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# Impacts of the COVID–19 Pandemic on the Financial Characteristics of Corporations in the Agri–food Supply Chain in Japan

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This study investigated the impact of the COVID–19 pandemic on the agri–food supply chain in Japan in terms of firms' financial characteristics, focusing on profitability, safety, and productivity–related indicators. We used the dataset of TKC Management Indicators (BAST) (Summary Version) from 2019 to 2021. The agri–food supply chain industries we focus on are "Agriculture," "Manufacture of food," "Wholesale trade (food and beverages)," "Retail trade (food and beverages)," "Eating and drinking places," and "Food take–out and delivery services." The results revealed that during the COVID–19 pandemic, "Agriculture" had high profitability and safety in the agri–food supply chain, making it the most resilient during the pandemic. Based on these results, we identified potential factors that affected profitability and safety in "Dairy cattle farming" during the pandemic: government support policies and a decline in beef consumption due to a drop in inbound demand. In addition, for "Rice farming," we identified government policy support, such as subsidies, and high value–added through direct sales to consumers.

**Key words**: agri–food, COVID–19, financial characteristics, supply chain

## INTRODUCTION

Coronavirus disease 2019 (COVID–19) was recognized by the World Health Organization (WHO) as a severely contagious disease that presented unprecedented health and economic challenges worldwide. By the end of November 2022, over 600 million cases and 6 million fatalities had been confirmed in more than 200 countries (WHO, 2022). Many countries and cities implemented prevention policies, such as stay–at–home orders and social lockdowns, to control the spread of the COVID–19 virus. These policies threatened the continuity of all companies' activities, from listed companies (Rababah *et al.*, 2020) to small and medium–sized enterprises (SMEs) (Kalemli–Ozcan *et al.*, 2020).

In Japan, the first COVID–19 case was confirmed on January 16, 2020. By the end of February, multiple cases of COVID–19 had been identified nationwide. An increase in the daily number of newly reported cases was observed in late February 2020, and to prevent and mitigate COVID–19, the Japanese government temporarily closed all elementary, junior high, and high schools at the end of February. Exponential growth in the daily number of newly reported cases started in late March, and the Japanese government declared a state of emergency on April 7, 2020. Subsequently, the daily number of newly reported cases decreased, and the state of emergency was lifted on May 25, 2020. Under this declaration, people were restricted from going out and were encouraged to stay at home, and many stores were forced to close. The COVID–19 pandemic devastated a wide range of industries worldwide and in Japan, including the tourism industry (Kitamura *et al.*, 2020) and the restaurant and hotel industry. Nevertheless, few studies have clarified the impact of COVID–19 on the agri–food industry relative to that on other domestic industries, which is a vital undertaking. Therefore, this study investigates the impact of the COVID–19 pandemic on the agri–food supply chain in Japan from the perspective of firms' financial characteristics.

The remainder of this paper proceeds as follows. Section 2 reviews the literature. In Section 3, we introduce our data and research methods. Section 4 presents the results and a discussion. Section 5 concludes with a summary of the findings.

## LITERATURE REVIEW

There is extensive literature on the impact of the COVID–19 shock. The state of agricultural food markets and supply chains during the COVID–19 pandemic has been evaluated mostly with respect to demand shocks and supply channel disruptions. The immediate impacts are tied primarily to price changes (Erol & Saghaian, 2022; Liu & Rabinowitz, 2021), changes in consumer purchasing behavior and food storage (Chang & Meyerhoefer, 2021; Wang *et al.*, 2020), changes in consumer eating habits (Chenarides *et al.*, 2021; Sasaki *et al.*, 2022), and consumers' perceived risk of the COVID–19 pandemic (Chen & Wang, 2022; Yenerall *et al.*, 2022).

Much research has been conducted on the impact of COVID–19 on the agri–food supply chain. Chen and Yang (2021) found that in China, the COVID–19 pandemic reduced the sales of agri–food products, and the sales of agri–food products by large agricultural companies had fallen more than those of SMEs. Hobbs (2020) showed that the pandemic's impact depends on the type of products and the size of the initiatives in Canada. Hobbs (2021) examined changes in the agri–food supply

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chains in Canada and the United States due to the COVID–19 pandemic. The food supply chains generally performed well, but COVID–19 outbreaks among workers in meat processing and fruit and vegetable production created disruptions. The study discussed the resilience of supply chains, and concluded that they could be enhanced by investments in adaptability and flexibility. Boughton *et al*. (2021) indicated that the agri–food system in Myanmar had considerable resilience in response to initial disruptions; however, persistent financial stress for a high proportion of households and agri–food system businesses indicated that the road to full recovery would take time. Hailu (2021) found that the food–processing sector in Canada was relatively stable during the COVID–19 pandemic as food was still processed and delivered to consumers. Hayes *et al*. (2021) analyzed the impact of the COVID–19 pandemic on the U.S. pork, turkey, and egg markets. Yang *et al*. (2022) investigated the impact of the COVID–19 pandemic on the Taiwanese food industry, including food manufacturing, wholesale, retail, and service sectors. They found that COVID–19 reduced the total sales value of the food industry by 24%. However, the negative effects were unequally distributed among different sectors of the food industry: the negative effect was more pronounced in the food manufacturing sector.

Moreover, some previous studies concentrated on the financial aspects of the COVID–19 pandemic. Achim *et al*. (2021) found that the total net profit of the market decreased by 37.43% during the pandemic. In addition, irrespective of size, on average, all service sectors, such as hotels and restaurants, pharmaceuticals, and real estate, significantly decreased. However, they also found that small companies engaged in agriculture, commerce, construction, IT R&D, and transport and storage registered significant improvements in their financial net profits during the pandemic compared with the previous period. Martínez–Victoria *et al*. (2018) analyzed the impact of COVID–19 on agri–food companies in Spain. Financially, they found a decrease in turnover, decrease/displacement in the demand for products, budget reduction in R&D projects, and increase in certain product sales. Höhler and Lansink (2021) analyzed stock prices to examine the impact of the COVID–19 pandemic on stock price volatility and profits of companies in the food supply chain. The results showed that manufacturers of fertilizers and agrochemicals, as well as food distributors, showed particularly high volatility in their stock prices. On the contrary, low price volatility is observed in food retailers' stocks.

## DATA AND METHODOLOGY

### Data

In this study, we use the TKC Management Indicators (BAST) (Summary Version) from 2019 to 2021 (TKC National Federation, 2020, 2021, 2022a)[1]. These indicators are the result of an analysis of the management performance and financial status of SMEs (with annual revenue of 10 billion yen or less) that used the TKC Financial System for 2 years or longer (TKC National Federation, 2022b).

The indicators are based on financial statements prepared in the course of field auditing and account closing conducted monthly by TKC National Federation members. These financial statements were used for filing corporate income tax returns. No other management indicators for SMEs in the world have such accuracy and speed and they have a good reputation with tax authorities, financial institutions, and other similar organizations.

The indicators do not disclose the financial statements of individual companies; they aggregate the data in the financial statements of at least three companies in a similar industry and of a similar size, and report the average data classified into those of (1) excellent companies, (2) profitable companies, (3) profitable companies near the average, and (4) loss–making companies.

Since the BAST (Summary Version) discloses only partial summaries for "excellent companies" and "profitable companies," this study uses data for "profitable companies." "Profitable companies" have positive net assets and income/loss before taxes at the year–end (TKC National Federation, 2022b). In other words, "profitable companies" can be regarded as companies with advanced management that flexibly respond to changes in internal and external environments. Therefore, by focusing on "profitable companies," we can clarify the characteristics of advanced agricultural corporate management.

The industrial classification of the BAST (Summary Version) is based on the Japan Standard Industrial Classification by the Ministry of Internal Affairs and Communications (revised in October 2013) (MIC, 2013). The major classification consists of 19 industries. The data are stratified in the order of large, medium, and small categories as well as sub–categories, and the BAST (Summary Version) provides data for medium and sub–categories (Figure 1). The BAST published data for 502 sub–categories in 2021, 485 sub–categories in 2020, and 505 sub–categories in 2019. The large category "Agriculture and forestry" consists of two medium categories: "Agriculture" and "Forestry." The medium cate-

[1] The TKC Management Indicators are based on the accounting books of SMEs with involvement by certified tax accountants and certified public accountants affiliated with the TKC National Federation. The accuracy and legality of these books are verified through monthly auditing visits to the enterprises and monthly closing of accounts, with the financial statements (balance sheets and profit–and–loss statements) produced from these accounting books used as basic data (TKC National Federation, 2022b). These financial statements are used directly for corporate tax returns. The 2021 edition of the TKC Management Index contains management analysis data based on the financial statements of 248,962 corporate enterprises in Japan for the period from January 2021 to December 2021, while the 2020 edition contains management analysis data of 248,289 corporate enterprises from January 2020 to December 2020. The 2019 edition contains management analysis data of 246,523 companies for January 2019 to December 2019.

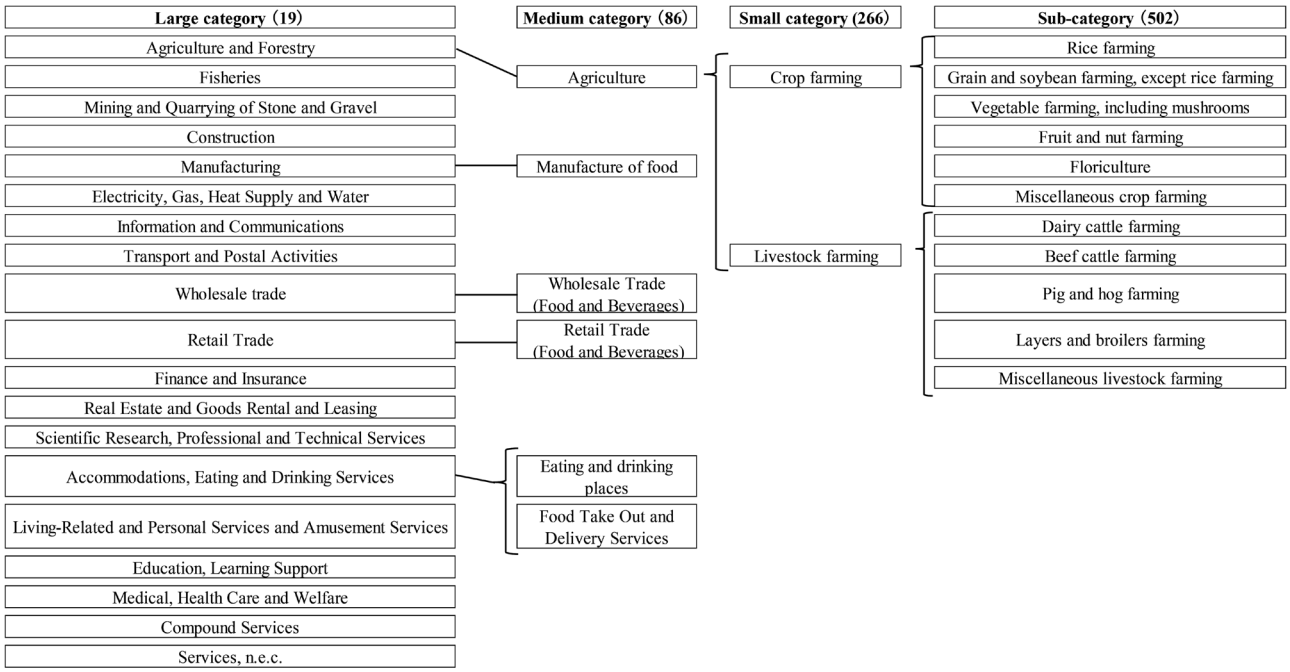


**Fig. 1.** BAST data structure (Summary Version)
Source: MIC (2013), TKC National Federation (2022a)
Note: Figures in parentheses for categories are the number of industries published in the BAST (Summary Version) for 2021.

gory "Agriculture" consists of four small categories: "Crop farming," "Livestock farming," "Establishments engaged in management and supporting economic activities," and "Agricultural services (excluding horticultural services)." In this study, we focus on "Crop farming" and "Livestock farming," which relate directly to agricultural production. In the BAST (Summary Version), the small category "Crop farming" consists of "Rice farming," "Grain and soybean farming," "Vegetable farming," "Fruit and nut farming," "Floriculture," and "Miscellaneous crop farming," while the small category "Livestock farming" consists of "Dairy cattle farming," "Beef cattle farming," "Pig and hog farming," "Layers and broilers farming," and "Miscellaneous livestock farming." We focus on these 11 sub–categories of "Agriculture." In addition, we focus on five medium categories: "Manufacture of food" (14 sub–categories), "Wholesale trade (food and beverages)" (13 sub–categories), "Retail trade (food and beverages)" (16 sub–categories), "Eating and drinking places" (14 sub–categories), and "Food take–out and delivery services" (2 sub–categories) as the agri–food supply chain (Figure 2).

Table 1 shows the number of profitable companies in the BAST: about 133,000 firms in 2021, 128,000 in 2020, and 133,000 in 2019. "Rice farming" has the most firms in the medium category of "Agriculture." The total number of companies combined in "Crop farming" and "Livestock farming" is 1,768 in 2021 and 1,616 in 2020.

There are various methods of financial analysis, such as profitability analysis, safety analysis, productivity analysis, and growth analysis (Furutsuka & Takada, 2021). This study focuses on indicators related to profitability, safety, and productivity. Specifically, we analyze the ordinary profit margin on sales and ordinary profit margin on total assets as profitability indicators, and the equity ratio and debt ratio as safety indicators. The debt ratio shows the balance struck by the management of a particular company between these forces of risk versus cost (Anthony *et al*., 2011). For reference, we also focus on the following indicators related to labor productivity: annual sales per worker and annual labor cost per worker. In the BAST, the ordinary profit margin on sales, ordinary profit margin on total assets, equity ratio, debt ratio, and annual labor cost per worker are defined as follows (TKC Group 2022). As annual sales per worker are not disclosed in the BAST, the calculation is our own:

1) Profitability Indicator

$$\textit{Ordinary profit margin on sales}\ (\%) = \frac{\textit{Ordinary income}}{\textit{Net sales}}$$

$$\textit{Ordinary profit margin on total assets}\ (\%) = \frac{\textit{Ordinary income}}{\textit{Total capital}}$$

2) Safety Indicator

$$\textit{Equity ratio}\ (\%) = \frac{\textit{Shareholders' equity}}{\textit{Total capital}}$$

$$\textit{Debt ratio}\ (\%) = \frac{\textit{Interest–bearing debt}}{\textit{Shareholders' equity}}$$

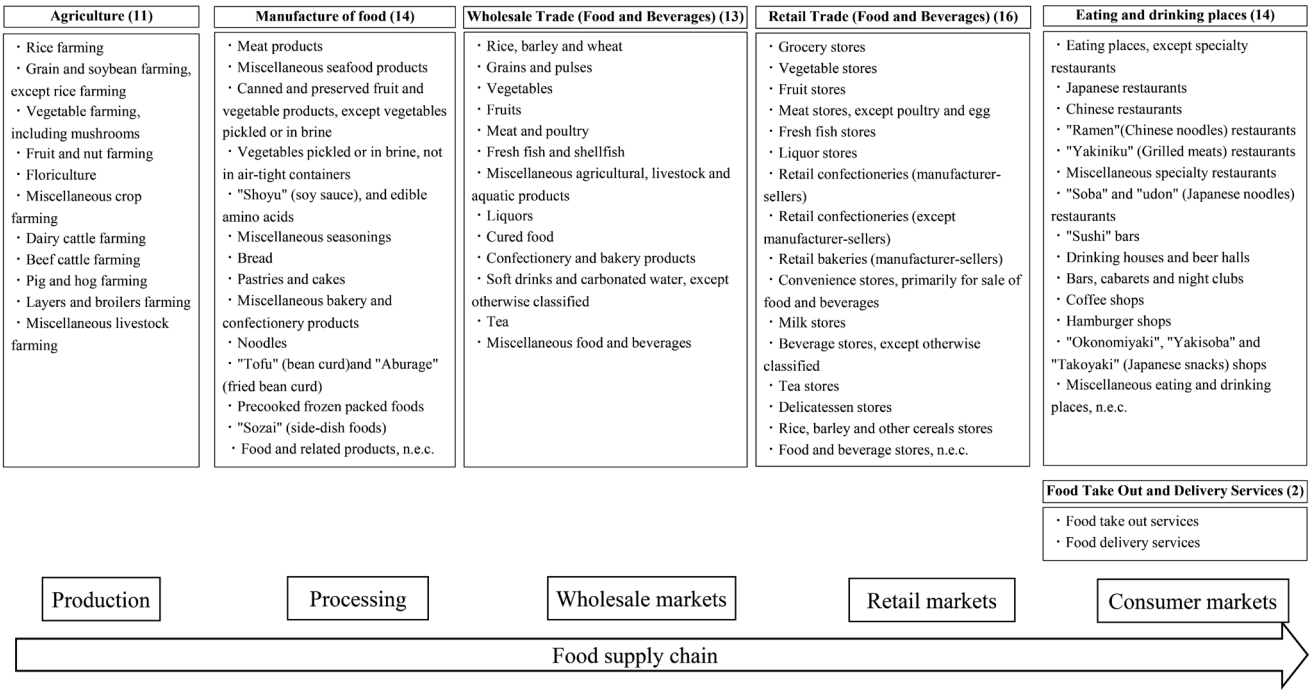


**Fig. 2.** Food supply chain and sub–categories covered in this study
Note: Parentheses indicate the number of sub–categories.

**Table 1.** Number of corporations and percentage increase/decrease (large categories)

| Large categories | Number of corporations | | | Percentage increase / decrease | |
|---|---|---|---|---|---|
| | 2019 | 2020 | 2021 | 2020 / 2019 | 2021 / 2020 |
| Agriculture and Forestry | 2,125 | 2,235 | 2,429 | 5.2% | 8.7% |
| Fisheries | 167 | 166 | 170 | –0.6% | 2.4% |
| Mining and Quarrying of Stone and Gravel | 187 | 195 | 185 | 4.3% | –5.1% |
| Construction | 27,806 | 27,855 | 27,673 | 0.2% | –0.7% |
| Manufacturing | 15,929 | 13,670 | 14,267 | –14.2% | 4.4% |
| Electricity, Gas, Heat Supply and Water | 381 | 424 | 521 | 11.3% | 22.9% |
| Information and Communications | 3,478 | 3,468 | 3,553 | –0.3% | 2.5% |
| Transport and Postal Activities | 4,890 | 4,649 | 4,490 | –4.9% | –3.4% |
| Wholesale trade | 12,946 | 12,167 | 12,766 | –6.0% | 4.9% |
| Retail Trade | 13,991 | 13,489 | 14,663 | –3.6% | 8.7% |
| Finance and Insurance | 1,247 | 1,389 | 1,430 | 11.4% | 3.0% |
| Real Estate and Goods Rental and Leasing | 16,221 | 16,612 | 17,462 | 2.4% | 5.1% |
| Scientific Research, Professional and Technical Services | 8,493 | 8,667 | 9,208 | 2.0% | 6.2% |
| Accommodations, Eating and Drinking Services | 4,518 | 3,261 | 3,408 | –27.8% | 4.5% |
| Living–Related and Personal Services and Amusement Services | 3,941 | 3,428 | 3,375 | –13.0% | –1.5% |
| Education, Learning Support | 782 | 785 | 829 | 0.4% | 5.6% |
| Medical, Health Care and Welfare | 4,634 | 4,593 | 5,050 | –0.9% | 9.9% |
| Compound Services | 774 | 814 | 835 | 5.2% | 2.6% |
| Services, n.e.c. | 10,297 | 10,016 | 10,707 | –2.7% | 6.9% |
| Total | 132,807 | 127,883 | 133,021 | –3.7% | 4.0% |

Source: TKC National Federation (2020, 2021, 2022a).

3) Productivity–related Indicator

$$\textit{Annual sales per worker}\ (1000\ \textit{JPY/year}) = \frac{\textit{Total sales}}{\textit{Average number of employees}}$$

$$\textit{Annual labor cost per worker}\ (1000\ \textit{JPY/year}) = \frac{\textit{Labor cost}}{\textit{Average number of employees}}$$

Labor productivity per worker is the amount of value added per employee (Ito, 1994). Labor productivity can be decomposed into labor cost per worker and labor share, as well as sales per worker and value–added to sales ratio (Shikata, 2012):

$$\textit{Labor productivity} = \frac{\textit{Value added}}{\textit{the number of employees}} = \frac{\textit{Labor cost}}{\textit{the number of employees}} \times \frac{\textit{Value added}}{\textit{Labor cost}} = \frac{\textit{Annual labor cost per worker}}{\textit{Labor share}}$$

$$= (\textit{Annual sales per worker}) \times (\textit{Value–added to sales ratio})$$

Thus, annual sales per worker and annual labor cost per worker are related to labor productivity and are important in business management. Therefore, we include these indicators.

Generally, higher ordinary profit margins on sales and total assets are desirable[2]. Moreover, a higher equity ratio is desirable because it indicates less debt to repay and a higher degree of financial security. A lower debt ratio is desirable because it indicates safer management. Annual sales per worker measures the amount of sales generated by each employee, with higher values being desirable. A high annual labor cost per worker may put pressure on management, whereas a low labor cost may lead to a decline in employee motivation, resulting in employee turnover and lower productivity. From the viewpoint of sustainable development of agricultural corporate management, this study considers a high annual labor cost as desirable.

**Methodology**

We apply principal component analysis (PCA) using the six financial indicators as variables. PCA uses principal components as a mechanism for reducing the number of variables (Linoff & Berry, 2011). Specifically, we apply PCA to the pooled data for the period 2019–2021 (1,492 sub–categories). The number of principal components is determined from the interpretability of the results, and variables with principal component loadings of 0.5 or more important variables that give meaning to the principal components. Finally, the principal component scores are plotted in a coordinate space to ascertain the position of each industry and clarify their financial characteristics under the COVID–19 pandemic. We use the princomp function of the stats package of the statistical software R (4.1.2) for the PCA.

## RESULTS AND DISCUSSION

**Descriptive statistics**

Table 2 presents the descriptive statistics of the sub–categories, while Table 3 shows the largest and smallest sub–categories for each indicator. Focusing on the same results for the full 3–year sample, the smallest ordinary profit margin on sales is "Convenience stores" ("Retail trade") and that on total assets is "Golf courses" ("Living–related and personal services and amusement services"). "Temples and Buddhist churches" ("Services, n.e.c.") has the largest equity ratio and the smallest debt ratio; thus, it is the safest among all sub–categories. "Hamburger shops" ("Accommodations, eating and drinking services") has the lowest annual labor cost per worker.

**Principal component analysis**

Table 4 reports the PCA results. The first principal component has an eigenvalue of 2.34 and a contribution ratio of 39.0%. This component indicates that "safety and profitability" as the principal component loading of ordinary profit margin on sales is –0.53, the ordinary profit margin on total assets is –0.59, the equity ratio is –0.86, and the debt ratio is 0.81. A high ordinary profit margin can increase safety by reducing debt and total capital. Therefore, the variables are considered to have been synthesized by profitability and safety.

The second principal component has an eigenvalue of 1.62 and a contribution rate of 26.9%. This component indicates "productivity–related," because the principal component loading of annual sales per worker is –0.80 and the annual labor cost per worker is –0.56. In terms of interpretability and cumulative contribution ratio (65.9%), we determine the number of principal components to be two.

For the first principal component score, a positive value indicates "low safety and low profitability," while a negative value indicates "high safety and high profitability." Similarly, if the second principal component score is positive, then we would find "low productivity–related," and vice versa for a negative score.

Figure 3 plots the first and second principal component scores for the 1,492 sub–categories. First, to ascertain the representative industries in each quadrant, Table 5 shows the sub–categories with a large distance from the origin.

The first quadrant (low safety and low profitability, low productivity–related) is represented by "Medical, health care and welfare" (4 out of 10) and

[2] Firms oriented toward long–term growth may prefer prior investment to short–term profits. Among SMEs, some may not be focused on increasing taxable profits. Thus, a high profit margin in a single year is not always desirable, though some level of profit is necessary to maintain and develop an enterprise.

**Table 2.** Descriptive statistics

| | Variable | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|---|
| 2021 | Ordinary profit margin on sales (%) | 502 | 6.60 | 3.70 | 0.9 | 33.4 |
| | Ordinary profit margin on total assets (%) | 502 | 6.25 | 2.63 | 1.6 | 22.0 |
| | Equity ratio (%) | 502 | 45.16 | 11.23 | 14.0 | 93.4 |
| | Debt ratio (%) | 502 | 85.48 | 59.39 | 4.9 | 442.8 |
| | Annual sales per worker (1000 yen / year) | 502 | 21834.62 | 15620.93 | 3773.2 | 90877.5 |
| | Annual labor cost per worker (1000 yen / year) | 502 | 4327.80 | 1135.45 | 1346.0 | 8022.0 |
| 2020 | Ordinary profit margin on sales (%) | 485 | 5.72 | 3.47 | 0.8 | 31.7 |
| | Ordinary profit margin on total assets (%) | 485 | 5.80 | 2.48 | 1.3 | 21.1 |
| | Equity ratio (%) | 485 | 45.45 | 11.05 | 16.0 | 95.1 |
| | Debt ratio (%) | 485 | 81.07 | 52.76 | 3.1 | 428.5 |
| | Annual sales per worker (1000 yen / year) | 485 | 22265.79 | 15697.19 | 3672.3 | 103435.4 |
| | Annual labor cost per worker ($100_0$ yen / year) | 485 | 4423.80 | 1146.13 | 1469.0 | 8397.0 |
| 2019 | Ordinary profit margin on sales (%) | 505 | 5.44 | 3.52 | 0.7 | 43.7 |
| | Ordinary profit margin on total assets (%) | 505 | 5.85 | 2.60 | 1.2 | 29.9 |
| | Equity ratio (%) | 505 | 44.33 | 10.68 | 12.2 | 93.6 |
| | Debt ratio (%) | 505 | 82.44 | 55.82 | 4.1 | 574.6 |
| | Annual sales per worker (1000 yen/year) | 505 | 22388.25 | 15694.93 | 3261.7 | 97113.1 |
| | Annual labor cost per worker (1000 yen/year) | 505 | 4420.32 | 1140.36 | 1395.0 | 7625.0 |

**Table 3.** The smallest / largest sub–categories for each financial indicator

| | | Smallest sub–categories | Largest sub–categories |
|---|---|---|---|
| 2021 | Ordinary profit margin on sales | Convenience stores, primarily for sale of food and beverages (Retail Trade) | Artists (Scientific Research, Professional and Technical Services) |
| | Ordinary profit margin on total assets | Golf Courses (Living–Related and Personal Services and Amusement Services) | Certified Social Insurance and Labor Consultants, Offices (Scientific Research, Professional and Technical Services) |
| | Equity ratio | Head Offices Primarily Engaged in Managerial Operations (Production, Transmission and Distribution of Electricity) (Electricity, Gas, Heat Supply and Water) | Temples and Buddhist Churches (Services, n.e.c.) |
| | Debt ratio | Temples and Buddhist Churches (Services, n.e.c.) | Head Offices Primarily Engaged in Managerial Operations (Eating and Drinking Places) (Accommodations, Eating and Drinking Services) |
| | Annual sales per worker | Worker Dispatching Services (Services, n.e.c.) | Cement (Wholesale) |
| | Annual labor cost per worker | Hamburger Shops (Accommodations, Eating and Drinking Services) | Lawyers' Offices (Scientific Research, Professional and Technical Services) |
| 2020 | Ordinary profit margin on sales | Convenience stores, primarily for sale of food and beverages (Retail trade) | Pure Holding Companies (Scientific Research, Professional and Technical Services) |
| | Ordinary profit margin on total assets | Golf Courses (Living–Related and Personal Services and Amusement Services) | Artists (Scientific Research, Professional and Technical Services) |
| | Equity ratio | Food Take–Out Services (Accommodations, Eating and Drinking Services) | Temples and Buddhist Churches (Services, n.e.c.) |
| | Debt ratio | Temples and Buddhist Churches (Services, n.e.c.) | Miscellaneous Welfare Services for the Aged and Care Services (Medical, Health Care and Welfare) |
| | Annual sales per worker | Miscellaneous Welfare Services for Disabled Persons (Medical, Health Care and Welfare) | Cement (Wholesale) |
| | Annual labor cost per worker | Hamburger Shops (Accommodations, Eating and Drinking Services) | Lawyers' Offices (Scientific Research, Professional and Technical Services) |
| 2019 | Ordinary profit margin on sales | Convenience stores, primarily for sale of food and beverages (Retail trade) | Authors (Scientific Research, Professional and Technical Services) |
| | Ordinary profit margin on total assets | Golf Courses (Living–Related and Personal Services and Amusement Services) | Authors (Scientific Research, Professional and Technical Services) |
| | Equity ratio | Automobile Rental (Real Estate and Goods Rental and Leasing) | Temples and Buddhist Churches (Services, n.e.c.) |
| | Debt ratio | Temples and Buddhist Churches (Services, n.e.c.) | Automobile Rental (Real Estate and Goods Rental and Leasing) |
| | Annual sales per worker | Miscellaneous Welfare Services for Disabled Persons (Medical, Health Care and Welfare) | Non–Ferrous Metal Ingots (Wholesale) |
| | Annual labor cost per worker | Hamburger Shops (Accommodations, Eating and Drinking Services) | Special Concrete Work (Construction) |

Note: Large categories in parentheses.

**Table 4.** Principal component analysis results

| Variable | | Principal component loadings | | |
|---|---|---|---|---|
| | | PC1 | PC2 | PC3 |
| Profitability | Ordinary profit margin on sales | –0.528 | 0.571 | 0.390 |
| | Ordinary profit margin on total assets | –0.590 | 0.457 | 0.414 |
| Safety | Equity ratio | –0.861 | –0.150 | –0.384 |
| | Debt ratio | 0.814 | 0.334 | 0.373 |
| Productivity | Annual sales per worker | 0.159 | –0.799 | 0.415 |
| | Annual labor cost per worker | –0.533 | –0.557 | 0.470 |
| Eigenvalue | | 2.340 | 1.617 | 1.003 |
| Contribution ratio | | 39.0% | 26.9% | 16.7% |
| Cumulative contribution ratio | | 39.0% | 65.9% | 82.7% |

Note: Principal component loadings with an absolute value of 0.5 or more are underlined.

"Accommodations, eating and drinking services" (3 out of 10). The second quadrant (high safety and high profitability, low productivity–related) is represented by "Scientific research, professional and technical services" (8 out of 10), with "Rice farming" also large among the sub–categories. The third quadrant (high safety and high profitability, high productivity–related) is represented by "Wholesale" (5 out of 10) and "Construction" (3 out of 10). The fourth quadrant (low safety and low profitability, high productivity–related) is represented by "Wholesale" (8 out of 10).

**The agri–food supply chain**

Table 6 shows the principal component scores and changes in the quadrants. The categories in the same quadrant throughout the 3 years show less annual variation than the other categories. For example, "Rice farming" is in the second quadrant throughout the 3 years. Hence, this industry is safer and more profitable than the other sub–industries.

Table 7 summarizes the financial characteristics of each industry based on the results in Table 6. For "Agriculture," the percentage of sub–categories with high first principal component scores for more than 2 years is the highest among the agri–food supply chain industries (45.5%). In "Manufacture of food," the percentage with high scores for all indicators for all 3 years is high (14.3%) and the percentage with low scores for all indicators for all 3 years is as high as 50%. For "Wholesale trade," the second principal component scores for all sub–categories are high in all 3 years (100%). In "Retail trade," the percentage with low scores for all indicators for all 3 years is as high as 50%. The majority of sub–categories in "Eating and drinking places" and "Food take–out and delivery services" (hereafter, "Eating and food take–out") had low scores for all 3 years (93.8%). These results indicate that "Agriculture," the upstream sector of the agri–food supply chain, has the highest profitability and safety, while "Eating and food take–out," the downstream sector, has the lowest overall indicators.

Table 8 reports the changes in the principal component scores. Figures 4 and 5 illustrate the changes in the first and second principal component scores, respectively. Regarding the first principal component score ("safety and profitability"), "Agriculture" has the highest percentage of the sub–categories that changed "safety and profitability" from low to high (28.6% in 2021/2020, 25.0% in 2020/2019). Meanwhile, for "Manufacture of food," "Wholesale trade," "Retail trade," and "Eating and food take–out," the percentage of industries that remain low is higher than that for "Agriculture." Therefore, we conclude that "Agriculture" had high profitability and safety in the agri–food supply chain during the COVID–19 pandemic. Focusing on "Agriculture," "Pig and hog farming" and "Miscellaneous crop farming" changed from low to high in 2020, and "Dairy cattle farming" and "Grain and soybean farming" in 2021 (Table 6). However, "Dairy cattle farming" changed from high to low in 2020. "Rice farming" had high "safety and profitability" for all 3 years.

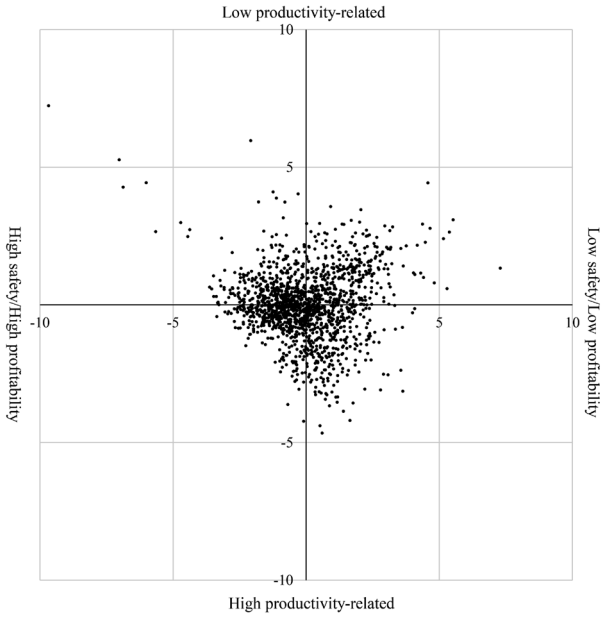


**Fig. 3.** Plot of principal component scores
Note: The horizontal and vertical axes indicate the first and second principal component scores, respectively. The figure plots 1,492 sub–categories.

**Table 5.** Representative industries in each quadrant

| | Large categories | Sub–categories |
|---|---|---|
| First quadrant low profitability and low safety, low productivity | Real Estate and Goods Rental and Leasing | Automobile Rental (19) |
| | Accommodations, Eating and Drinking Services | Head Offices Primarily Engaged in Managerial Operations (Eating and Drinking Places) (21) |
| | Medical, Health Care and Welfare | Miscellaneous Welfare Services for the Aged and Care Services (19) |
| | Medical, Health Care and Welfare | Miscellaneous Welfare Services for the Aged and Care Services (20) |
| | Medical, Health Care and Welfare | Miscellaneous Welfare Services for the Aged and Care Services (21) |
| | Accommodations, Eating and Drinking Services | Food Take–Out Services (20) |
| | Real Estate and Goods Rental and Leasing | Automobile Rental (21) |
| | Accommodations, Eating and Drinking Services | "Okonomiyaki", "Yakisoba" and "Takoyaki" (Japanese snacks) Shops (21) |
| | Medical, Health Care and Welfare | Fee Charging Homes for the Aged (19) |
| | Electricity, Gas, Heat Supply and Water | Head Offices Primarily Engaged in Managerial Operations (Production, Transmission and Distribution of Electricity) (21) |
| Second quadrant high profitability and high safety, low productivity | Scientific Research, Professional and Technical Services | Authors (19) |
| | Scientific Research, Professional and Technical Services | Artists (21) |
| | Scientific Research, Professional and Technical Services | Authors (21) |
| | Scientific Research, Professional and Technical Services | Artists (20) |
| | Education, Learning Support | Foreign Language Instructions (21) |
| | Scientific Research, Professional and Technical Services | Artists (19) |
| | Scientific Research, Professional and Technical Services | Certified Social Insurance and Labor Consultants' Offices (21) |
| | Scientific Research, Professional and Technical Services | Certified Social Insurance and Labor Consultants' Offices (20) |
| | Scientific Research, Professional and Technical Services | Authors (20) |
| | Agriculture and Forestry | Rice Farming (20) |
| Third quadrant high profitability and high safety, high productivity | Wholesale | Iron and Steel Crude Products (19) |
| | Wholesale | Minerals, Except Petroleum (19) |
| | Scientific Research, Professional and Technical Services | Patent Attorneys› Offices (21) |
| | Wholesale | Metalworking Machinery and Equipment (19) |
| | Construction | Electrical Signal System Work (20) |
| | Construction | Electrical Signal System Work (19) |
| | Services, n.e.c. | Night Soil Collection Transportation Business (19) |
| | Construction | Furnace Construction Work (20) |
| | Wholesale | Metalworking Machinery and Equipment (21) |
| | Wholesale | Metalworking Machinery and Equipment (20) |
| Fourth quadrant low profitability and low safety, high productivity | Wholesale | Rice, Barley and Wheat (20) |
| | Wholesale | Non–Ferrous Metal Ingots (20) |
| | Wholesale | Cement (20) |
| | Wholesale | Non–Ferrous Metal Ingots (19) |
| | Wholesale | Rice, Barley and Wheat (21) |
| | Wholesale | Rice, Barley and Wheat (19) |
| | Wholesale | Cement (19) |
| | Real Estate and Goods Rental and Leasing | Automobile Rental (20) |
| | Real Estate and Goods Rental and Leasing | Head Offices Primarily Engaged in Managerial Operations (Real Estate Agencies) (19) |
| | Wholesale | Motor Vehicles, Including Motorcycles (21) |

Note: The numbers in parentheses in the sub–categories indicates the year: 21 indicates the year 2021, 20 indicates 2020, and 19 indicates 2019.

**Table 6.** Principal component scores and quadrants in the agri–food supply chain

| | | 2019 | | 2020 | | 2021 | | Quadrant | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | First principal component score | Second principal component score | First principal component score | Second principal component score | First principal component score | Second principal component score | 2019 | 2020 | 2021 |
| Agriculture | Rice farming | –1.12 | 3.88 | –1.25 | 4.11 | –0.80 | 3.74 | 2 | 2 | 2 |
| | Grain and soybean farming, except rice farming | 0.73 | 2.34 | 0.18 | 2.67 | –0.30 | 4.04 | 1 | 1 | 2 |
| | Vegetable farming, including mushrooms | 2.73 | 1.29 | 2.78 | 1.59 | 1.52 | 1.65 | 1 | 1 | 1 |
| | Fruit and nut farming | 3.64 | 1.42 | 2.41 | 1.59 | 2.59 | 1.69 | 1 | 1 | 1 |
| | Floriculture | 2.48 | 1.12 | 2.54 | 1.14 | 2.58 | 2.13 | 1 | 1 | 1 |
| | Miscellaneous crop farming | 2.70 | 1.35 | –0.37 | 0.47 | –0.39 | 1.61 | 1 | 2 | 2 |
| | Dairy cattle farming | –0.31 | 0.53 | 0.13 | –0.18 | –0.14 | –0.49 | 2 | 4 | 3 |
| | Beef cattle farming | 2.73 | –1.36 | 3.61 | –0.81 | 3.35 | –0.88 | 4 | 4 | 4 |
| | Pig and hog farming | 0.26 | –0.90 | –0.33 | –0.60 | –0.52 | –0.40 | 4 | 3 | 3 |
| | Layers and broilers farming | 2.91 | 0.26 | 1.81 | –0.06 | 1.60 | –0.16 | 1 | 4 | 4 |
| | Miscellaneous livestock farming | –1.10 | 0.83 | –0.90 | 0.31 | –0.74 | –0.34 | 2 | 2 | 2 |
| Manufacture of Food | Meat products | 1.76 | 0.16 | 1.71 | 0.01 | 1.14 | 0.21 | 1 | 1 | 1 |
| | Miscellaneous seafood products | 1.78 | –0.33 | 2.28 | 0.00 | 2.12 | 0.17 | 4 | 1 | 1 |
| | Canned and preserved fruit and vegetable products, except vegetables pickled or in brine | 2.17 | 0.01 | 1.65 | 0.01 | 1.44 | 0.34 | 1 | 1 | 1 |
| | Vegetables pickled or in brine, not in air–tight containers | 0.94 | –0.03 | 1.00 | –0.04 | 0.61 | –0.07 | 4 | 4 | 4 |
| | "Shoyu" (soy sauce), and edible amino acids | 1.69 | –0.26 | 1.35 | –0.42 | 1.31 | –0.42 | 4 | 4 | 4 |
| | Miscellaneous seasonings | –0.66 | –0.08 | –0.96 | –0.45 | –0.48 | –0.04 | 3 | 3 | 3 |
| | Bread | 0.37 | 0.99 | 1.51 | 0.43 | 1.76 | 0.40 | 1 | 1 | 1 |
| | Pastries and cakes | 0.73 | 0.52 | 0.68 | 0.59 | 0.61 | 0.93 | 1 | 1 | 1 |
| | Miscellaneous bakery and confectionery products | 0.69 | –0.07 | –0.07 | 0.31 | 0.54 | –0.10 | 4 | 2 | 4 |
| | Noodles | –0.98 | –0.13 | –1.19 | –0.22 | –0.94 | –0.23 | 3 | 3 | 3 |
| | "Tofu" (bean curd) and "Aburage" (fried bean curd) | 3.09 | 1.11 | 2.37 | 1.15 | 2.36 | 1.27 | 1 | 1 | 1 |
| | Precooked frozen packed foods | 0.57 | 0.21 | 0.71 | 0.42 | –0.55 | 1.04 | 1 | 1 | 2 |
| | "Sozai" (side–dish foods) | 2.44 | 0.47 | 1.41 | 0.49 | 1.76 | 0.81 | 1 | 1 | 1 |
| | Food and related products, n.e.c. | 0.56 | 0.35 | 0.31 | 0.31 | 0.90 | 0.46 | 1 | 1 | 1 |
| Wholesale Trade (Food and Beverages) | Rice, barley and wheat | 2.79 | –3.09 | 3.63 | –3.14 | 3.55 | –2.37 | 4 | 4 | 4 |
| | Grains and pulses | 1.19 | –1.61 | 0.64 | –2.70 | 1.84 | –2.18 | 4 | 4 | 4 |
| | Vegetables | 1.05 | –1.75 | 0.98 | –1.83 | 0.87 | –1.87 | 4 | 4 | 4 |
| | Fruits | 1.20 | –2.03 | 1.65 | –1.51 | 2.27 | –1.45 | 4 | 4 | 4 |
| | Meat and poultry | 1.87 | –1.25 | 1.53 | –1.17 | 1.42 | –1.27 | 4 | 4 | 4 |
| | Fresh fish and shellfish | 2.54 | –1.35 | 1.85 | –2.01 | 2.31 | –1.76 | 4 | 4 | 4 |
| | Miscellaneous agricultural, livestock and aquatic products | 1.83 | –1.60 | 1.91 | –1.47 | 1.84 | –1.41 | 4 | 4 | 4 |
| | Liquors | 0.85 | –2.24 | 0.94 | –2.02 | 0.73 | –3.22 | 4 | 4 | 4 |
| | Cured food | 2.93 | –0.91 | 2.38 | –1.04 | 2.34 | –1.13 | 4 | 4 | 4 |
| | Confectionery and bakery products | 0.08 | –1.65 | –0.15 | –1.51 | –0.39 | –1.88 | 4 | 3 | 3 |
| | Soft drinks and carbonated water, except otherwise classified | 0.89 | –1.04 | 1.18 | –0.92 | 0.60 | –1.01 | 4 | 4 | 4 |
| | Tea | 2.14 | –0.19 | 1.28 | –0.59 | 1.18 | –0.71 | 4 | 4 | 4 |
| | Miscellaneous food and beverages | 1.36 | –1.54 | 1.34 | –1.80 | 1.12 | –1.59 | 4 | 4 | 4 |
| Retail Trade (Food and Beverage) | Grocery stores | 1.01 | 0.05 | 1.08 | –0.03 | 0.88 | 0.16 | 1 | 4 | 1 |
| | Vegetable stores | 0.91 | –0.32 | 1.70 | 0.73 | 0.93 | 0.42 | 4 | 1 | 1 |
| | Fruit stores | 4.08 | 1.11 | 4.03 | 1.17 | 4.40 | 1.00 | 1 | 1 | 1 |
| | Meat stores, except poultry and egg | 1.33 | –0.20 | 1.76 | 0.05 | 0.72 | 0.50 | 4 | 1 | 1 |
| | Fresh fish stores | 0.99 | –0.21 | –0.01 | –0.44 | 0.35 | –0.11 | 4 | 3 | 4 |
| | Liquor stores | 2.16 | –0.44 | 2.37 | –0.13 | 2.04 | 0.02 | 4 | 4 | 1 |
| | Retail confectioneries (manufacturer–sellers) | 0.99 | 0.83 | 0.66 | 0.95 | 0.82 | 1.19 | 1 | 1 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Retail Trade (Food and Beverage) | Retail confectioneries (except manufacturer–sellers) | –1.13 | 0.88 | –2.05 | 1.22 | –0.95 | 0.76 | 2 → 2 → 2 |
| | Retail bakeries (manufacturer–sellers) | 1.27 | 1.26 | 1.18 | 1.23 | 0.73 | 1.72 | 1 → 1 → 1 |
| | Convenience stores, primarily for sale of food and beverages | 1.99 | 0.83 | 1.87 | 0.88 | 1.73 | 0.96 | 1 → 1 → 1 |
| | Milk stores | 1.98 | 0.65 | 2.04 | 0.94 | 1.03 | 1.35 | 1 → 1 → 1 |
| | Beverage stores, except otherwise classified | –0.06 | –1.64 | 0.12 | –1.33 | 0.08 | –1.31 | 3 → 4 → 4 |
| | Tea stores | 2.45 | 0.63 | 1.61 | 0.18 | 1.39 | 1.79 | 1 → 1 → 1 |
| | Delicatessen stores | 1.62 | 0.90 | 1.69 | 1.41 | 1.02 | 1.32 | 1 → 1 → 1 |
| | Rice, barley and other cereals stores | 2.58 | –0.99 | 2.00 | –1.07 | 1.65 | –0.61 | 4 → 4 → 4 |
| | Food and beverage stores, n.e.c. | 1.29 | 0.32 | 1.68 | 0.40 | 0.35 | 0.51 | 1 → 1 → 1 |
| Eating and Drinking Places | Eating places, except specialty restaurants | 1.88 | 1.36 | 1.83 | 1.19 | 2.20 | 1.89 | 1 → 1 → 1 |
| | Japanese restaurants | 0.67 | 1.04 | 1.34 | 0.99 | 0.60 | 2.22 | 1 → 1 → 1 |
| | Chinese restaurants | 0.55 | 0.70 | 1.57 | 1.35 | 1.49 | 1.93 | 1 → 1 → 1 |
| | “Ramen”(Chinese noodles) restaurants | 2.46 | 1.05 | 3.07 | 1.31 | 3.14 | 2.70 | 1 → 1 → 1 |
| | “Yakiniku” (Grilled meats) restaurants | 1.15 | 1.40 | 2.39 | 1.24 | 2.66 | 1.91 | 1 → 1 → 1 |
| | Miscellaneous specialty restaurants | 1.42 | 1.32 | 2.23 | 1.22 | 2.95 | 2.87 | 1 → 1 → 1 |
| | “Soba” and “udon” (Japanese noodles) restaurants | 1.78 | 1.25 | 1.02 | 1.49 | 0.33 | 2.49 | 1 → 1 → 1 |
| | “Sushi” bars | 0.79 | 1.43 | 0.73 | 1.78 | 0.03 | 1.68 | 1 → 1 → 1 |
| | Drinking houses and beer halls | 1.25 | 1.29 | 1.58 | 1.16 | 2.26 | 2.72 | 1 → 1 → 1 |
| | Bars, cabarets and night clubs | –0.95 | 1.21 | 0.07 | 0.98 | –0.05 | 2.17 | 2 → 1 → 2 |
| | Coffee shops | 1.77 | 1.37 | 3.22 | 1.50 | 2.65 | 2.46 | 1 → 1 → 1 |
| | Hamburger shops | 2.85 | 1.86 | 1.84 | 2.19 | 1.09 | 2.75 | 1 → 1 → 1 |
| | “Okonomiyaki”, “Yakisoba” and “Takoyaki” (Japanese snacks) shops | 1.57 | 1.81 | 1.80 | 1.34 | 4.36 | 2.94 | 1 → 1 → 1 |
| | Miscellaneous eating and drinking places, n.e.c. | 1.24 | 1.00 | 1.19 | 1.36 | 0.39 | 2.32 | 1 → 1 → 1 |
| Food Take Out and Delivery Services | Food take out services | 2.98 | 1.47 | 4.65 | 2.78 | 4.17 | 2.17 | 1 → 1 → 1 |
| | Food delivery services | 1.74 | 1.18 | 1.75 | 1.29 | 1.04 | 1.17 | 1 → 1 → 1 |

**Table 7.** Financial characteristics of each industry

| | All indicators are high for all three years | First principal component score is high (more than 2 years) | Second principal component score is high (more than 2 years) | All indicators are low for all 3 years |
|---|---|---|---|---|
| Agriculture (11) | 0.0% (0) | 45.5% (5) | 36.4% (4) | 27.3% (3) |
| Manufacture of Food (14) | 14.3% (2) | 14.3% (2) | 35.7% (5) | 50.0% (7) |
| Wholesale Trade (Food and Beverages) (13) | 0.0% (0) | 7.7% (1) | 100.0% (13) | 0.0% (0) |
| Retail Trade (Food and Beverage) (16) | 0.0% (0) | 6.3% (1) | 25.0% (4) | 50.0% (8) |
| Eating and Drinking Places, Food Take–Out and Delivery Services (16) | 0.0% (0) | 6.3% (1) | 0.0% (0) | 93.8% (15) |

Note: The numbers in parentheses indicate the number of sub–categories.

Regarding the second principal component score (“productivity–related”), “Retail trade” remained high throughout the 3 years. Several sub–categories also changed from low to high: “Agriculture,” “Manufacture of food,” and “Retail trade.” In addition, several sub–categories changed from high to low: “Manufacture of food” and “Retail trade.” Meanwhile, “Agriculture” did not change from high to low. These results reveal that “Retail trade” consistently achieved a high “productivity–related” score during the COVID–19 pandemic.

We thus conclude that “Agriculture” was the most resilient among the agri–food supply chain industries during the COVID–19 pandemic. Within “Agriculture,” “Dairy cattle farming” and “Rice farming” are the most distinctive sub–categories. “Dairy cattle farming” changed from high to low “safety and profitability” in 2020, and from low to high in 2021. “Rice farming” remained high in “safety and profitability” during the COVID–19 pandemic. For these reasons, we examine the factors in these farming types in the next section.

**Table 8.** Change in principal component scores

| | | First principal component score | | | | Second principal component score | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Positive → Negative values | Positive → Positive values | Negative → Positive values | Negative → Negative values | Positive → Negative values | Positive → Positive values | Negative → Positive values | Negative → Negative values |
| "Safety and profitability" or "Productivity–related" | | low → high | low → low | high → low | high → high | low → high | low → low | high → low | high → high |
| 2021 / 2020 | Agriculture | 28.6% (2/7) | 71.4% (5/7) | 0.0% (0/4) | 100.0% (4/4) | 0% (0/7) | 100.0% (7/7) | 0.0% (0/4) | 100.0% (4/4) |
| | Manufacture of Food | 9.1% (1/11) | 90.9% (10/11) | 33.3% (1/3) | 66.7% (2/3) | 10.0% (1/10) | 90.0% (9/10) | 0.0% (0/4) | 100.0% (4/4) |
| | Wholesale Trade (Food and Beverages) | 0.0% (0/12) | 100.0% (12/12) | 0.0% (0/1) | 100.0% (1/1) | – (0/0) | – (0/0) | 0.0% (0/13) | 100.0% (13/13) |
| | Retail Trade (Food and Beverage) | 0.0% (0/14) | 100.0% (14/14) | 50.0% (1/2) | 50.0% (1/2) | 0% (0/11) | 100.0% (11/11) | 40.0% (2/5) | 60.0% (3/5) |
| | Eating and Drinking Places, Food Take Out and Delivery Services | 6.3% (1/16) | 93.8% (15/16) | – (0/0) | – (0/0) | 0% (0/16) | 100.0% (16/16) | – (0/0) | – (0/0) |
| 2020 / 2019 | Agriculture | 25.0% (2/8) | 75.0% (6/8) | 33.3% (1/3) | 66.7% (2/3) | 22.2% (2/9) | 77.8% (7/9) | 0.0% (0/2) | 100.0% (2/2) |
| | Manufacture of Food | 8.3% (1/12) | 91.7% (11/12) | 0.0% (0/2) | 100.0% (2/2) | 0% (0/8) | 100.0% (8/8) | 33.3% (2/6) | 66.7% (4/6) |
| | Wholesale Trade (Food and Beverages) | 7.7% (1/13) | 92.3% (12/13) | – (0/0) | – (0/0) | – (0/0) | – (0/0) | 0.0% (0/13) | 100.0% (13/13) |
| | Retail Trade (Food and Beverage) | 7.1% (1/14) | 92.9% (13/14) | 50.0% (1/2) | 50.0% (1/2) | 10.0% (1/10) | 90.0% (9/10) | 33.3% (2/6) | 66.7% (4/6) |
| | Eating and Drinking Places, Food Take Out and Delivery Services | 0.0% (0/15) | 100.0% (15/15) | 100.0% (1/1) | 0.0% (0/1) | 0% (0/16) | 100.0% (16/16) | – (0/0) | – (0/0) |

Note: The parentheses in "Positive → Negative values" indicate the number of sub–categories whose principal component scores changed from positive to negative / the number of sub–categories with positive principal component scores. The parentheses in "Positive → Positive values" indicate the number of sub–categories whose principal component scores didn't change from positive value / the number of sub–categories with positive principal component scores.

**Dairy cattle farming and rice farming**

*Dairy cattle farming*

Compared with other industries, "Dairy cattle farming" has a high level of safety and profitability. The first factor could be the structure of milk distribution in Japan. Raw milk is produced throughout the year; however, it is difficult for individual dairy farmers to respond to fluctuating supply and demand because of its perishability and lack of storability. Therefore, there is a designated milk producers' group system in Japan to stabilize the milk price and dairy farm management. Most dairy farmers sell their milk on consignment through designated organizations, and the share of sales through designated organizations is over 95% (Japan Dairy Council, 2016). The milk price for the following year is determined in milk price negotiations between the designated organizations and dairy manufacturers, and the same milk price is applied for the following one year. The milk price level is determined based on milk production costs, dairy farmers' income, and supply and demand trends for milk and dairy products.

The total milk price, which is the milk price received by dairy farmers, was raised in 2008 in response to the sharp rise in the price of compound feed since 2007 and has continued to rise since then (MAFF, 2022). As described above, dairy farming is more profitable than other industries in Japan because of its stable sales channels and prices, and safety is also considered to be at a high level because of this effect.

Next, we examine the factors that led to the decline in profitability and safety in 2020. During 2020, the Japanese government decided to temporarily close all elementary, junior high, and high schools from the beginning of March in response to the COVID–19 pandemic. The demand for school lunch milk and dairy milk products for commercial use sharply decreased. However, the supply–demand adjustment system of designated raw milk producer organizations was able to function, and raw milk waste was avoided in Japan by processing it into butter and other dairy products. Behind this achievement was the Japanese government's COVID–19 support program ("Supply and Demand Alleviation

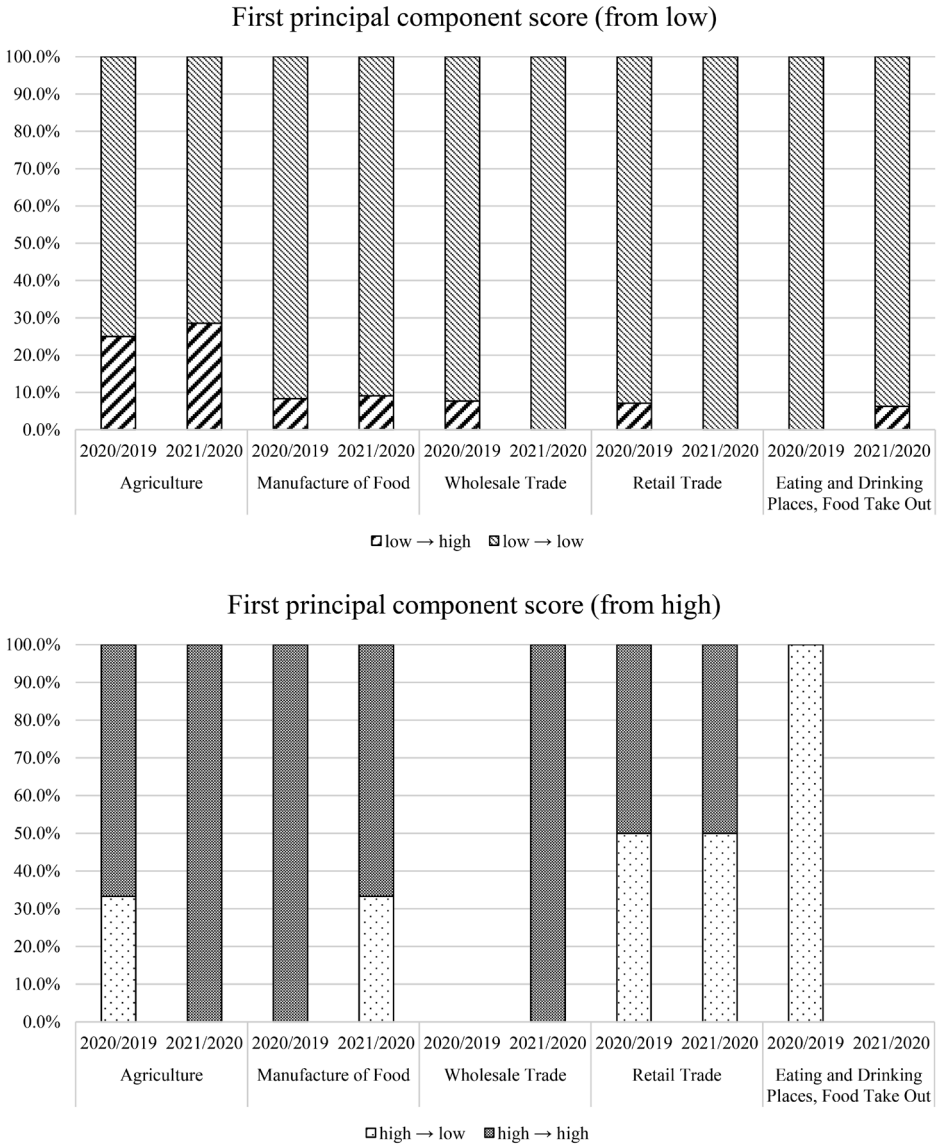


**Fig. 4.** Change in the first principal component scores

Project for School Milk Supply Disruption"), which paid producers the same price as if they had shipped school milk, even when the canceled raw milk for school milk was used for non–fat milk powder and other purposes (Oda 2020; Shimizuike 2021). However, the recession of inbound demand caused the market price of Japanese beef to sharply decrease, and the by–product income of dairy farmers was expected to decrease significantly (Oda, 2020). Thus, the impact of the decrease in demand for milk during the COVID–19 pandemic was limited, but the sharp decline in by–product income is expected to have worsened the profitability of dairy farming in 2020.

*Rice farming*

"Rice farming" showed high "safety and profitability" in all 3 years. One reason might be the impact of Japanese government policy support, such as subsidies (Nanseki, 2012; Omuro *et al.*, 2019). This study focuses on the ordinary profit margin as a profitability indicator, and the impact of the addition of non–operating income, such as subsidies and grants, is significant. Nanseki (2012) compared the ratio of ordinary income to total capital and the ratio of operating income to total capital for each farming type in Japanese farming corporations and found that the operating income ratio was negative for almost all farming types, but the ordinary income ratio was positive for "Rice farming" and "Dairy cattle farming," indicating that policy support, such as subsidies, has a large impact on the operating income ratio.

The second point is the realization of high value–added through direct sales to consumers. Kikushima (2018), who clarified the status of direct–to–consumer sales using individual data from the Census of Agriculture and Forestry in 2015, found that the percentage of corporate entities engaged in direct–to–consumer sales (excluding single household corporations) was the highest for paddy and upland rice (35.2%), fol-

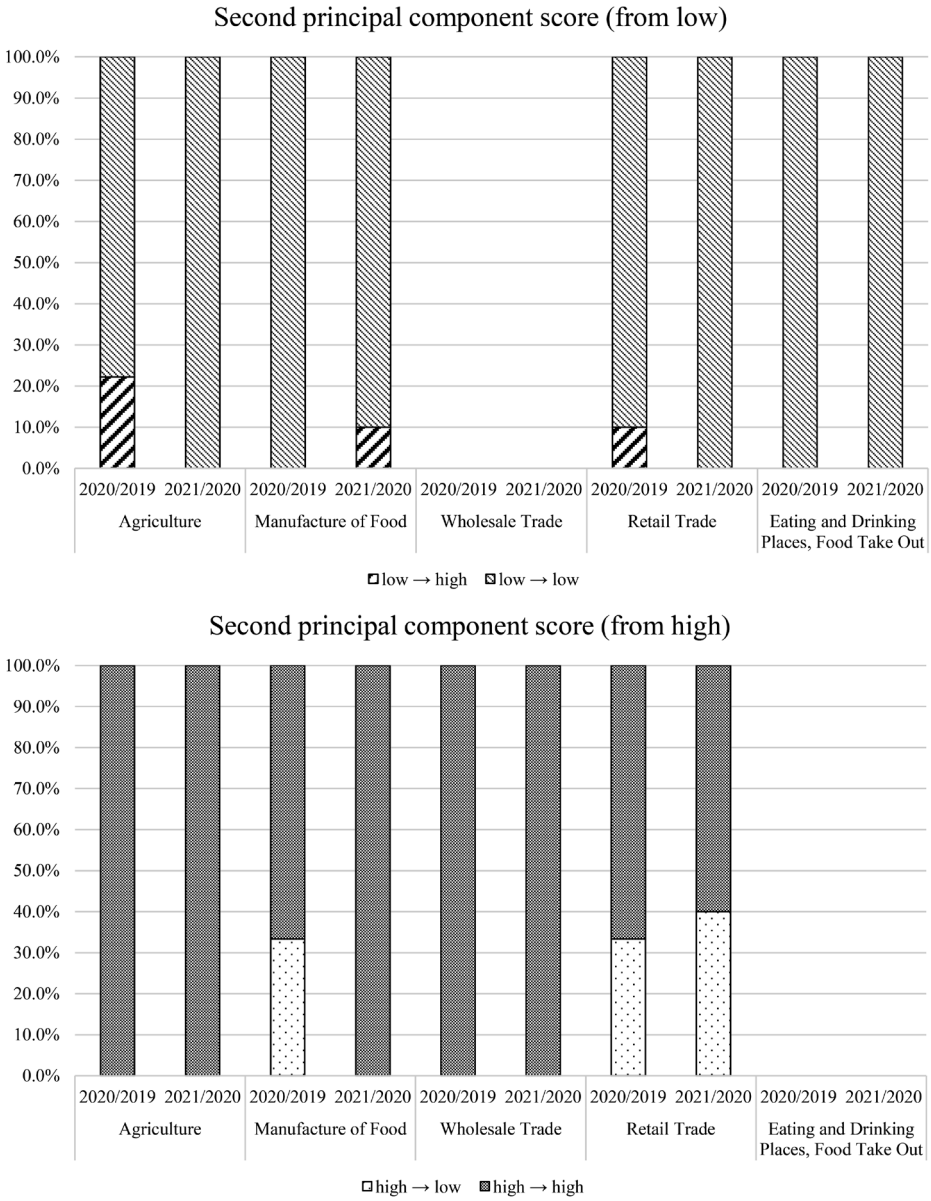


**Fig. 5.** Change in the second principal component scores

lowed by open–field vegetables (10.9%), fruit trees (10.7%), institutional vegetables (10.6%), and flowering plants (7.4%). This result indicates that many "Rice farming" firms engaged in direct sales to consumers and realized high value–added by optimizing the value chain, resulting in a high level of profitability, and consequently, a high safety level.

## CONCLUSIONS

This study investigated the impact of COVID–19 on the agri–food supply chain in Japan in terms of financial. We found that agriculture had high profitability and safety in the agri–food supply chain during the COVID–19 pandemic. Thus, agriculture was the most resilient among the agri–food supply chain industries. Based on these results, we identified potential factors that brought changes in profitability and safety in "Dairy cattle farming" during the COVID–19 pandemic: government support policies and a decline in beef consumption due to a drop in inbound demand. In addition, for "Rice farming," several factors may have contributed to high safety and profitability during the COVID–19 pandemic: the impact of Japanese government policy support, such as subsidies, and high value–added through direct sales to consumers.

Due to data limitations, this study included only SMEs and profitable firms. However, to understand the agri–food supply chain in more detail, it is necessary to examine the characteristics of large and loss–making firms as well. In addition, because of the seasonal characteristics of labor in some types of farming, such as rice farming, it would be effective to analyze sales and labor costs per worker by considering employee wages or labor costs per hour worked. We plan to research these issues in the future.

## AUTHOR CONTRIBUTIONS

All authors discussed the results and contributed to the final manuscript. Uenishi Yoshihiro suggested the original idea, performed empirical computations, and drafted the manuscript. Nanseki Teruaki designed the research framework, advised on data interpretation, and edited the manuscript.

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