58.0 years to 59.1 years, indicating a difference of 1.1 years.

We also compare the age profiles of CEOs in family-owned and non-family-owned firms. We use the name of the owner written in Chinese characters (Kanji) to identify family-owned firms. We define family-owned firms as firms whose CEO's Kanji surnames match those of at least one of the owners identified in the dataset, irrespective of the size of their stakes. Our definition differs from those of Anderson and Reeb (2003) and Saito (2008), who define family firms as those in which the members of the founder's family take managerial positions in the firm or have any other influences on the firm's decision-making. Table 3 shows that the average age of CEOs in both family-owned and non-family-owned firms increased over the sample period, but family-owned firms aged faster. The average age of CEOs in family-owned firms increased by almost 2%, from 57.78 years in 2008 to 59.72 years in 2020. The average age of CEOs in non-family-owned firms increased by less than 1% over

[5]Figure A.1 summarizes age distribution by year from 2016 to 2020.

the same period.

4.1.3. Zombification, Firm Exit, and CEO Turnover by CEO Age Groups

	Total	By Location		By Ownership	
		Core	Periphery	Family	Non-family
2008	58.03	58.19	57.93	57.78	59.23
2009	58.11	57.98	58.18	57.85	59.15
2010	58.24	58.03	58.35	57.99	59.19
2011	58.46	58.18	58.59	58.22	59.27
2012	58.60	58.18	58.80	58.37	59.21
2013	58.74	58.17	59.00	58.51	59.24
2014	58.89	58.25	59.18	58.65	59.38
2015	59.03	58.36	59.33	58.76	59.50
2016	59.18	58.52	59.48	58.90	59.63
2017	59.39	58.69	59.72	59.12	59.74
2018	59.49	58.83	59.83	59.30	59.86
2019	59.72	58.96	60.10	59.52	60.01
2020	59.92	59.12	60.34	59.72	60.14

Table 3: Summary statistics of CEO ages

Table 4 presents summary statistics for zombification, firm exit, and CEO turnover by CEO age tercile. In each year, we divided the firms into three terciles based on their CEO age distribution, from youngest to oldest. For example, in 2013, the CEO age ranged from 35–55, 56–64, and 65–83 years old. By 2018, the ranges had shifted to 35–55, 56–65, and 66–83 years old. This shows that the CEO age distribution has been gradually shifting to older individuals in the sample period.

Table 4 presents the summary statistics for the key dependent variables of zombification, firm exit, and CEO turnover, disaggregated by CEO age tercile. We constructed three age groups based on the distribution of CEO age for each year. We divided the firms into three terciles based on CEO age distribution each year. For example, in 2013, the CEO age ranges were 35–55, 56–64, and 65–83 years old. In

2018, the ranges were 35–55, 56–65, and 66–83 years old. These ranges show that the CEO age distribution is gradually shifting to the left.

Our findings suggest that firms led by CEOs in the youngest and oldest age terciles are more likely to be zombie firms than those led by CEOs in the middle tercile. However, the underlying causes of zombification differ for firms with younger and older CEOs. Firms led by younger CEOs tend to have higher leverage ratios, while firms led by older CEOs tend to be less profitable but able to better obtain loans at interest rates below the minimum required level.

During the COVID-19 pandemic, the share of zombie firms led by CEOs in the youngest age tercile increased the most, from 17.9% in 2013-2018 to 24.5% thereafter. This increase was accompanied by a sharp rise in debt levels, with 46.9% of firms in the youngest tercile reporting an increase in total debt, up from 36.6%. Additionally, the share of firms in the youngest tercile that paid interest expenses below the minimum required rate increased to 31.3%, approaching the level of firms in the oldest tercile (32.0%). Conversely, firms with CEOs in the oldest age tercile experienced the greatest increase in the probability of exit during the COVID-19 pandemic, from 0.49% in 2013-2018 to 0.64%. This increase was primarily driven by an increase in voluntary exits, from 0.27% in 2013-2018 to 0.43%. Additionally, there was a significant increase in CEO turnover rates, especially in the oldest age tercile. These findings suggest that CEO age may play a significant role in zombification, firm exit, and CEO turnover in Japan, particularly during times of economic uncertainty. The next section will explore this relationship in more detail.[6]

[6]Table A.11 provides summary statistics of control variables by year

4.2. Main results

Table 5 presents the regression results. Column 1 elucidates the determinants of a firm's likelihood of being classified as a zombie. *Panel A* reveals that $ceoage_{i,t}$ is insignificant. However, the interaction term between $ceoage_{i,t}$ and $covid_t$ is negative and highly significant at the 1% level. Given the observed rise in zombie firms during the pandemic, estimation results suggest that firms with younger CEOs are more prone to becoming zombies than those with older CEOs. *Panel B* indicates that the marginal effect of $ceoage_{i,t}$ is insignificant pre-COVID-19 but becomes negative and significant during the pandemic, with a coefficient of -0.0003993 (SE = 0.0000574). This translates to a 0.03993% decline in zombie probability for each year increase in CEO age.

Preiods	Variables	Tercile 1 (Young)		Tercile 2		Tercile 3 (Old)	
		Obs.	Mean	Obs.	Mean	Obs.	Mean
2008-12	$zombie_{i,t+1}$	311,247	25.8	293,562	23.9	267,284	25.9
	$profitable_{i,t+1}$	311,247	66.0	293,562	66.7	267,284	63.8
	$debtrises_{i,t+1}$	311,245	38.8	293,559	34.6	267,284	34.2
	$stloanrises_{i,t+1}$	311,246	26.9	293,559	25.4	267,284	25.5
	$ltloanrises_{i,t+1}$	311,246	34.3	293,562	29.6	267,284	29.8
	$intbelowmin_{i,t+1}$	311,247	32.7	293,562	32.1	267,284	33.5
	$totalexit_{i,t+1}$	312,935	0.56	295,539	0.70	269,084	0.70
	$bankruptcy_{i,t+1}$	312,935	0.35	295,539	0.31	269,084	0.36
	$voluntaryexit_{i,t+1}$	312,935	0.09	295,539	0.16	269,084	0.23
	$CEOturnover_{i,t+1}$	311,359	1.97	293,715	4.37	267,498	8.96
2013-18	$zombie_{i,t+1}$	472,106	17.9	432,864	16.1	415,459	18.0
	$profitable_{i,t+1}$	472,106	73.6	432,864	73.7	415,459	70.2
	$debtrises_{i,t+1}$	472,104	36.6	432,863	30.4	415,459	29.8
	$stloanrises_{i,t+1}$	472,104	24.9	432,863	22.3	415,459	22.2
	$ltloanrises_{i,t+1}$	472,106	30.9	432,864	24.6	415,459	24.1
	$intbelowmin_{i,t+1}$	472,106	29.8	432,864	28.3	415,459	31.1
	$totalexit_{i,t+1}$	473,429	0.29	434,660	0.43	417,448	0.49
	$bankruptcy_{i,t+1}$	473,429	0.10	434,660	0.10	417,448	0.13
	$voluntaryexit_{i,t+1}$	473,429	0.07	434,660	0.15	417,448	0.27
	$CEOturnover_{i,t+1}$	472,190	1.51	433,015	4.06	415,711	7.96
2019-20	$zombie_{i,t+1}$	126,696	24.5	114,655	22.0	117,614	23.8
	$profitable_{i,t+1}$	126,696	65.7	114,655	65.6	117,614	61.7
	$debtrises_{i,t+1}$	126,695	46.9	114,655	39.3	117,614	37.2
	$stloanrises_{i,t+1}$	126,695	19.8	114,655	18.2	117,614	17.7
	$ltloanrises_{i,t+1}$	126,696	44.5	114,655	36.2	117,614	34.0
	$intbelowmin_{i,t+1}$	126,696	31.3	114,655	29.3	117,614	32.0
	$totalexit_{i,t+1}$	127,021	0.27	115,197	0.50	118,338	0.64
	$bankruptcy_{i,t+1}$	127,021	0.06	115,197	0.05	118,338	0.08
	$voluntaryexit_{i,t+1}$	127,021	0.06	115,197	0.18	118,338	0.43
	$CEOturnover_{i,t+1}$	126,682	1.61	114,623	4.61	117,584	8.93

Table 4: Summary statistics by CEO age terciles

Dependent Variable	(1) $zombie_{i,t+1}$	(2) $profitable_{i,t+1}$	(3) $debtrises_{i,t+1}$	(4) $stloanrises_{i,t+1}$	(5) $ltloanrises_{i,t+1}$	(6) $intbelowmin_{i,t+1}$
	A. Estimated Coefficients					
$ceoage_{i,t}$	-0.0000672	-0.00175***	-0.00474***	-0.00160***	-0.00560***	0.00113***
	(0.000172)	(0.000157)	(0.000133)	(0.000152)	(0.000140)	(0.000198)
$ceoage_{i,t} \times covid_t$	-0.00157***	0.000645**	-0.00163***	0.000841***	-0.00179***	-0.000568**
	(0.000269)	(0.000251)	(0.000227)	(0.000262)	(0.000230)	(0.000252)
	B. Marginal Effects					
$covid_t = 0$	-0.0000176	-0.0005657***	-0.001724***	-0.0004696***	-0.0019076***	.0003854***
	(0.0000452)	(0.0000508)	(-0.001724)	(0.000044)	(0.000047)	(0.0000675)
$covid_t = 1$	-0.0003993***	-0.0003511***	-0.0022308***	-0.0002308***	-0.0023821***	0.000189**
	(0.0000574)	(0.0000761)	(0.000064)	(0.0000745)	(0.0000565)	(0.0000886)
Observations	1,496,180	1,496,172	1,496,176	1,496,176	1,496,180	1,496,172
Pseudo R^2	0.0670	0.0737	0.0269	0.0218	0.0336	0.0287
Control Variables	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Prefecture FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Cluster	Firms	Firms	Firms	Firms	Firms	Firms

Notes. This table presents the estimates of the association between the indicators of zombifications (and criteria variables) and CEO age before and during the COVID-19 pandemic. The sample is a subset of firms in the TSR dataset that report balance sheets and firm exit status. The regressors of interest are the age of CEOs and the COVID-19 dummy variable that takes the value of 1 for 2019 and 2020 and 0 otherwise. The covariates included in each model are reported at the bottom of the table. All models contain the following control variables: logarithm of the number of employment, logarithm of labor productivity, logarithm of firm age, current ratio, a dummy for whether a firm reports CEO turnover. All models are controlled for two-digit JSIC industry fixed effects, prefecture fixed effects and year fixed effects. The standard errors clustered by firm are in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Table 5: Regression results: Zombification, 2013–20

The rise in zombies during the COVID-19 pandemic was driven by unprofitability and increased financial leverage. In Column 2, $ceoage_{i,t}$ is negative and statistically significant, suggesting that younger CEOs are more likely to lead profitable firms prior to the pandemic. The interaction term with $covid_t$ is moderately significant at the 5% level, indicating that Covid-19 adversely affects the profitability of firms led by younger more than those led by older CEOs. Column 3 shows that $ceoage_{i,t}$ is negative and significant, suggesting that firms led by younger CEOs are more likely to experience an increase in debt level before the COVID-19 pandemic. Importantly, the interaction term between $ceoage_{i,t}$ and $covid_t$ is also negative and significant, indicating that the probability of firms led by younger CEOs showing a rise in debt goes up more than firms led by older CEOs during the COVID-19 pandemic.

Previous sections reveal that the increase in financial leverage is primarily attributable to long-term loans. Columns 4 and 5 show that the interaction term between $ceoage_{i,t}$ and $covid_t$ is negatively correlated with long-term borrowing but positively with short-term borrowing, inferring that younger CEOs are more likely to opt for long-term financial leverage. Finally, Column 6 reports that $ceoage_{i,t}$ is positive and significant, suggesting an increase in the probability of a firm paying interest expenses under the minimum required level with increasing CEO age. However, this relationship attenuates during the pandemic, implying that younger CEOs have a higher likelihood of paying interest expenses below the minimum required interest expenses.

Table 6 reports regression results for firm exit and CEO turnover. The first column shows the results with respect to the overall exit rate. In *Panel A*, $ceoage_{i,t}$ and the interaction term between $ceoage_{i,t}$ and $covid_t$ are both positive and statistically significant. *Panel B* further shows the positive and significant marginal effects of $ceoage_{i,t}$ on firm exit before and during the COVID-19 pandemic. Notably,

Dependent Variable	(1) $totalexit_{i,t+1}$	(2) $bankruptcy_{i,t+1}$	(3) $voluntaryexit_{i,t+1}$	(4) $CEOturnover_{i,t+1}$
	A. Estimated Coefficients			
$ceoage_{i,t}$	0.00916***	0.00456***	0.0143***	0.0362***
	(0.000469)	(0.000792)	(0.000744)	(0.000253)
$ceoage_{i,t} \times covid_t$	0.00446***	0.00223	0.00564***	0.00125***
	(0.000934)	(0.00216)	(0.00137)	(0.000483)
	B. Marginal Effects			
$covid_t = 0$	0.0000935***	0.0000157***	0.0000563***	0.0031533***
	(0.00000)	(0.00000)	(.00000)	(.0000468)
$covid_t = 1$	0.0002761***	0.0000348	0.0002011***	0.0036732***
	(0.0000473)	(0.0000216)	(.0000474)	(0.0001666)
Observations	1,501,189	1,474,627	1,494,605	1,496,553
Pseudo R^2	0.0296	0.0279	0.118	0.0983
Control Variables	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓
Prefecture FE	✓	✓	✓	✓
Year FE	✓	✓	✓	✓
Cluster	Firms	Firms	Firms	Firms

Notes. This table presents the estimates of the association between the indicators of firm exit/CEO turnover and CEO age before and during the COVID-19 pandemic. The sample is a subset of firms in the TSR dataset that report balance sheets and firm exit status. The regressors of interest are logarithm of the age of CEOs and the COVID-19 dummy variable that takes the value of 1 for 2019 and 2020 and 0 otherwise. The covariates included in each model are reported at the bottom of the table. All models contain the following control variables: logarithm of the number of employment, logarithm of labor productivity, logarithm of firm age, current ratio, a dummy for whether a firm reported CEO turnover. All models are controlled for two-digit JSIC industry fixed effects, prefecture fixed effects and year fixed effects. The standard errors clustered by firm are in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6: Regression results: firm exit and CEO turnover, 2013–20

the marginal effects during the COVID-19 pandemic are estimated to be 0.0002761 (SE = 0.0000473), almost triple the estimated marginal effects before the COVID-19 pandemic. The estimates indicate that a year increase in the age of CEOs is associated with a 0.02761% increase in the probability of exit. As we observe that the overall exit rate during the COVID-19 pandemic is broadly unchanged from the pre-COVID-19 levels, the results indicate that the probability of exit of firms run by older CEOs increases more than those run by their younger counterparts.

The association between firm exit and CEO age is caused by voluntary exit. Comparing regression results in Columns 2 and 3 of Panel A, we find that $ceoage_{i,t}$ is positively associated with bankruptcy and voluntary exit rate before the COVID-19 pandemic. During the COVID-19 pandemic, the association between voluntary exit and CEO age strengthens, while the positive relationship between bankruptcy and CEO age disappears. Column 3 suggests that, during the COVID-19 pandemic, the marginal effects of CEO age on voluntary exit increase almost fourfold from 0.0000563 (SE = 0.00000) before the COVID-19 pandemic to 0.000201 (SE = 0.0000474) during the COVID-19 pandemic. These estimates suggest that a yearly increase in the age of CEO is associated with a 0.0201% increase in the probability of voluntary exit. On the other hand, the marginal effects of CEO age on bankruptcy during the COVID-19 pandemic are insignificant.

Table 6 also reports the effects of the COVID-19 pandemic on the relationship between CEO age and CEO turnover in the following year. $ceoage_{i,t}$ is positive and significant, suggesting that firms run by older CEOs are more likely to experience CEO turnover. The estimated coefficient of the interaction between $ceoage_{i,t}$ and $covid_t$ dummy is also positive and significant. In *Panel B*, we estimate the marginal effects of CEO age on CEO turnover before and during the COVID-19 pandemic. During the pandemic, a yearly increase in CEO age corresponds to a 0.37% increase in the likelihood of CEO turnover. As the overall CEO turnover rate increases during the COVID-19 pandemic, the results indicate that the chance of an older CEO leaving their job increases more during the pandemic than the chance of a younger CEO leaving their job.

4.3. COVID-19 Effects in Core and Peripheral Prefectures

In this section, we investigate the differential impact of the COVID-19 pandemic on zombification, firm exit, and CEO turnover and how the age of the CEO moderates these effects between firms in core and peripheral prefectures. We begin with stylized facts. Table 7 shows that zombie shares in peripheral prefectures are higher than those in core prefectures throughout the sample period. During the COVID-19 pandemic, the zombie share of firms in core prefectures increased by 8.7 percentage points, from 13.1% in 2019 to 21.8% in 2021. The zombie share of firms in peripheral prefectures increased by 8.2 percentage points, from 16.8% in 2019 to 25.0% in 2021. The size of the increase in the zombie share of firms was comparable between core and peripheral prefectures. The voluntary exit rates in core and peripheral prefectures were broadly similar until 2017. Voluntary exit rates in peripheral prefectures have steadily increased from 2018 to 2019, while the voluntary exit rates in the core prefectures have remained relatively stable. There is no evidence of a significant increase in the voluntary exit rates of firms in either core or peripheral prefectures during the COVID-19 pandemic. In contrast to zombie shares and voluntary exit rates, CEO turnover rates were consistently higher in core prefectures than in peripheral prefectures; CEO turnover rates in both areas did not increase significantly during the 2020-21 period.

The estimation results for the zombification equations suggest that firms in core and peripheral prefectures exhibit comparable results, which are close to the aggregate results. The coefficient on $ceoage_{i,t}$ is statistically insignificant. However, the interaction term between $ceoage_{i,t}$ and $covid_t$ is negative and significant at the 5% significance level. This implies that during the COVID-19 pandemic, core and peripheral firms led by younger CEOs are more likely to become zombies than their older counterparts. For voluntary exit, the coefficient on $ceoage_{i,t}$ is positive and

Year	$zombie_{i,t+1}$		$voluntaryexit_{i,t+1}$		$CEOturnover_{i,t+1}$	
	Core	Peripheral	Core	Peripheral	Core	Peripheral
2008	24.78	29.29	0.149	0.200	7.66	5.15
2009	24.39	28.24	0.203	0.197	7.11	4.62
2010	24.00	26.80	0.140	0.174	6.47	4.18
2011	21.74	23.56	0.160	0.164	6.22	3.88
2012	20.52	21.56	0.140	0.150	6.05	3.82
2013	16.22	17.41	0.139	0.154	5.54	3.64
2014	15.73	18.10	0.098	0.159	5.55	3.66
2015	14.41	17.31	0.149	0.185	5.97	3.97
2016	13.49	16.69	0.118	0.171	5.70	4.00
2017	13.40	16.53	0.174	0.240	5.52	4.02
2018	13.09	16.82	0.175	0.285	5.30	3.91
2019	18.11	20.78	0.197	0.304	5.88	4.59
2020	21.83	25.04	0.190	0.301	5.65	4.36

Table 7: Summary Statistics by Location

statistically significant for firms in both core and peripheral prefectures. However, the interaction term between $ceoage_{i,t}$ and $covid_t$ is insignificant for firms in core prefectures but positive and significant for firms in peripheral prefectures. The estimated coefficient of the interaction term in core prefectures was considerably larger than that in peripheral prefectures. These regression results imply that the higher rate of voluntary exits among firms led by older CEOs is mainly driven by firms in peripheral prefectures. In contrast to the findings on voluntary exit, there is no evidence that the COVID-19 pandemic has changed the relationship between CEO age and probability of CEO turnover in both core and peripheral prefectures. CEO age is positive and significant, while the interaction term between CEO age and the COVID-19 pandemic is insignificant. The size of the coefficients is comparable between core and peripheral prefectures.

Dependent Variable	$zombie_{i,t+1}$		$voluntaryexit_{i,t+1}$		$CEOturnover_{i,t+1}$	
	Core	Peripheral	Core	Peripheral	Core	Peripheral
$ceoage_{i,t}$	-0.000246	-0.0000744	0.0151***	0.0141***	0.0333***	0.0381***
	(0.000302)	(0.000210)	(0.00150)	(0.000860)	(0.000403)	(0.000327)
$ceoage_{i,t} \times covid_t$	-0.00172**	-0.00130**	0.00269	0.00689***	0.00142*	0.000957
	(0.000484)	(0.000323)	(0.00269)	(0.00159)	(0.000782)	(0.000668)
Observation	481,664	1,014,487	469,904	1,002,128	481,778	1,014,764
Pseudo R^2	0.0714	0.0641	0.117	0.118	0.0933	0.100
Control Variables	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Prefecture FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Cluster	Firms	Firms	Firms	Firms	Firms	Firms

Notes. This table presents the estimates of the association between the indicators of zombifications, voluntary exits, and CEO turnover, and CEO age before and during the COVID-19 pandemic by location (core and peripheral prefectures). The sample is a subset of firms in the TSR dataset that report balance sheets and firm exit status. The regressors of interest are the age of CEOs and the COVID-19 dummy variable that takes the value of 1 for 2019 and 2020 and 0 otherwise. The covariates included in each model are reported at the bottom of the table. All models contain the following control variables: logarithm of the number of employment, logarithm of labour productivity, logarithm of firm age, current ratio, a dummy for whether a firm reported CEO turnover. All models are controlled for two-digit JSIC industry fixed effects, prefecture fixed effects and year fixed effects. The standard errors clustered by firm are in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Table 8: Regression results: core and peripheral prefectures, 2013–20

4.4. COVID-19 Effects on Family-owned Firms

In this section, we examine how the COVID-19 pandemic affects zombification, firm exit, and CEO turnover differently in family-owned and non-family-owned firms and how CEO age influences these effects. Table 9 shows the zombie shares among family-owned and non-family-owned firms. Before the COVID-19 pandemic, both types of firms experienced a decline in zombie shares. However, in 2020 and 2021, the zombie share increased significantly, especially for family-owned firms, which increased from 18.4% in 2019 to 28.6% in 2020, representing a record increase of 10.2 percentage points. Notably, the zombie share of family-owned firms returned to the levels observed between 2009 and 2010 after the GFC. Next, we examine the voluntary exit rates of family-owned and non-family-owned firms. Before the COVID-19 pandemic in 2020, the exit rates of family-owned firms stabilized, while those of non-family-owned firms gradually decreased. While the voluntary exit rates of non-family-owned firms stabilized in 2018, those of family-owned firms increased to 0.21% from 0.19% in 2017. Because family-owned firms are more likely to have difficulty finding successors to the CEO position than non-family-owned firms, this evidence possibly supports the hypothesis of Hong et al. (2020) that voluntary exits increase because older CEOs often fail to find suitable successors. We do not observe any significant increase in the voluntary exit rates of either family-owned or non-family-owned firms during the COVID-19 pandemic.

Table 10 reports the regression results. The coefficient of $ceoage_{i,t}$ is insignificant, suggesting that CEO age is not associated with the zombie shares of family-owned firms before the COVID-19 pandemic. However, the interaction term between $ceoage_{i,t}$ and $covid_t$ is negative and statistically significant, indicating that family-owned firms led by young CEOs are more likely to become zombie firms during the pandemic. In contrast, the interaction term between $ceoage_{i,t}$ and $covid_t$ is in-

year	$zombie_{i,t+1}$		$voluntaryexit_{i,t+1}$		$CEOturnover_{i,t+1}$	
	Family	Non-family	Family	Non-family	Family	Non-family
2008	30.74	15.91	0.140	0.432	4.32	17.86
2009	30.47	13.97	0.171	0.434	4.08	15.98
2010	30.76	13.23	0.145	0.287	3.81	15.54
2011	27.99	12.54	0.153	0.298	3.75	14.86
2012	25.74	12.03	0.134	0.302	3.70	14.94
2013	20.57	9.63	0.137	0.279	3.50	13.81
2014	21.10	9.13	0.133	0.189	3.56	13.38
2015	19.89	8.38	0.154	0.247	3.74	14.24
2016	19.17	8.15	0.141	0.206	3.72	13.74
2017	18.95	8.16	0.199	0.210	3.67	13.31
2018	18.38	8.39	0.211	0.181	3.42	12.30
2019	23.72	11.04	0.226	0.260	4.02	13.72
2020	28.60	12.86	0.208	0.225	3.63	13.42

Table 9: Summary Statistics by Ownership

significant for non-family-owned firms. For voluntary exit, the coefficient on *ceo_age* was positive, indicating that family-owned firms led by older CEOs were more likely to exit voluntarily before the COVID-19 pandemic. The interaction term between *ceo_age* and *covid* is likewise positive. Because the voluntary exit rate remains unchanged during the COVID-19 pandemic, the regression results suggest that family-owned firms with older CEOs are more likely to exit voluntarily, while their younger counterparts are less likely to exit voluntarily during the pandemic. This pattern is not observed among non-family-owned firms.

The regression results of CEO turnover mirror those of voluntary exit. The coefficient on *ceo_age* is estimated to be positive, suggesting that family-owned firms led by older CEOs are more likely to undergo a CEO change before the COVID-19 pandemic. The interaction term between *ceo_age* and *covid* was also positive and significant. As the rate at which a firm undergoes CEO change was stable during the COVID-19 pandemic, the regression results imply that the likelihood that family-

owned firms led by older CEOs undergo CEO changes increases further compared to younger counterparts. Overall, the regression results suggest that the estimated impact of the COVID-19 pandemic on the relationship between CEO ages and firm outcomes (zombification, firm exit, and CEO turnover) is driven mainly by family-owned firms.

Dependent Variable	$zombie_{i,t+1}$		$voluntaryexit_{i,t+1}$		$CEOturnover_{i,t+1}$	
	Family	Non-family	Family	Non-family	Family	Non-family
$ceoage_{i,t}$	-0.0000862	-0.00699***	0.0160***	0.00632***	0.0398***	0.0261***
	(0.000184)	(0.000750)	(0.000878)	(0.00210)	(0.000304)	(0.000625)
$ceoage_{i,t} \times covid_t$	-0.00135***	0.000993	0.00565***	0.00214	0.00219***	-0.00137
	(0.000291)	(0.00110)	(0.00160)	(0.00417)	(0.000609)	(0.00113)
Observation	1,225,430	165,305	1,220,094	151,353	1,225,671	165,351
Pseudo R^2	0.0607	0.0859	0.135	0.122	0.0989	0.0479
Control Variables	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Prefecture FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Cluster	Firms	Firms	Firms	Firms	Firms	Firms

Notes. This table presents the estimates of the association between the indicators of zombifications, voluntary exits, and CEO turnover, and CEO age before and during the COVID-19 pandemic by type of business (family-owned and non-family-owned). The sample is a subset of firms in the TSR dataset that report balance sheets and firm exit status. The regressors of interest are the age of CEOs and the COVID-19 dummy variable that takes the value of 1 for 2019 and 2020 and 0 otherwise. The covariates included in each model are reported at the bottom of the table. All models contain the following control variables: logarithm of the number of employment, logarithm of labor productivity, logarithm of firm age, current ratio, a dummy for whether a firm reported CEO turnover. All models are controlled for two-digit JSIC industry fixed effects, prefecture fixed effects and year fixed effects. The standard errors clustered by firm are in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Table 10: Regression results: Family-owned and non-family-owned firms, 2013–20

5. Conclusion

In this study, we investigate the role of CEO age profiles in determining the impact of the COVID-19 pandemic on zombification, firm exit, and CEO turnover using a panel dataset of Japanese firms. We find that zombification increased during the pandemic as leverage increased, possibly due to government lending support. Firms led by younger CEOs were the main drivers of this increase. Conversely, firms led by older CEOs were more likely to exit voluntarily or experience CEO turnover, especially family-owned firms in peripheral prefectures.

A plausible interpretation of these findings is that older CEOs may be more likely to retire or step down during times of economic uncertainty. This may be attributed to factors, such as older CEOs being more risk-averse or having limited physical and mental capacity to manage crises. Additionally, older CEOs may be more likely to have difficulty adapting to new technologies or business models. The contribution of these underlying factors to zombification, firm exit, and CEO turnover deserves further exploration.

The long-term implications of increased leverage during the COVID-19 pandemic on productivity and economic growth represent another promising area for future research. It remains to be determined whether firms, particularly those led by younger CEOs, will be able to recover from the pandemic, become viable as the economy resumes normal operations, and contribute to aggregate productivity growth in the long term. However, the limited post-COVID-19 data currently available restricts our ability to answer these questions definitively. Therefore, we leave this topic for future research.

Despite the limitations of our study, our findings have important implications for policymakers. By understanding the factors that make firms more vulnerable to

economic crises, policymakers can develop targeted support programs to help these firms weather difficult times. In the long term, our findings suggest that policymakers should focus on developing solutions to voluntary exits and CEO turnover, especially for family firms in peripheral prefectures. As Hong et al. (2020) show, voluntary exits owing to the difficulty of finding a suitable successor can have a negative impact on partners, thereby creating a ripple effect throughout the firm network. Our study provides a foundation for future policy research and recommendations on this topic.

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Appendix A. Supplementary Figures and Tables

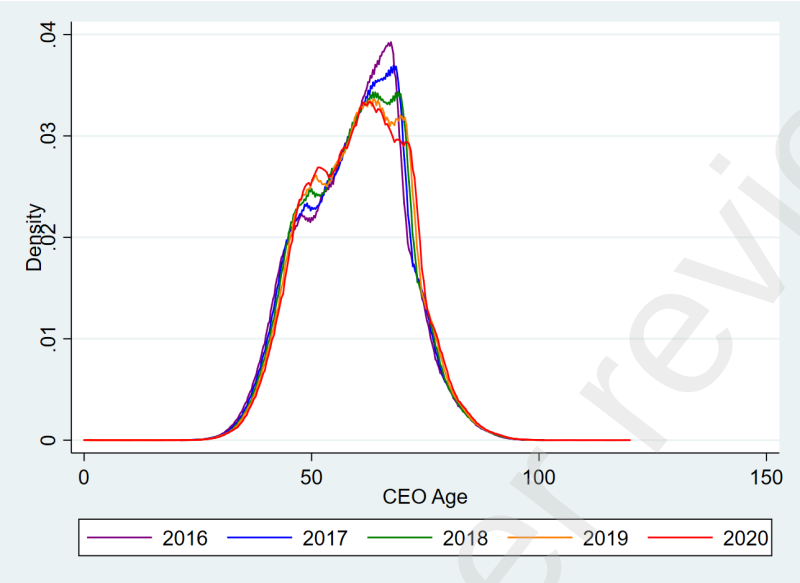

Figure A.1: CEO age distribution by year

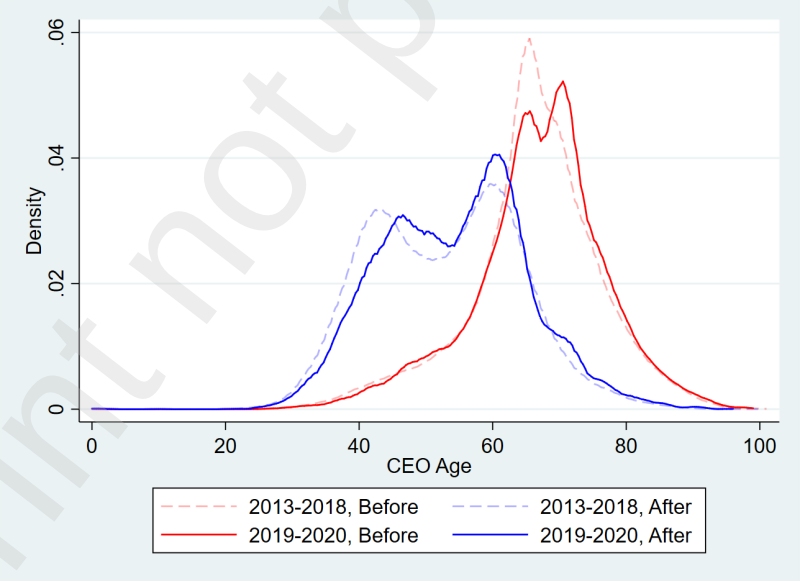

Figure A.2: CEO age distribution before and after CEO turnover

Year	Sales (Million JPY)	Sales per employment (Million JPY)	Employment	Firm age	Current ratio
2008	5.899	0.053	73.579	31.386	0.630
2009	4.983	0.048	69.926	30.937	0.619
2010	3.689	0.040	62.695	29.934	0.619
2011	3.280	0.038	56.017	29.500	0.623
2012	2.885	0.037	49.469	29.401	0.631
2013	2.743	0.037	47.591	29.619	0.634
2014	2.840	0.039	47.125	29.910	0.638
2015	3.075	0.041	50.773	30.595	0.636
2016	3.090	0.041	52.851	30.965	0.633
2017	3.089	0.041	54.663	31.507	0.634
2018	3.558	0.044	58.946	32.477	0.634
2019	3.711	0.046	60.714	32.590	0.634
2020	3.493	0.044	59.864	32.988	0.639
Total	3.413	0.042	55.923	30.898	0.632

Table A.11: Mean of control variables by year

Appendix B. Other CEO Characteristics

In this section, we explore the role of CEO gender in determining the probability of firms becoming zombies, exiting voluntarily, or experiencing CEO turnover. We define the variable $ceosex_{i,t}$ for CEO gender which takes the value of 1 if a CEO is male and 0 otherwise. Columns 1, 3, and 5 of Table B.12 show the regression results where we use CEO gender and the interaction term between CEO gender and the COVID-19 dummy as the explanatory variables without controlling for CEO ages. In Columns 2, 4, and 6, we control for both CEO gender and CEO age.

Before the COVID-19 pandemic, Columns 5 and 6 suggest that $ceosex_{i,t}$ is negative and statistically significant against $CEOturnover_{i,t+1}$. The estimated coefficient is robust to controlling for $ceoage_{i,t}$. These results indicate that female CEOs are more likely to experience CEO turnover than male CEOs before the COVID-19 pandemic. We do not find any other robust evidence that $ceosex_{i,t}$ is associated with

zombification or voluntary exits before the pandemic.

During the COVID-19 pandemic, Column 1 suggests that the interaction term between $ceosex_{i,t}$ and $covid_t$ is positive and significant, indicating that male CEOs are more likely to be zombies during the COVID-19 pandemic. Our results are fairly robust when controlling for CEO age, as Column 2 suggests that the estimated coefficients on the interaction term between $ceosex_{i,t}$ and $covid_t$ remains statistically significant at the 5% level, while the size of the coefficient does not change much. We find no other robust evidence that the association between $ceosex_{i,t}$ and other firm outcomes (voluntary exit and CEO turnover) changes during the COVID-19 pandemic.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	$zombie_{i,t+1}$		$voluntaryexit_{i,t+1}$		$CEOturnover_{i,t+1}$	
$ceosex_{i,t}$	-0.0207**	-0.0107	-0.0246	-0.0109	-0.174***	-0.123***
	(0.00877)	(0.00935)	(0.0331)	(0.0371)	(0.00943)	(0.0112)
$ceosex_{i,t} \times covid_t$	0.0467***	0.0328**	0.0425	0.127	0.0262	0.0338
	(0.0133)	(0.0150)	(0.0597)	(0.0771)	(0.0185)	(0.0225)
$ceoage_{i,t}$		-0.0000757		0.0143***		0.0361***
		(0.000172)		(0.000747)		(0.000254)
$ceoage_{i,t} \times covid_t$		-0.00155***		0.00576***		0.00128***
		(0.000269)		(0.00137)		(0.000484)
N	1,673,222	1,496,180	1,675,223	1,494,605	1,673,613	1,496,553
Pseudo R^2	0.0712	0.0670	0.0973	0.118	0.0378	0.0986
Control Variables	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Prefecture FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Cluster	Firms	Firms	Firms	Firms	Firms	Firms

Notes. This table presents the estimates of the association between firm outcomes (zombifications, firm exit, and CEO succession) and CEO gender before and during the COVID-19 pandemic. The sample is a subset of firms in the TSR dataset that report balance sheets and firm exit status. The regressors of interest are the logarithm of the age of CEOs and the Covid-19 dummy variable that takes the value of 1 for 2019 and 2020 and 0 otherwise. The covariates included in each model are reported at the bottom of the table. All models contain the following control variables: logarithm of the number of employment, logarithm of labor productivity, logarithm of firm age, current ratio, a dummy for whether a firm reported CEO turnover. All models are controlled for two-digit JSIC industry fixed effects, prefecture fixed effects and year fixed effects. The standard errors clustered by firm are in parentheses. $*$, $**$, and $***$ denote significance at the 10%, 5%, and 1% levels, respectively.

Table B.12: Association between firm outcomes and CEO gender before and during the COVID-19 pandemic, 2013–20