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Swinging Unstable Market after the Great Depression:
Daily Rice Pricing of Japan's Futures and Spot Trades

Kiyotaka Maeda

Swinging Unstable Market after the Great Depression: Daily Rice Pricing of Japan’s Futures and Spot Trades*

Kiyotaka Maeda†

Keio University

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Abstract

This study quantitatively investigates daily rice prices in Osaka’s futures and spot markets from 1925 to 1939 to examine how the futures market served as the index price of the spot trade under the government’s frequent interventions. The functions of the futures market fundamentally varied with seasons in response to the rice harvest. After the Great Depression, the government extended its manipulations to control rice prices, and its interventions greatly reduced the futures market’s role at times other than during the harvest season. Consequently, the unstable futures market functionally swung in the 1930s.

Keywords: futures market, government intervention, agricultural product, Japan

JEL classification codes: C22, G13, N25

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† Department of Japanese History, Faculty of Letters, Keio University, 2-15-45 Mita, Minato-ku, Tokyo 108-8345, Japan; E-mail: k-maeda@keio.jp

1. Introduction

Economists have been discussing the roles and failures of the government and the market, and economic historians have investigated how the government dynamically interacts with the market. Particularly, they pay close attention to monetary policies and related financial markets (Barro and David 1983; Clarida, Gali, and Gertler 1999; Quennouëlle-Corre 2016, pp. 421–22). By contrast, there is little literature on commodity markets and related policies, whereas Federico (2013, p. 164) asserts that the government strengthened its intervention in commodity markets after the First World War (WWI). During the modern period, the futures market plays a crucial role in the pricing of commodity trade.

The futures market collects disseminated information to provide index prices for spot trading (Goss 1981, p. 150; 1986, p. 2). Japan has the longest commodity futures market history and traded rice in futures markets. Rice is a significant commodity in Japanese society. Asian people have consumed rice as a staple since ancient times, and the Japanese authorities collected rice as tax from farmers until the pre-modern period (Hane and Perez 2015, pp. 198–201; Latham and Larry 1983, p. 260). Japan established the rice futures market in Osaka at the end of the seventeenth century, and rice dealers traded in the futures market to hedge their risks until 1939 (Schaede 1989, pp. 499–502). Western countries also established futures commodity markets in the mid-nineteenth century, such as the Chicago Board of Trade in 1848 (Kaufmann 1984, p. 11). During the same century, the rice futures market in Osaka was transformed into a modernized commodity exchange, and the Osaka-Dojima Rice Exchange (ODRE) began operating in 1893 (Bakken 1966, pp. 12–13). At the beginning of the next century, governments tightened their regulations on commodity futures markets.

WWI altered the equilibrium of the commodity market. Specifically, agricultural production expanded in the Americas during WWI, and farm product prices plummeted after the war ended (Neal and Cameron 2016, p. 334). To respond to catastrophic situations, the United States (US) government enacted the Futures Trading Act of 1921 and the Grain Futures Act of 1922 to supervise and regulate futures markets (Markham 2014, pp. 44–56). The US government reinforced its regulation of the futures trade after the 1920s (Lurie 1980, pp. 233–56).

Other Western countries also strengthened their regulations and interventions in the market, and governments enlarged their roles during the interwar period. Even after WWI, countries participating in the war did not repeal their protectionist policies (Findlay and O'Rourke 2007, pp. 443–48). Furthermore, the Great Depression boosted the government's role. The US government launched protectionist policies to bolster the American economy and intervened in agricultural markets through the Commodity Credit Corporation and the Federal Farm Board (Fausold 1977, pp. 362–77; Rucker and Pasour 2007, pp. 459–62). European countries have also protected their domestic industries (Persson and Sharp 2015, p. 215); some imposed heavy tariffs and established quantitative restrictions on agricultural commodities (Fernández 2016, pp. 104–06). These policies led to the disintegration of the international commodity market (Hynes, Jacks, and O'Rourke 2012, pp. 119–43). Analogous to Western countries, as the next section circumstantially mentions, the Japanese government strengthened its control over the rice market after WWI and enacted new legislation to fortify its capacity in 1933. It considered rice policies to be food policies aimed at stabilizing general prices.

Rice price fluctuations were a fundamental cause of general price-level changes in Japan. Rice accounted for 13.1 percent of the weight of the Bank of Japan's 1933-based wholesale price index, whereas wheat accounted for only 1.6 percent (Bank of Japan, Research and Statistics Department 1987, p. 40). This measurement of the price index was based on the fact that rice was one of the most important goods in Japan's commodity futures markets until the 1930s. It held 69.5 percent of the commodity futures trade value from January 1923 to December 1932, while grain consisting of wheat and barley accounted for approximately 50 percent of the trade value in US commodity exchanges in 1921 (Figure A1; Carlton 1984, pp. 245, 247). In short, rice had two remarkable aspects during the interwar period in Japan: it was an object handled by economic policies and was a futures commodity. Hence, we focus on the relationship between the markets and rice policies in Japan to explore how the government's interventions affected pricing in the commodity futures market after the 1920s because few studies focus on the influence of the government's policies on the commodity market's performance.

Many scholars have studied the political history of government regulations and the manipulation of commodity futures markets during the interwar period. Economists, historians, and scholars of jurisprudence and public administration have analyzed futures market policies in the US since the 1980s (Keaveny 2005; Lurie 1980; Markham 1987; 2014; Stassen 1982). The latest literature investigates historical documents that were not utilized by previous studies, and Saleuddin (2018) analyzes the Chicago Mercantile Exchange Group Archive's documents. Antithetically, economic historians have finally scrutinized pricing in commodity futures markets since the late 2000s, along with the diffusion of cliometric techniques.

Previous studies have shed light on cases in the US and the United Kingdom (UK). Jacks (2007) and Harrison (2023) focus on the US's commodity futures markets. The former asserts that the futures market suppressed price volatility from the late nineteenth century to the mid-twentieth century, whereas the latter stresses that commodity market integration progressed after the 1910s. Cifarelli and Paesani (2016) analyze the Liverpool cotton futures market and maintain that speculative feedback trades became a major cause of price fluctuations during the interwar period. By contrast, Chambers and Saleuddin (2020) contend that copper and tin option prices approximated the Black-Scholes-Merton theoretical values on the London Metal Exchange during the same period. Although these studies employ advanced cliometric techniques, they do not extend their perspectives on the relationship between pricing in commodity futures markets and related policies. The literature on commodity futures markets in Japan shows the same tendency as that in the US and the UK.

Much literature exists on the history of rice policies and commodity exchanges in Japan. The former includes Kawahigashi (1990), Mochida (1970), and Omameuda (1993), whereas the latter includes Haneji (1989), Kotani (1953), and Teranishi (2011). However, there are only two quantitative studies on pricing in rice futures markets and related policies. Ito, Maeda, and Noda (2017) find that the government's policies to boost colonial rice distribution during WWI precluded appropriate rice pricing. Ito, Maeda, and Noda (2018) mention that the variation in the rice futures market's role in generating the index prices of the spot trade relied on fluctuations in the quality difference between domestic and colonial rice from the 1900s to the 1920s. However, these studies have two limitations.

The first limitation is the lack of an investigation into the period after 1933 when the government introduced new legislation to tighten the control of rice prices. The second limitation is the use of monthly data. Empirical studies on Japan's stock market before the Second World War employ a time-series analysis based on daily data to grasp minute changes in pricing (Bassino and Lagoarde-Segot 2015; Daglish and Moore 2013). High-frequency data are requisites for an accurate understanding of the continuous changes in the relationship between market pricing and related policies. This study tackles these limitations and quantitatively investigates the daily rice prices in the futures and spot markets in Osaka from 1925 to 1939. We examine how the futures market served the index prices of the spot trade under the government's frequent interventions.

The remainder of this paper is organized as follows. Section 2 provides a brief history of the rice market and government rice policies in Japan during the interwar period. Section 3 presents our time-series econometric models and analysis strategies for scrutinizing rice pricing in the futures and spot markets. Section 4 illustrates the properties of our daily price data and preliminary test results. Section 5 utilizes an impulse response function (IRF) analysis to indicate the time-varying structure of rice markets. Section 6 employs a historical decomposition (HD) technique to examine the relationship between pricing in rice futures and spot markets and the government's rice policies. Finally, Section 7 presents our conclusions.

2. Historical Settings

2.1. Rice Market During the First Half of the Twentieth Century

Japan experienced modernization and industrialization after the 1880s, and its population and living standards increased. These social changes promoted the expansion of rice demand, and the volume of rice consumption per capita grew until the 1910s. After the following decade, although the trend in rice consumption per capita was sustained, the total volume of rice consumption continued to increase because of population growth (Figure A2).

The mechanism behind the growth in the rice supply changed drastically by the end of the 1910s. Before this turning point, growth in domestic rice production led to an increase in the rice supply (Figure A3). Local governments constructed irrigation facilities in agricultural regions, and these utilities enabled farmers in Western Japan with a warm climate to utilize the double-cropping method (Ohkawa 1970, pp. 11–12). This change in farming methods boosted agricultural land productivity, and the production volume per hectare of rice paddy soared from approximately 15 *koku*s in the 1890s to approximately 19 *koku*s by the end of the 1910s (Figure A4).[1] However, the growth in domestic rice cultivation had not kept pace with the expansion in rice demand.

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[1] The "*koku*" is a standard unit of measurement in Japanese agriculture. One *koku* is equal to 180.39 liters and is roughly equivalent to 150 kilograms.

Japan increased its colonial rice imports from Taiwan and Korea after WWI (Figure A3). Japan established Taiwan and Korea as colonies in 1895 and 1910, respectively. These colonies initially cultivated rice breeds that were different from the domestic ones, and colonial rice did not suit the Japanese palate. Accordingly, colonial governments modified the rice breeds in Taiwan and Korea to ameliorate their taste and texture to make them similar to those of domestic rice. This countermeasure diffused colonial rice in Japan after the late 1910s (Ito, Maeda, and Noda 2017, pp. 331–33).

Improvements in cropping methods and the growth in colonial imports raised the rice supply in Japan. Nevertheless, these factors did not suppress supply fluctuations because climate change affected rice cultivation (Figure A3). Land productivity and rice prices oscillated annually (Figures A2 and A4). These properties forced rice dealers to face price volatility risk, and the futures trade functioned to hedge this risk.

There were 17 rice exchanges in August 1939, when the rice futures trade ceased because of wartime regulations. The two major rice exchanges, the ODRE and the Tokyo Rice and Merchandise Exchange, held 36.2 percent and 26.8 percent of the futures trade volume in all rice exchanges from January 1930 to August 1939 (Tokyo Stock Exchange, Investigation Department 1930a; 1930b; 1931–1939 (monthly series)). They handled more than 60 percent of the rice futures trade, and the ODRE thrived as the largest rice exchange in Japan. The rice futures trade in every exchange consisted of three contract types: deferred contracts (three months), second-nearest contracts (two months), and nearby contracts (one month). There were differences in trade volume among these contracts, with the deferred contract having the largest volume. From January 1930 to August 1939, in the ODRE, deferred contracts accounted for 65.1 percent of the total trade volume, while second-nearest and nearby contracts accounted for 21.3 percent and 13.6 percent, respectively (Osaka-Dojima Rice Exchange 1930–1935; 1936a; 1937–1939 (monthly series); Tokyo Stock Exchange, Investigation Department 1930a (monthly series)).

2.2. Skyrocketing Rice Prices and the Rice Riots

The government labeled the futures trade as a cause of the speculative increase in rice prices. Japan suffered from famine for two years starting in 1917, while enjoying consecutively abundant crops for three years until 1916 (Figure A4). Although this change in harvest conditions induced a surge in rice prices, the government misconstrued active purchases in the futures market as the reason for the sharp price movement in the spot market (Ministry of Agriculture and Commerce, Food Bureau 1924, p. 52; Figure A2). The Ministry of Agriculture and Commerce decided to suppress the speculative trade of essentials for life and enacted the *Bōri Torishimari Rei* (Ban on Anti-Excessive Profits) in September 1917.[2] Nevertheless, rice prices continued to skyrocket the following year because of famine and the overseas deployment of troops.

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[2] Nakashoji, Ren (Minister of Agriculture and Commerce). *Bōri wo Mokuteki to suru Baibai no Torishimari ni kansuru Shōrei Happu no Ken wo kettei su* (*The Decision of Issuance of the Ban of Anti-Excessive Profit*). National Archives of Japan. Rui-01265100. Tokyo, Japan, August 29 1917.

According to the Anglo-Japanese Alliance, Japan deployed its military force in Siberia in August 1918 as a part of WWI (Dunscomb 2011, pp. 55–56). This military action required large quantities of rice. Rice demand suddenly expanded, and traders hoarded rice, expecting higher prices. These circumstances raised rice prices considerably, and ordinary people fell into hardship (Figure A2). Consequently, the *Kome Sōdō* (Rice Riots) occurred in the summer of 1918. A few million protesters displayed disorderly behavior throughout the country and ousted the Terauchi Cabinet in September 1918 (Lewis 1990, pp. 11–15). The government utilized the Ban on Anti-Excessive Profits to crack down on speculative transactions in rice exchanges from the end of 1917. Eleven cases were detected from November 1917 to August 1918, and dealers in the ODRE engaged in five cases (Ministry of Agriculture and Commerce, Food Bureau 1924, pp. 66–68). The ODRE also imposed strict controls on speculative trade and punished 35 dealers from 1917 to 1919, while it had approximately 60 dealers (Osaka-Dojima Rice Exchange, 1917a, pp. 3–4; 1917b, p. 6; 1918b, p. 6; 1919a, p. 8; 1919b, pp. 7–8).

Japanese rice cultivation experienced abundant crops for two years beginning in 1919, and rice prices stopped increasing (Figures A2 and A4). However, the government maintained its hostile view of futures transactions even after 1921 and ordered the ODRE to strictly supervise trade and dealers in August 1922.[3] Through the Rice Riots, the Japanese government realized the importance of rice market control. Accordingly, the government provided the necessary legislation.

2.3. Market Control by the Rice Law

The government enforced the *Beikoku Hō* (Rice Law) to adjust the balance of the rice supply and demand on 4 April 1921. This law allowed the government to sell or purchase rice when the rice market faced a shortage or excess supply.[4] However, it did not stipulate that the government could trade in response to price fluctuations. The law required the government to estimate the balance between the rice supply and demand before intervening. Accordingly, the government could not quickly respond to the sudden movement in rice prices and revised the Rice Law three times after 1925 (Ministry of Agriculture and Forestry 1959, pp. 173–74).

The government enforced the first, second, and third revised laws on 1 November 1925, 1 July 1931, and 4 October 1932, respectively. The first revised law empowered it to intervene directly in

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[3] Tsurumi, Sakio (Chief, Commercial Bureau, Ministry of Agriculture and Commerce). *Osaka Dojima Beikoku Torihikijo Rijichō ate Tsūchō, Kaisei Torihikijo Hō Shikō no Ken* (*Notice of the Revised Exchange Law to the president of the Osaka-Dojima Rice Exchange*). Kansai University Library. Dōjima Kome Shijō Monjo 1-101. Suita City, Osaka Prefecture, Japan, 30 August 1922.

[4] Yamamoto, Tatsuo (Minister of Agriculture and Commerce). *Beikoku Hō An Riyūsho* (*The Statement of Reason of the Establishment of the Rice Law*). National Archives of Japan. Rui-01405100. Tokyo, Japan, 16 February 1921.

the market to adjust rice prices.[5] Nevertheless, the government faced difficulties in controlling prices because the first revised law did not state the criteria for government intervention. The second revised law clearly indicated these criteria. According to this law, the government fixed the maximum and minimum rice prices by deliberating on fluctuations in rice and general prices. When rice prices deviated from the range between the maximum and minimum prices, the government intervened in the rice spot market.[6] During the same period, the depression and decreased rice prices negatively affected farmers' lives.

Japanese farmers earned income from agriculture and sericulture. The latter was one of the representative side businesses in farming villages, and raw silk was Japan's most significant export commodity to the US from the end of the nineteenth century to the 1930s (Hemmi 1970, pp. 312–13). However, the Great Depression of 1929 had a tremendous negative impact on Japan's raw silk market. From 1929 to the following year, raw silk prices and export values decreased by 34 percent and 47 percent, respectively (Bank of Japan, Research and Statistics Department 1987, p. 51; Kobara 1935, pp. 376–77). Furthermore, Japanese agriculture experienced bumper crops in 1930 and rice prices fell significantly the following year (Figures A2 and A4). The Great Depression and the plummeting prices of agricultural products caused the Showa Depression. These depressions suppressed rice prices until 1934 (Figure A2). Farmers faced a reduction in their income and suffered poverty (Gordon 2009, p. 182). This situation required the government to strengthen its control over rice prices.

The government enforced its third revised Rice Law in October 1932. This law stipulated that the government should factor in rice production costs when deciding minimum prices. This was a support measure for farmers. The Imperial Diet discussed further agricultural assistance measures.

Japanese politics introduced a two-party system in the 1920s: the *Rikken Seiyūkai* (Association of Friends of Constitutional Government: AFCG) and *Rikken Minseitō* (Constitutional Democratic Party). On 4 June 1928, the Kwantung Troop of the Japanese Army assassinated Zhang Zuolin, General of the Fengtian clique in China, without the Japanese government's order. This incident reversed the standings between the governing and opposition parties and resulted in the banishment of the AFCG from politics in July 1929. The AFCG planned to strongly support the farmers in winning the next election. It proposed the introduction of the Rice Monopoly System to rigidly control rice prices in August 1931 (Confederation of Japanese Exchanges, Executive Board of Rice Division 1932, pp. 1–4). This proposal stimulated discussions on the stabilization of rice prices. The government established the *Beikoku Tōsei Chōsakai* (Investigation Committee on Rice Control) to incorporate the plan for rice

[5] Ministry of Agriculture and Forestry. *Setsumei: Beikoku Hō chū Kaisei Hōritsu An* (*Explanations: Draft of the Revised Rice Law*). National Archives of Japan. Hei12-Nōsui00002100. Tokyo, Japan, 24 January 1925.

[6] Machida, Chuji (Minister of Agriculture and Forestry), Inoue Junnosuke (Minister of Finance), and Matsuda, Genji (Minister of Colonial Affairs). *Beikoku Hō chū Kaisei Hōritsu An Riyūsho* (*The Statement of Reasons of the Revised Rice Law*). National Archives of Japan. Rui-01759100. Tokyo, Japan, 23 January 1931.

price control in November 1932.[7] Finally, it abolished the third revised Rice Law on 31 October and enforced the *Beikoku Tōsei Hō* (Rice Control Law) on 1 November.[8]

2.4. The Rice Control Law and Wartime Regime

The Rice Control Law strengthened the promptness, autonomy, and scale of the government's authority to control rice prices (Ministry of Agriculture and Forestry 1959, pp. 206–07). First, the government acquired the ability to respond quickly to fluctuations in rice prices. Under the Rice Law, it received permission from the *Beikoku Iinkai* (Rice Committee) before intervening in the rice market. By contrast, the Rice Control Law did not require the government to obtain clearance from the committee. This shortened procedure improved the promptness of government price controls. Second, the Rice Control Law offered autonomy over the government's control of rice prices. The government autonomously determined intervention prices to steer market prices, while the Rice Law mandated that the government purchased and sold rice at market prices. Third, the Rice Control Law increased the scale of government intervention. The government raised the budget for purchasing rice by 37 percent, from 350 million yen to 480 million yen (Omameuda 1993, pp. 296–97).

The Rice Control Law was characterized by the above features and increased the scale and frequency of government intervention. Figure 1 shows the monthly volume of domestic rice supplied by the government from April 1921 to December 1937.[9]

During the Rice Law's operation, the government occasionally intervened in the rice spot market, and the intervention volume was less than 0.5 million *koku*s. By contrast, after enforcing the Rice Control Law in November 1933, it intervened nearly every month and increased its intervention volume. The Rice Control Law intensified the government's activities to control rice prices. Furthermore, in 1936, the government acquired the ability to adjust the inflow volume from production areas to distribution and consumption regions.

Rice prices remained low until 1934, and farmers suffered from poverty even after the Rice Control Law was enforced in 1933 (Figure A2). In response, the government established the *Beikoku Taisaku Chōsakai* (Committee on the Rice Problem) in September 1934 to investigate countermeasures.[10] The committee recommended that the government should create the *Beikoku Jichi*

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[7] Investigation Committee on Rice Control. *Beikoku Tōsei Chōsakai Kansei* (Edict of the Investigation Committee on Rice Control). National Archives of Japan. Hei15-Zaimu00309100. Tokyo, Japan, 8 November 1932.

[8] Ministry of Agriculture and Forestry. *Beikoku Tōsei Hō Shikō Kijitsu no Ken* (*Implementation date of the Rice Control Law*). National Archives of Japan. Hei12-Nōsui00011100. Tokyo, Japan, 22 September 1923.

[9] There is no date on the intervention volume after January 1938.

[10] The Cabinet. *Beikoku Taisaku Chōsakai Kansei wo sadamu* (*Enactment of the Committee on Rice Problem*). National Archives of Japan. Rui-01849100. Tokyo, Japan, 31 August 1934.

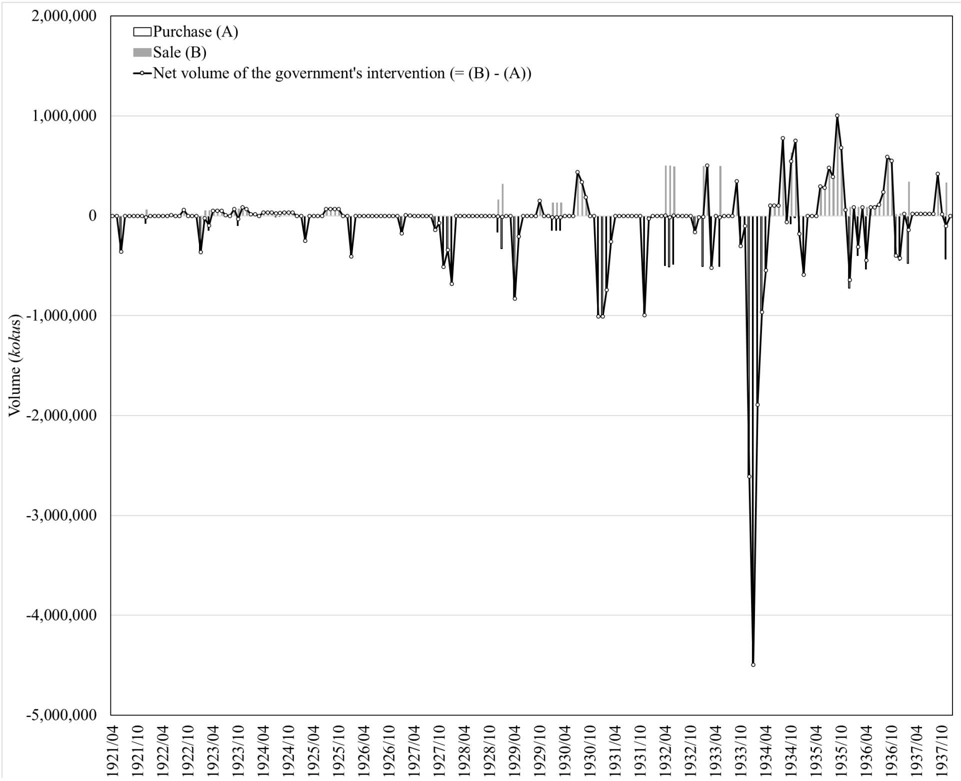

Figure 1

Government's supply of domestic rice in Japan (April 1921–December 1937)

Sources: Ministry of Agriculture and Commerce, Food Bureau 1922–1923, 1925a, 1925b; Ministry of Agriculture and Forestry, Agricultural Bureau 1926–1930; Hasumi 1957; Ota 1938.

Kanri Hō (Rice Autonomous Management Law) in January 1935.[11] In compliance with this recommendation, the government promulgated and enforced the law on 28 May and 20 September 1936, respectively. This law enabled the government to force production areas to store excess rice in exchange for subsidies.[12] When rice farmers had abundant crops, the government could reduce the inflow of rice in the spot market to prevent a decrease in prices. Nevertheless, it did not invoke this law since rice prices skyrocketed after 1935 (Figure A2; Ministry of Agriculture and Forestry 1959, pp. 250–51).

The Japanese government strengthened its ability to control rice prices in the spot market in 1925 and gained power to manipulate rice distribution in 1936. These policies were transformed in 1937 when Japan initiated a wartime regime.

Japan and China exchanged gunfire at the Marco Polo Bridge Incident in the suburbs of Beijing on 7 July 1937. Then, they expanded their hostility and launched the Second Sino-Japanese War

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[11] Committee on Rice Problem. *Beikoku Taisaku An* (*Plan of Rice Control*). National Archives of Japan. San-02124100. Tokyo, Japan, 19 January 1935.

[12] The Cabinet. *Beikoku Jichi Kanri Hō no Shikō Kijitsu wo sadamu* (*Implementation date of the Rice Autonomous Management Law*). National Archives of Japan. Rui-01994100. Tokyo, Japan, 15 September 1936.

(Tanaka 2023, pp. 140–42). The Japanese government constituted wartime legislation and enforced the *Kokka Sōdōin Hō* (National Mobilization Law) on 5 May 1938.[13] Wartime legislation attempted to maximize Japan's industrial and agricultural production capacities.[14] This regime compelled rice policies to secure and control necessities (Ministry of Agriculture, Forestry and Fisheries 1980, pp. 321–22). Finally, the government enacted the *Beikoku Haikyū Tōsei Hō* (Rice Distribution Control Law) on 11 April 1939.[15] This law forbade the rice futures trade because the government directly controlled the prices and distribution of staple food. Thus, all rice exchanges had abolished their futures markets by the end of August 1939.

This section explores the government's control of the rice market from the 1910s to the 1930s and reveals two points. First, the government regarded the futures trade as a cause of disturbances in the spot market and cracked down on dealers in exchanges. Second, it intervened in the spot market to control rice prices after the first revision of the Rice Law and changed legislation frequently until the end of the 1930s. Accordingly, we focus on the relationship between futures and spot prices and the influence of government policies on rice pricing. The next section examines the methodology used to investigate these two points.

3. Methodology

We apply a four-dimensional vector error correction (VEC) model using spot prices and three series of futures prices: deferred, second-nearest, and nearby contracts. The VEC model originates from the following vector autoregressive model:

$$\boldsymbol{y_t} = \boldsymbol{v} + \sum_{i=1}^{p} \boldsymbol{A_1^i}\, \boldsymbol{y_{t-i}} + \boldsymbol{\varepsilon_t} \qquad (1)$$

where $\boldsymbol{y_t} = [y_{1t}, y_{2t}, y_{3t}, y_{4t}]'$: y_{1t}, y_{2t}, y_{3t}, and y_{4t} are the futures prices of the deferred, second-nearest, and nearby contracts, and the spot prices, respectively; $\boldsymbol{v}$ is a four-dimensional constant vector; $\boldsymbol{A_1^i}$ is a four-by-four parameter vector; and a four-dimensional white-noise vector $\boldsymbol{\varepsilon_t} = [\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}]'$.

We subtract $\boldsymbol{y_{t-1}}$ from both sides of Equation 1 and present the results in Equation 2:

$$\Delta\boldsymbol{y_t} = \boldsymbol{v} + \boldsymbol{\Pi}\boldsymbol{y_{t-1}} + \sum_{i=1}^{p} \boldsymbol{\Gamma_i}\Delta\boldsymbol{y_{t-i}} + \boldsymbol{\varepsilon_t} \qquad (2)$$

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[13] The Cabinet. *Kokka Sōdōin Hō wo sadamu* (*Enactment of the National Mobilization Law*). National Archives of Japan. Rui-02157100. Tokyo, Japan, 31 March 1938.

[14] The Cabinet. *Gunjyu Kōgyō Dōin Hō no Tekiyō ni kansuru Hōritsu wo sadamu* (*Enactment of the Applicable Law of the Military Industry and Mobilization Act*). National Archives of Japan. Rui-02075100. Tokyo, Japan, September 9 1937.

[15] The Cabinet. *Beikoku Haikyū Tōsei Hō wo sadamu* (*Enactment of the Rice Distribution Control Law*). National Archives of Japan. Rui-02262100. Tokyo, Japan, 29 March 1939.

where a coefficient matrix $\boldsymbol{\Pi} = \sum_{j=1}^{p} \boldsymbol{A_j} - \boldsymbol{I_m}$ contains a loading matrix $\boldsymbol{\alpha}$ and a cointegration matrix $\boldsymbol{\beta}$, such that $\boldsymbol{\Pi} = \boldsymbol{\alpha\beta'}$. If the cointegration order is r, both matrices $\boldsymbol{\Pi}$ and $\boldsymbol{\Gamma_i} = -\sum_{j=i+1}^{p} \boldsymbol{A_j}$ have r values less than four. Finally, the VEC model is as follows:

$$\Delta \boldsymbol{y_t} = \boldsymbol{v} + \boldsymbol{\alpha\beta' y_{t-1}} + \sum_{i=1}^{p} \boldsymbol{\Gamma_i} \Delta \boldsymbol{y_{t-i}} + \boldsymbol{\varepsilon_t} \tag{3}$$

Using the calculated parameters of the VEC model, we estimate a vector autoregressive model to apply innovation accounting that stems from a vector moving average (VMA) representation. The VMA form can be expressed as follows:

$$\boldsymbol{y_t} = \boldsymbol{\mu} + \sum_{i=0}^{\infty} \boldsymbol{\phi_i \varepsilon_{t-i}} \tag{4}$$

where $\boldsymbol{\mu} = (\boldsymbol{I} - \boldsymbol{A_1 L})^{-1} \boldsymbol{v}$ and $\boldsymbol{\phi_i} = \boldsymbol{A_1^i}$. Equation 4 is a VMA representation, enabling us to compute an IRF. We supply a standard deviation unit of impulse on the disturbance term in the zero period in Equation 4 and multiply the parameters by the impulses in each period to compute the IRF. The IRF indicates the time path of various shocks to variables in a VEC system (Sims 1980). We then apply an IRF analysis to capture the government's political influence on pricing in the futures and spot markets. The IRF analysis procedure consists of four steps.

First, we divide the entire sample into multiple subsamples according to the alterations in the government's legislation for controlling rice prices. Second, we utilize subsamples and estimate multiple VEC models. Third, we employ the parameters derived from the estimated VEC models to compute the IRFs. Fourth, we compare the IRFs stemming from the different subsamples. The distinction between the IRFs demonstrates that pricing in the futures and spot markets varied with changes in the government's control of rice prices. If we detect this distinction, we apply an additional analysis to precisely identify the relationship between government policies and rice pricing.

Balcilar et al. (2018) assert that an IRF cannot grasp the influence of a subsequent shock on the variables and illustrates only the average structure of the market. By contrast, Burbidge and Harrison (1985) propose an HD that captures the cumulative effects of subsequent shocks and the variability of relative shocks (Kilian and Lütkepohl 2017). This method is based on the VEC model in Equation 4 and is specified as follows:

$$\boldsymbol{y_{t+j}} = \sum_{i=0}^{j-1} \boldsymbol{\psi_i \varepsilon_{t+j-i}} + \left[\boldsymbol{X_{t+j} \beta} + \sum_{i=j}^{\infty} \boldsymbol{\psi_i \varepsilon_{t+j-i}} \right] \tag{5}$$

where $\boldsymbol{y_{t+j}}$ is a multivariate stochastic process; $\boldsymbol{\varepsilon}$ is its multivariate noise process; $\boldsymbol{X}$ is the deterministic part of $\boldsymbol{y_{t+j}}$; and $\boldsymbol{i}$ is the number of periods. The first term on the right-hand side represents the part of $\boldsymbol{y_{t+j}}$ caused by the shock and the second term illustrates the prediction of the price series stemming from information at time $\boldsymbol{t}$ indicating the event date. We run the HD analysis using the entire sample to investigate consecutive changes in rice pricing.

This methodology requires a large number of data points on rice prices. For this, we use the ODRE's historical documents to create our own high-frequency datasets.

4. Data

4.1. Data Sources

The official statistics of the Japanese government report only monthly rice price data, and many previous studies refer to the Ministry of Agriculture and Commerce, Commercial Bureau (1925–1926), Ministry of Commerce and Industry, Commercial Bureau (1927–1929; 1933–1940), and Ministry of Commerce and Industry (1930–1932). However, we need to explore daily prices, because the investigation of monthly prices cannot reveal the government's political influence on rice pricing. The government frequently changed the legislation for rice price control during the 1920s and the following decade and the monthly price data do not provide a sufficient sample size to obtain accurate results. For example, the government implemented the second and third revisions of the Rice Law in July 1931 and October 1932, respectively; hence, it revised the law again after only 15 months from the previous revision. No econometric technique can accept only 15 pieces of price data; hence, an increase in sample size is required. To overcome this problem, we do not rely on published official statistics; rather, we discover historical documents issued by the ODRE to construct daily price data.

There were only a few historical documents on the futures trade in Japan until the 1930s since the US Armed Forces repeatedly carried out air raids on most Japanese cities from 1942 to 1945 (Totman 2014, p. 447). These assaults burned massive amounts of historical material stored in cities. Nevertheless, the ODRE's historical documents miraculously survived. The ODRE abandoned its operations in 1939 and moved its documents to Kansai University in Osaka Prefecture (Kansai University Library 1960, p. 179). This university was located in Chisato Village, which was merged with three adjacent towns and villages in Suita City in 1940 (Kansai University, Editorial Committee of the Seventy Years' History 1956, pp. 5, 232; Suita City Office 1989, pp. 283–85). This city is approximately 10 km from the center of Osaka City, where the US launched 28 massive air strikes in 1945 (Osaka City Office 1953, pp. 620–26). Suita suffered only minor war damage (Suita City Office 1989, p. 285). Thus, we collaborated with the Kansai University Library to employ the rare documents and records of the ODRE.

These documents supply the daily futures prices of the three contract months in the ODRE from 1 September 1914 to 19 August 1939. The ODRE recorded the daily prices of all contract months in a ledger entitled *Kome Seisan Torihiki Sōbahyō* (*Price Table of Rice Futures Trade*), and this material provides the daily prices from September 1914 to December 1920.[16] During this period, the ODRE also recorded the daily trade volume of every contract month in another ledger entitled *Genzai Torikumidaka Baibaidekidaka oyobi Tesūryō Shūnyūdaka Hōkokuhyō* (*Daily Report of Open Interest, Trade Volume,*

[16] Osaka-Dojima Rice Exchange. *Kome Seisan Torihiki Sōbahyō, Yori Taisho 3-nen Itaru Showa 9-nen* (*Price Table of Rice Futures Trade, 1914–1934*). Kansai University Library. Dōjima Kome Shijō Monjo 1-87. Suita City, Osaka Prefecture, Japan, 1914–1934.

and Commission Revenue).[17] In January 1921, it began to issue the monthly report entitled *Osaka-Dojima Beikoku Torihikijo Seisanbu Geppō* (*Monthly Report of the Osaka-Dojima Rice Exchange*), which includes the daily prices and trade volume of all contract months. We use these documents as data sources for daily prices and trade volumes in futures markets (Osaka-Dojima Rice Exchange 1921–1926; 1927a; 1928–1939). By contrast, acquiring daily spot prices is an arduous task.

Data sources indicating continuous daily spot prices in Osaka until October 1925 do not exist; however, we can obtain data after November 1925 from two data sources. The first is the Ministry of Agriculture and Forestry Rice Bureau (1937), which contains data from November 1925 to April 1937. The second is *Osaka Asahi Shimbun* (1937–1939), a major daily newspaper in Osaka, which provides the same kind of data for the remaining period until August 1939.[18] The futures and spot price data include various types of data breaches.

4.2. Data Breaches

Primarily, the futures and spot markets were closed every Sunday; hence, our data include six prices in each series per week. Furthermore, there are three other types of breaches. The first is regular holidays, which consist of national holidays and religious ceremonies at the Imamiya Ebisu Shrine and Osaka Tenmangu Shrine near the ODRE (Table A1). The second type is temporal national holidays, which comprise four types of events: military reviews attended by the emperor, state funerals, imperial ceremonies, and religious ceremonies at the Meiji Jingu Shrine, Ise Jingu Shrine, and Atsuta Jingu Shrine (Table A2). These shrines were closely related to the Imperial Family. The third type is a temporary trade suspension, which can be caused by four things (Table A3).

The first is the government's order. In April 1927, the government ordered all rice exchanges to suspend futures trading. From March to May 1927, Japan faced a banking panic, and 11 private banks went into liquidation (Flath 2014, p. 58). Under this upheaval in the domestic financial market, the government issued a moratorium in April 1927 directing financial institutions to extend payments. According to this order, the ODRE suspended its operations from 22 April to 13 May 1927 (Osaka-Dojima Rice Exchange 1927b, p. 2). The second reason is the ODRE's decision to resolve market disturbances. The ODRE occasionally stopped its futures trade to calm turmoil when futures prices

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[17] Osaka-Dojima Rice Exchange. *Genzai Torikumidaka Baibaidekidaka oyobi Tesūryō Shūnyūdaka Hōkokuhyō, Yori Meiji 45-nen Itaru Taisho 5-nen* (*Daily Report of Open Interest, Trade Volume, and Commission Revenue, 1912–1916*). Kansai University Library. Dōjima Kome Shijō Monjo 3-3. Suita City, Osaka Prefecture, Japan, 1912–1916; Osaka-Dojima Rice Exchange. *Genzai Torikumidaka Baibaidekidaka oyobi Tesūryō Shūnyūdaka Hōkokuhyō, Yori Taisho 6-nen Itaru Taisho 10-nen* (*Daily Report of Open Interest, Trade Volume, and Commission Revenue, 1917–1921*). Kansai University Library. Dōjima Kome Shijō Monjo 3-4. Suita City, Osaka Prefecture, Japan, 1917–1921.

[18] *Osaka Asahi Shimbun*, various dates (2 May 1937–26 August 1939). We browse this newspaper by utilizing the Asahi Shimbun Cross-Search (https://database.asahi.com/index.shtml), an online article database provided by the Asahi Shimbun Company in Japan.

skyrocketed. The third reason is natural disasters such as typhoons halting Osaka's regular functioning. For example, the ODRE closed its market on 21 September 1934 after a heavy typhoon hit Osaka and destroyed major warehouses. The ODRE could not deliver rice and suspended trade in nearby contracts from 25 to 29 September 1934. The fourth reason is coup attempts. Japan experienced coup attempts by military officers on 15 May 1932 and 26 February 1936, resulting in the ODRE stopping trading on 16 May 1932 and over 26–29 February 1936, respectively.

As our daily dataset contains these breaches, we analyze only the days when the ODRE operated its futures market. We ignore these breaches and connect the data before and after suspension. These connected data include a few breaches of nearby contracts every month because the expiration date of nearby contracts was a few days earlier than that of the other contracts. A nearby contract was required to ensure sufficient days to deliver physical rice. Therefore, we disregard these breaches and connect them to the remaining data.

In contrast to futures prices, the spot market closed for only nine days after November 1925, when the ODRE was in operation. We apply the Catmull-Rom spline interpolation technique to interpolate the nine missing spot prices (Catmull and Rom 1974). The completed dataset includes 3,762 observations in each series from 2 November 1925 to 19 August 1939.

4.3. Preliminary Analyses

Figure 2 shows the daily futures and spot rice prices in Osaka from 2 November 1925 to 19 August 1939.

We take the first difference in the natural log of the four rice price series to satisfy the stationarity condition and obtain a sample of 3,761 observations. We divide the entire sample into five subsamples according to the enforcement of the legislation for controlling rice prices: the second revised Rice Law on 1 July 1931, the third revised Rice Law on 4 October 1932, the Rice Control Law on 1 November 1933, and the Rice Autonomous Management Law on 20 September 1936. These five subsamples contain 1,517, 351, 298, 792, and 803 observations, respectively (Table A4). Before estimating the VEC models, we conduct the unit root test, seasonal-trend decomposition procedure based on local regression (STL), and cointegration test in the preliminary analysis.

As the first step in the preliminary analysis, we apply the augmented Dickey-Fuller and Phillips-Perron tests as unit root tests to confirm whether the data satisfy the stationarity condition. The augmented Dickey-Fuller test uses the Akaike information criterion to select the optimal lag length. The Phillips-Perron test adopts Newey and West's (1987) method based on the Bartlett kernel to fix the optimal bandwidth. These tests indicate that the first difference in the natural log of all price series satisfies the stationarity condition (Table A4).

The second step of the preliminary analysis is the STL analysis. The rice trade fluctuated seasonally, and the trade volume increased during the harvest season. Japanese farmers harvest rice from September to November, and rice circulation expanded before and after the year-end during the first half of the twentieth century. The volume of rice stocked in Osaka tended to peak in December or

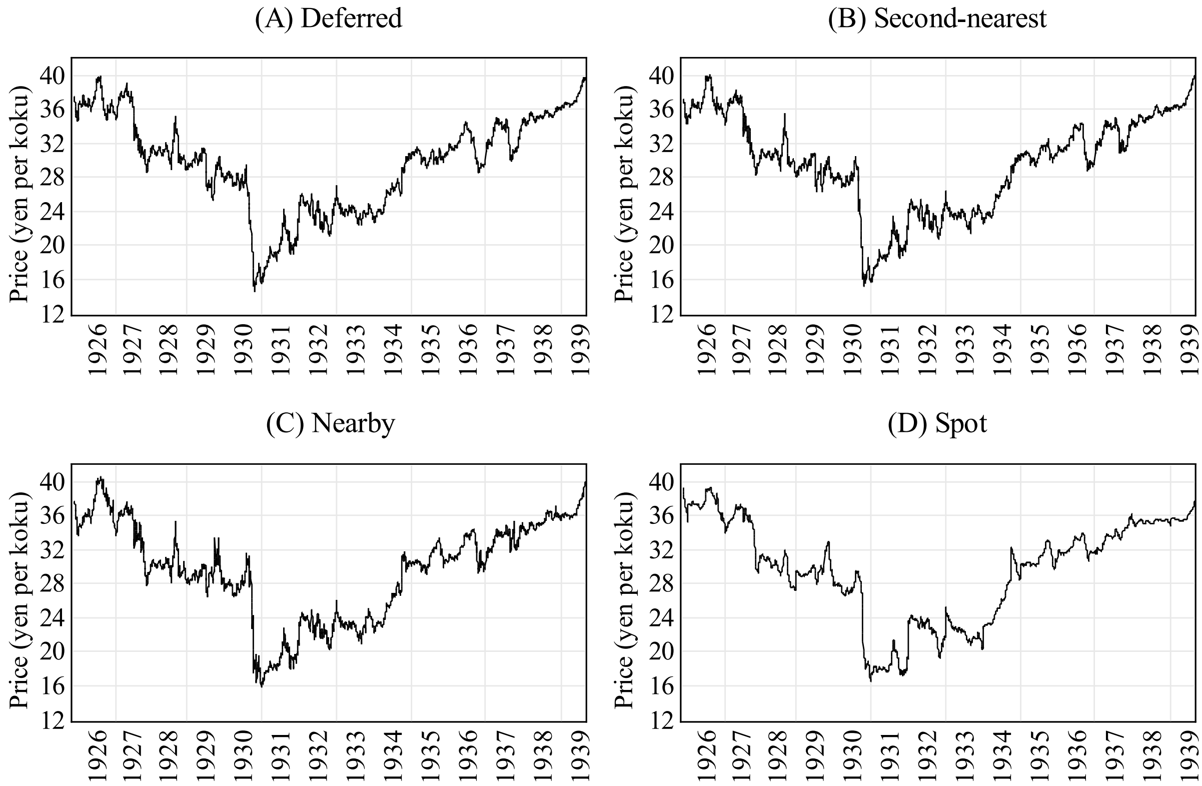


Figure 2

Futures and spot prices of rice in Osaka (2 November 1925–19 August 1939)

Sources: Ministry of Agriculture and Forestry, Rice Bureau 1937; Osaka Asahi Shimbun 2 May 1937–26 August 1939; Osaka-Dojima Rice Exchange 1921–1924, 1925a, 1926a, 1927a, 1928–1935, 1936a, 1937a, 1938a, 1939; *Kome Seisan Torihiki Sōbahyō, Yori Taisho 3-nen Itaru Showa 9-nen* (*Price Table of Rice Futures Trade, 1914–1934*). Kansai University Library. Dōjima Kome Shijō Monjo 1-87. Suita City, Osaka Prefecture, Japan, 1914–1934.

January between 1926 and 1939 (Figure A5). The futures market thrived during the harvest season. Figure 3 shows the daily volume of the rice futures trade in the ODRE from November 1925 to August 1939.

Deferred contracts held approximately 70 percent of the total futures trade volume in the ODRE, and its volume tended to increase during the fall. Therefore, we should assume the possibility that price data exhibit seasonality.

Econometric studies ordinarily utilize seasonal unit root tests such as the HEGY and Canova and Hansen tests to confirm the seasonality of data (Canova and Hansen 1995; Hylleberg et al. 1990). These tests require the periodicity to be set according to the data frequency. For example, the periodicity of monthly data is 12. However, fixing the periodicity of our data is difficult because the number of observations per year fluctuates from 250 to 277. Alternatively, we apply the STL analysis to the entire sample to confirm seasonality.

Cleveland et al. (1990) suggest the following basic idea of the STL analysis:

$$\boldsymbol{Y}_v = \boldsymbol{T}_v + \boldsymbol{S}_v + \boldsymbol{R}_v \tag{6}$$

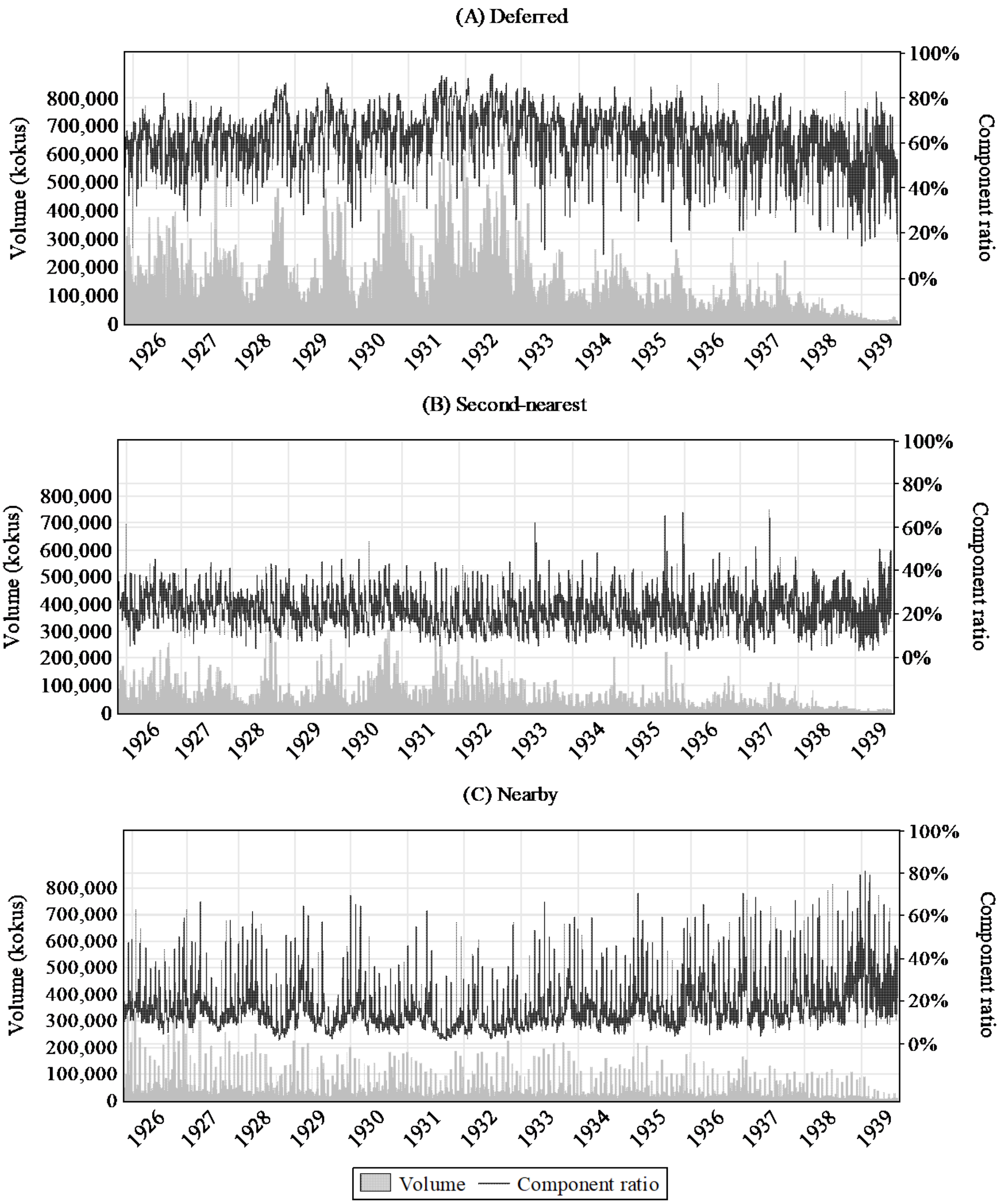


Figure 3

Daily volume of the rice futures trade in the ODRE (2 November 1925–19 August 1939)

Sources: Osaka-Dojima Rice Exchange 1925a, 1926a, 1927a, 1928–1935, 1936a, 1937a, 1938a, 1939.

where $\boldsymbol{Y}_v$, $\boldsymbol{T}_v$, $\boldsymbol{S}_v$, and $\boldsymbol{R}_v$ represent the price, trend, seasonal, and remainder components, respectively. We assign 272, 23, 437, and 273 as the cycle specification, seasonal smoothing parameter, trend smoothing parameter, and smoothing parameter of the low-pass filter, respectively, following Cleveland et al. (1990). The cycle specification is the annual average number of observations. The results of the STL analysis show that the seasonal components of the four price series border on zero (Figure A6), suggesting that we can ignore the seasonality of the price data. The conversion of the original price data into the first difference of the natural log of the data removes such seasonality.

The final step of the preliminary analysis is a cointegration test. A VEC model requires data with cointegration relationships. We apply Johansen's (1991) trace test to the natural log of the entire sample and five subsamples. This test rejects at least one null hypothesis at the one percent significance level: $r = 0$ (no cointegration). It also indicates the number of cointegration relationships among the variables of each sample as requisite information for VEC estimations (Table A5).

The next section utilizes the five subsamples and employs IRF analysis to investigate whether changes in the government's rice policies affected rice pricing in the futures and spot markets.

5. IRF Analyses on the Subsamples

5.1. VEC Estimation and IRF Computation

We apply the lag exclusion Wald test to the subsamples to obtain the optimal lag length for the VEC estimations (Panels A to E of Table A6). This study estimates five VEC models by utilizing the optimal lag length and number of cointegration relationships derived from Johansen's (1991) trace test (Table A5 and Panels A to E of Table A7).

We use these five estimated VEC models to compute the IRFs. Before calculating the IRFs, we determine the Cholesky order as follows: deferred, second-nearest, nearby futures prices, and spot prices. This sequence of futures prices is followed by the trade volume in the ODRE, as Figure 3 shows. Finally, we compute five IRFs for the subsamples. Each panel of Figure 4 shows the IRFs of the subsamples in each period.

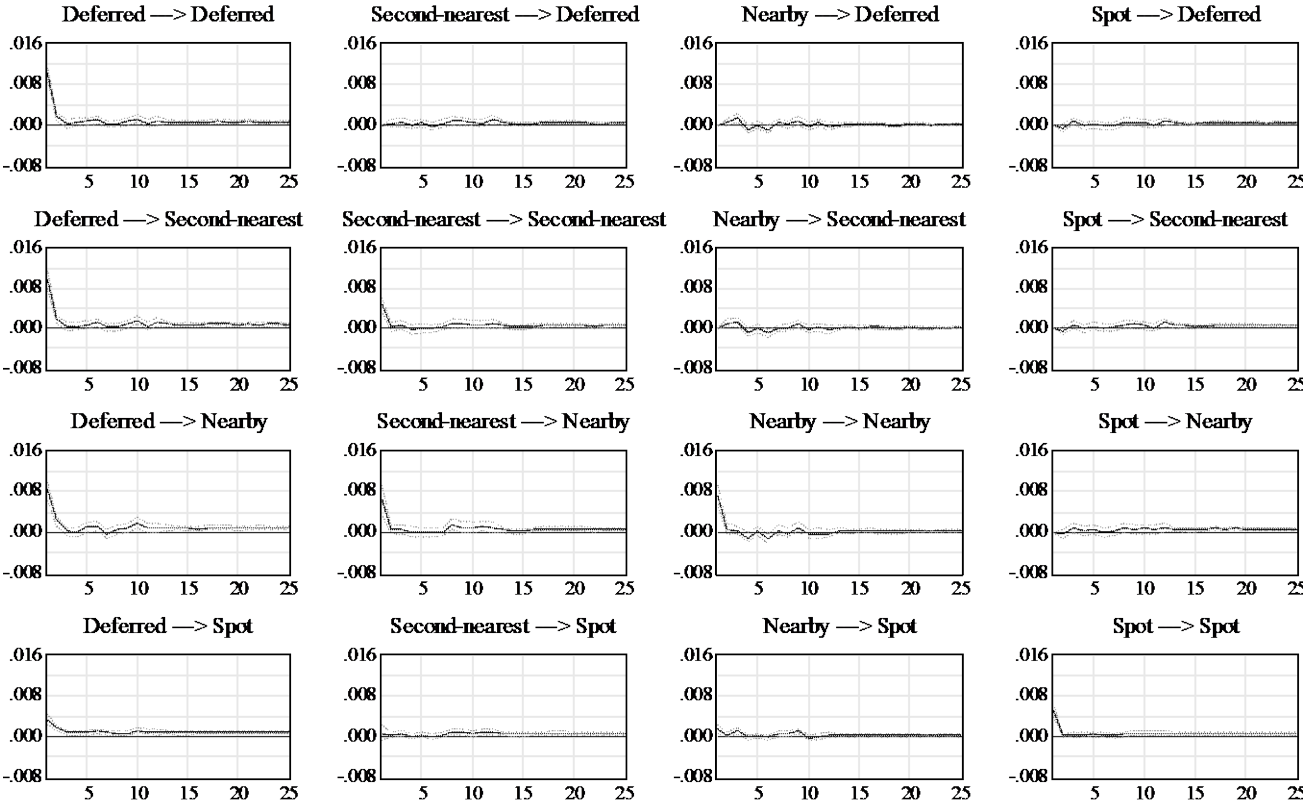
We observe these five IRFs to explore changes in the relationships among the four price series, along with alterations in the government's rice policies in each period.

5.2. Interpretations of the IRFs

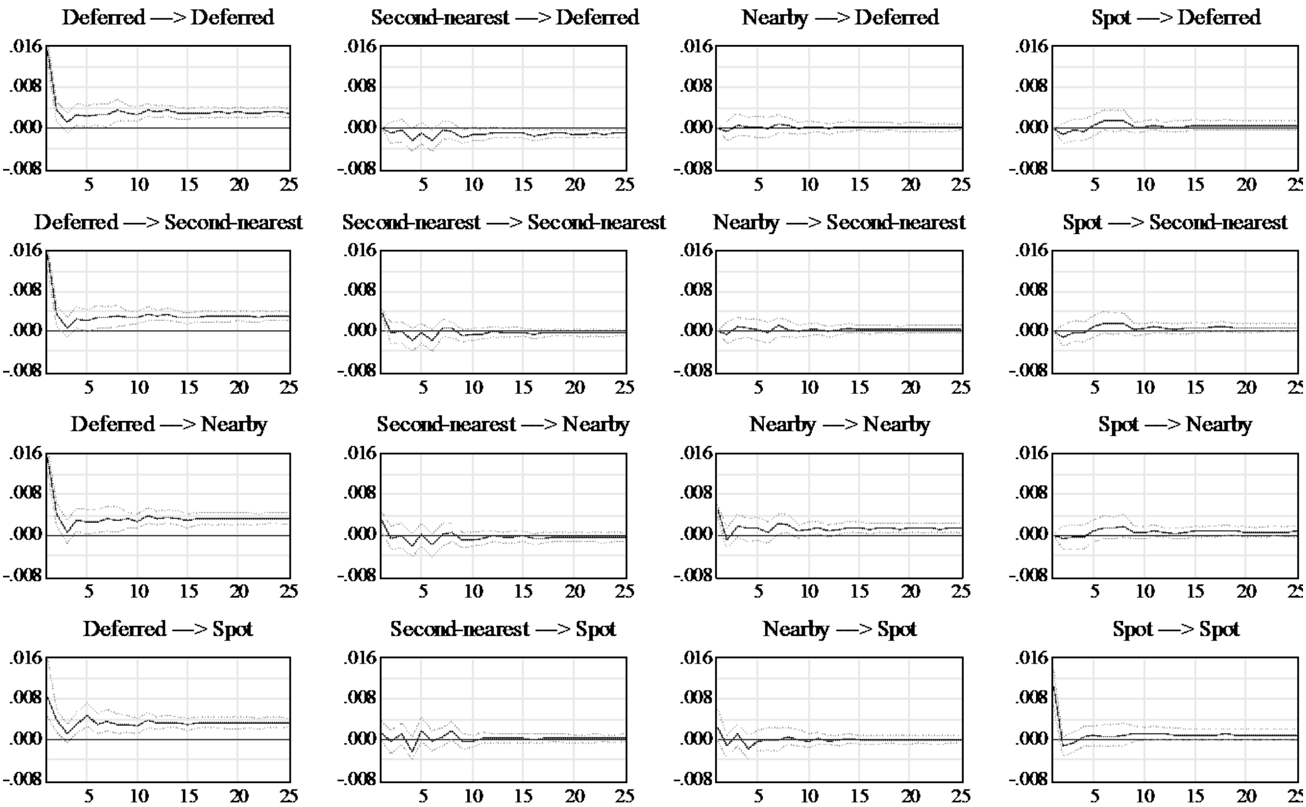
Panel A in Figure 4 shows the IRF for the first period under the first revised Rice Law. This indicates the following. First, the futures market formed deferred prices independently. The first row of Panel A demonstrates that the other prices did not affect fluctuations in deferred prices. Second, the fluctuation in deferred prices influenced other futures and spot prices, according to the first column of Panel A. Third, as the fourth row of Panel A indicates, the variation in deferred and spot prices determined the movement of spot prices. In summary, deferred prices acted as index prices in the futures and spot markets during the first period.

Panel B presents the IRF during the second period under the second revised Rice Law. The shape of the IRF is the same as that of the first period. This implies that the pricing structure did not change from the first to the second period. Nevertheless, the four functions in the first column and bottom-right corner are higher than those in the first period. Therefore, the deferred contract trade in

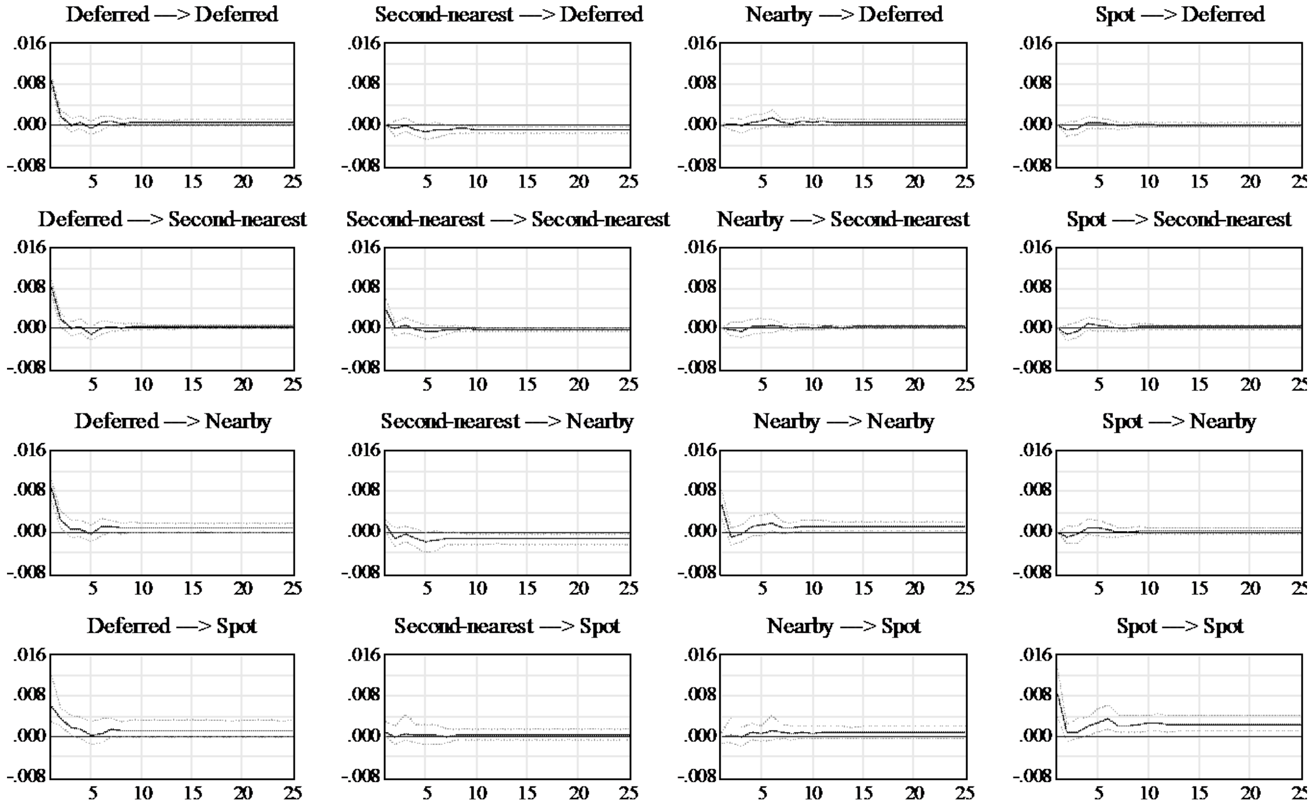
(A) First period (2 November 1925–29 June 1931)



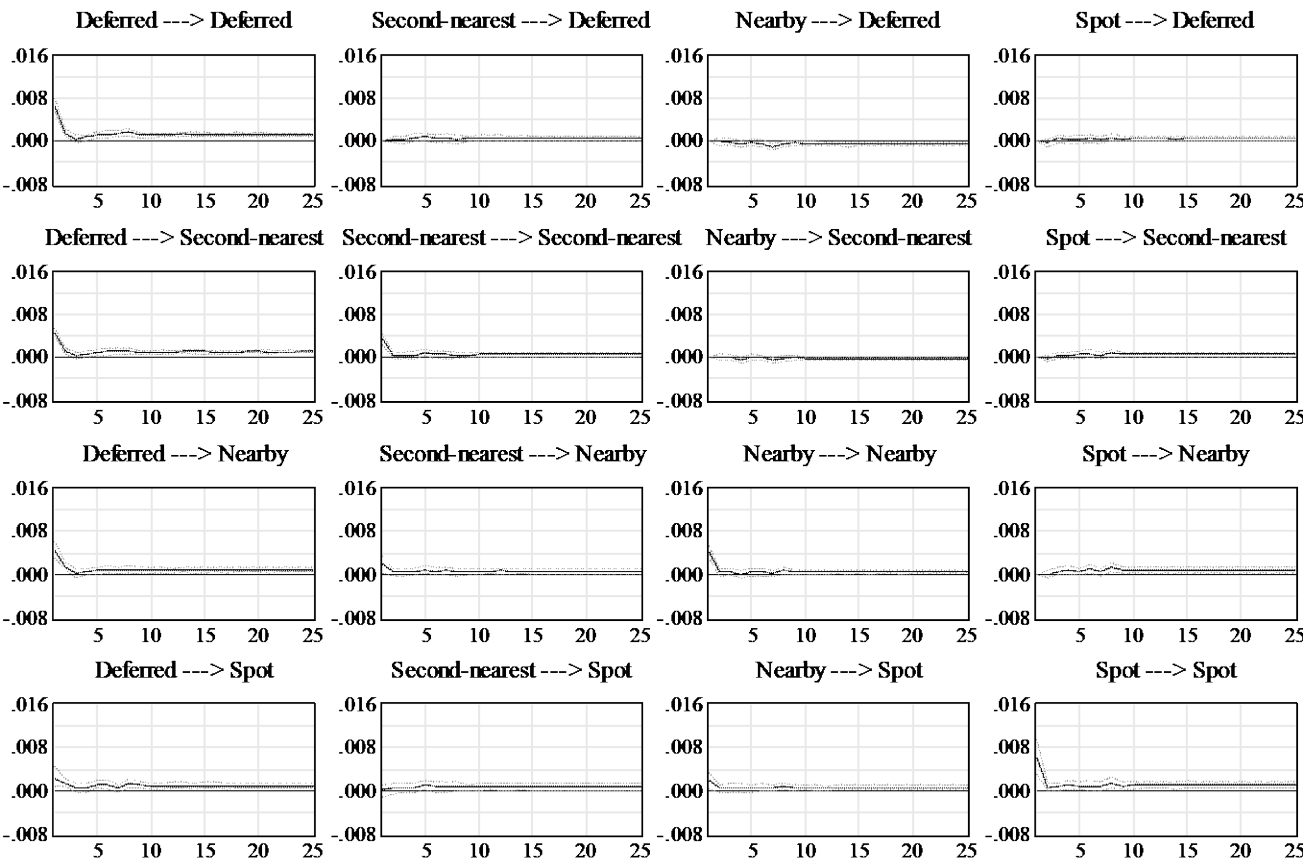
(B) Second period (1 July 1931–3 October 1932)



(C) Third period (4 October 1932–30 October 1933)



(D) Fourth period (1 November 1933–19 September 1936)



(E) Fifth period (21 September 1936–19 August 1939)

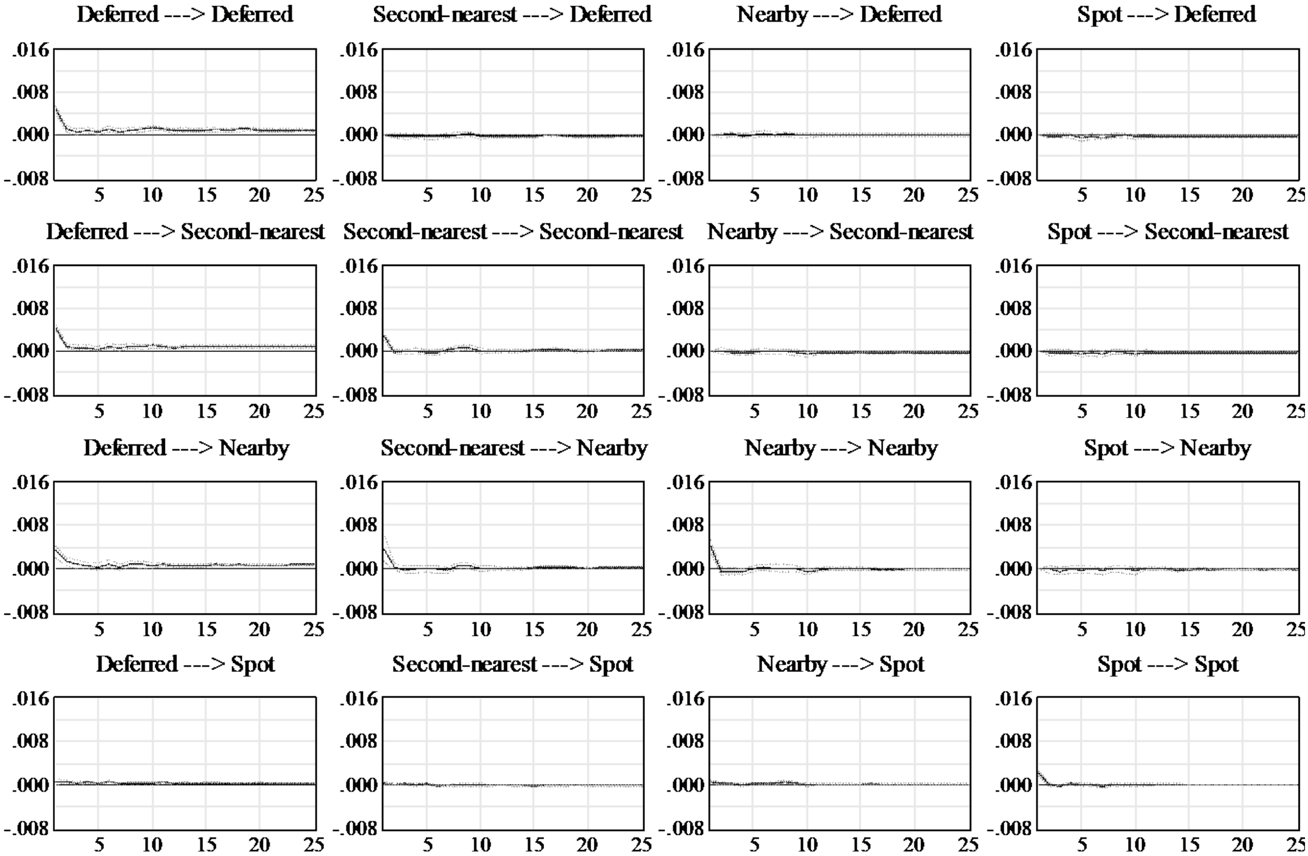


Figure 4

Impulse response functions for the rice futures and spot trades in Osaka

Note: Dashed lines represent the 99% confidence interval.

the futures market and spot trade enhanced their power to generate prices under the second revised Rice Law.

Panel C illustrates the third period under the third revised Rice Law. This explains that the relationships among the four price series remained fixed. The interrelation between deferred and spot prices did not change from the second to the third period, although the influence of deferred prices on second-nearest and nearby prices declined slightly in the futures market.

Panel D indicates the IRF of the fourth period when the government frequently intervened in the rice market according to the Rice Control Law. The pricing structure was altered from the second and third periods to the fourth period. The first column shows that the three functions from deferred prices to second-nearest, nearby, and spot prices decreased. The deferred contract's role in providing index prices in the futures and spot markets declined after the enforcement of the Rice Control Law.

Panel E shows the IRF during the fifth period when the government administered the Rice Control Law and the Rice Autonomous Management Law simultaneously. The pricing relationship between the futures and spot markets disappeared during this period. According to the first column, the deferred price's role as an index price declined markedly. Specifically, the function in the bottom-left corner, which describes the influence of deferred prices on spot prices, borders zero. On the other hand, the function in the upper-right corner indicates that the interrelation between spot and deferred prices remains zero. Consequently, the Rice Control Law and the Rice Autonomous Management Law separated the futures and spot markets.

The IRF analyses in this section demonstrate that the pricing structures in the futures and spot rice markets varied accordance to alterations in rice price control legislation. Accordingly, the following section applies the HD analyses to the entire sample and investigates consecutive changes in rice pricing.

6. HD Analyses on the Whole Sample

6.1. Computation of the 30-Day Moving Average Absolute HD Ratio

By employing the optimal lag length and the number of cointegration relationships that stem from the lag exclusion Wald test and Johansen's (1991) trace test, respectively, we estimate the VEC model to compute the HD (Table A5, Panel F of Table A6, and Panel F of Table A7).

Panel A of Figure 5 shows the HD value and total stochastic value. The HD value is the degree of influence of the causal variable on the outcome variable. The total stochastic values are equal to the sum of the HD values in the same column. Hence, they have equal values in the same column. Accordingly, we divide the HD value by its relevant total stochastic value to monitor the relative contribution to fluctuations in the outcome variable. This is the HD ratio (HDR), whose deviation from zero indicates the power of the causal variable to alter the outcome variable (Panel A of Figure A7). We observe this deviation by converting the HDR to the absolute HDR (AHDR) (Panel B of Figure A7). The AHDR varies widely because this ratio is based on daily data, and we transform the AHDR to the 30-day moving average AHDR (30DMA-AHDR) to focus on changes in the AHDR values. Panel B of Figure 5 illustrates the 30DMA-AHDR.

6.2. Interpretations of the 30DMA-AHDR

Panel B of Figure 5 indicates the same results for rice pricing under the Rice Law until 1933 as for the IRF analyses in the previous section, which consists of three points. First, deferred prices were index prices in the futures and spot markets. Second, deferred prices enhanced the role of index prices after the enforcement of the second revised Rice Law in July 1931. Third, the spot market strengthened its ability to generate prices under the second revised Rice Law. By contrast, the 30DMA-AHDR and IRF analyses show different rice pricing structures after the enforcement of the Rice Control Law in November 1933.

When the government implemented only the Rice Control Law, the IRF analyses show that the futures market did not provide index prices for spot trades. By contrast, the 30DMA-AHDR demonstrates that the deferred trade strengthened its role in offering index prices, and the influence of fluctuations in spot prices on deferred prices also increased. Under the Rice Control Law and the Rice Autonomous Management Law, the IRF analyses indicate that the relationship between prices in the futures and spot markets disappeared. Antithetically, the 30DMA-AHDR shows that the effect of the

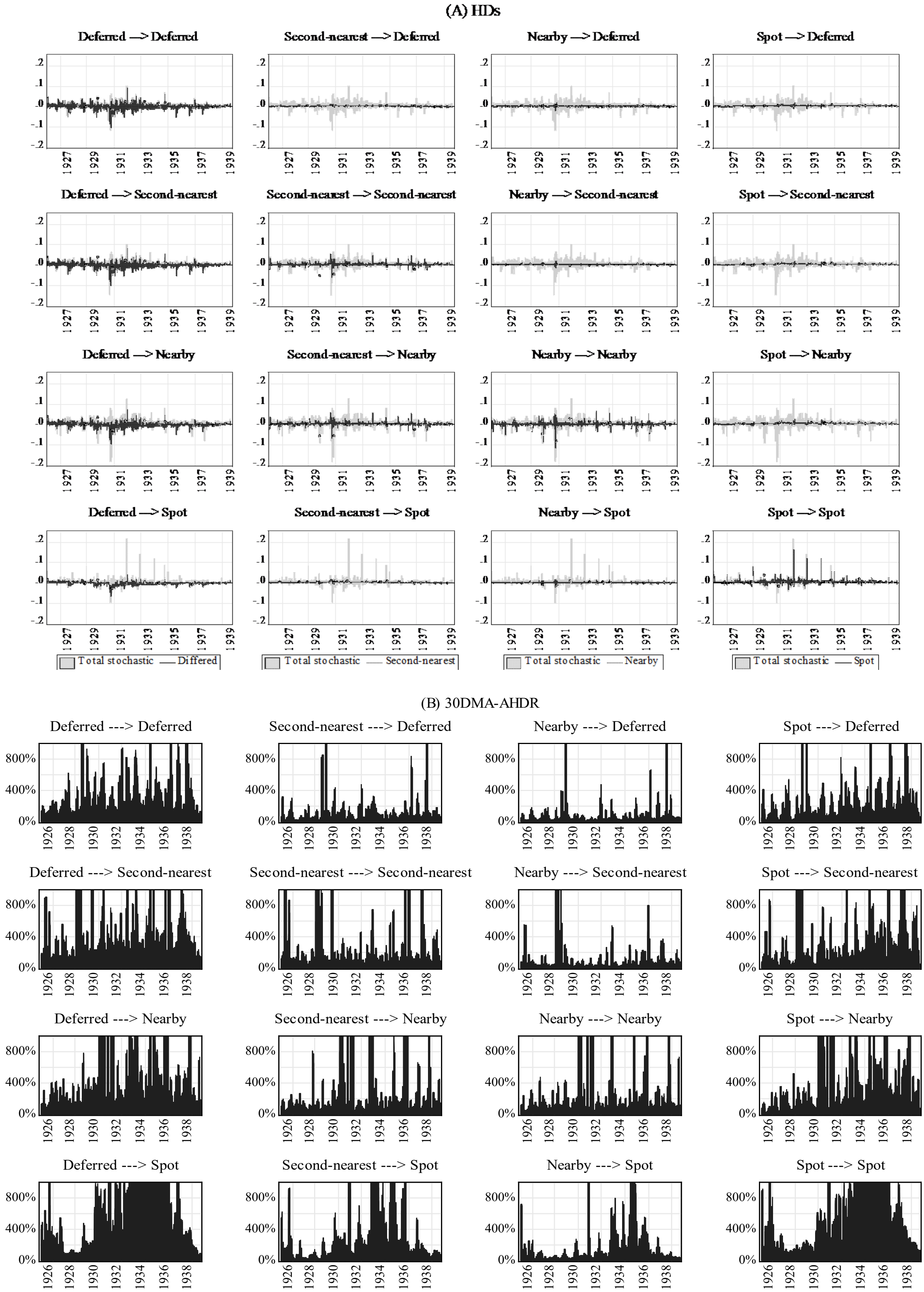


Figure 5

HDRs and 30DMA-AHDRs of the rice futures and spot trades in Osaka variation in spot prices on deferred prices increased, while the deferred trade's function to supply the spot trade index prices diminished. Accordingly, the following subsection examines changes in the relationship between futures and spot prices.

6.3. Relationship Between Futures and Spot Prices

We calculate two ratios stemming from the 30DMA-AHDR to observe alterations in the relationship between deferred and spot prices. The first is the ratio of the 30DMA-AHDR from deferred prices to spot prices to that of to and from spot prices. This indicates the deferred price's power to alter spot prices against spot prices' ability to fluctuate. The second ratio is derived by dividing the 30DMA-AHDR from spot prices to deferred prices by that of to and from deferred prices. This shows the influence of the opposite direction to the first ratio and denotes the spot price's capability to change deferred prices against the deferred price's capacity to vary. Panels A and B of Figure 6 show these two ratios, and Panel C illustrates the differences calculated by subtracting the second ratio from the first.

Figure 6 shows the seasonal trends of the relative powers of deferred and spot trades to generate index prices. During the harvest season, the influence of deferred prices on variations in spot prices strengthened, whereas the opposite effect declined. It fluctuated seasonally, and the futures market did not stably display its ability to offer index prices throughout the year. Specifically, the influence of deferred prices on spot prices was less than the opposite effect, except during the harvest season until 1929 (Panel C of Figure 6). That is, the deferred trade provided the index prices of spot trades only during the harvest season even before the Great Depression. Fundamentally, Osaka's rice market had a fluid structure. The relationship between deferred and spot prices sustained this seasonal trend until 1939. Harvest conditions in the fall determined the fluctuations and levels of rice prices for a year until the next harvest. The dealers strived to predict the rice price movement over a few months and actively traded deferred contracts in the harvest season. However, the deferred trade's function of supplying index prices fluctuated further after the Great Depression.

6.4. Enhancement of Rice Price Policies after the Great Depression

The Great Depression of 1929 and the bumper crops of the following year depressed rice prices during the harvest season of 1930 (Figure 2). The plummeting prices of agricultural products triggered the Showa Depression. Japan's gross domestic product per capita faltered until 1932, and the recession interrupted the growth in rice consumption per capita (Figure A2). Accordingly, after 1930, the government implemented significant interventions in the spot market to control rice prices according to the Rice Law. Figure 7 shows the volume of trade and government supply in Osaka's rice spot market from 1926 to 1933.

Figure 7 shows that, after 1930, the government sold and purchased large quantities of rice in the spot market. In the previous year, Japanese farmers experienced a poor crop (Figure A2). The government was wary of surges in rice prices and sold its stock rice in the spot market from July to September 1930. However, the government encountered bumper crops in the fall. Thus, it thus

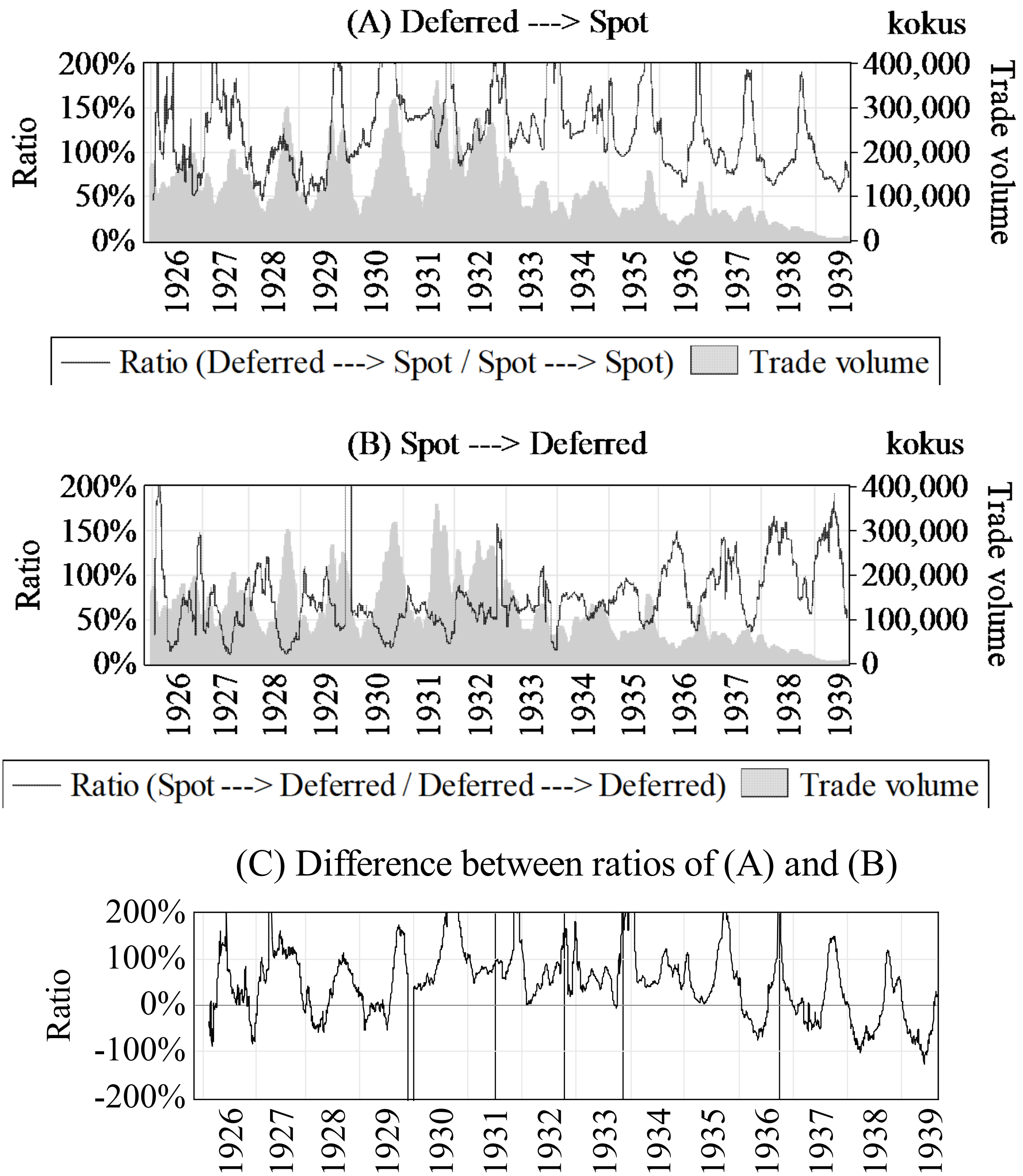


Figure 6

30 days moving average trade volumes and AHDRs for deferred contracts and spot prices

Note: Panel (C) shows the four vertical lines that indicate the enforcement of the second revised Rice Law on 1 July 1931, the third revised Rice Law on 4 October 1932, the Rice Control Law on 1 November 1933, and the Rice Autonomous Management Law on 20 September 1936.

purchased rice after December 1930 to boost prices, and the ratio of its purchase volume to the estimated trade volume skyrocketed frequently in the 1930s. The government re-enacted the Rice Law twice and intervened in the spot market to control rice prices.

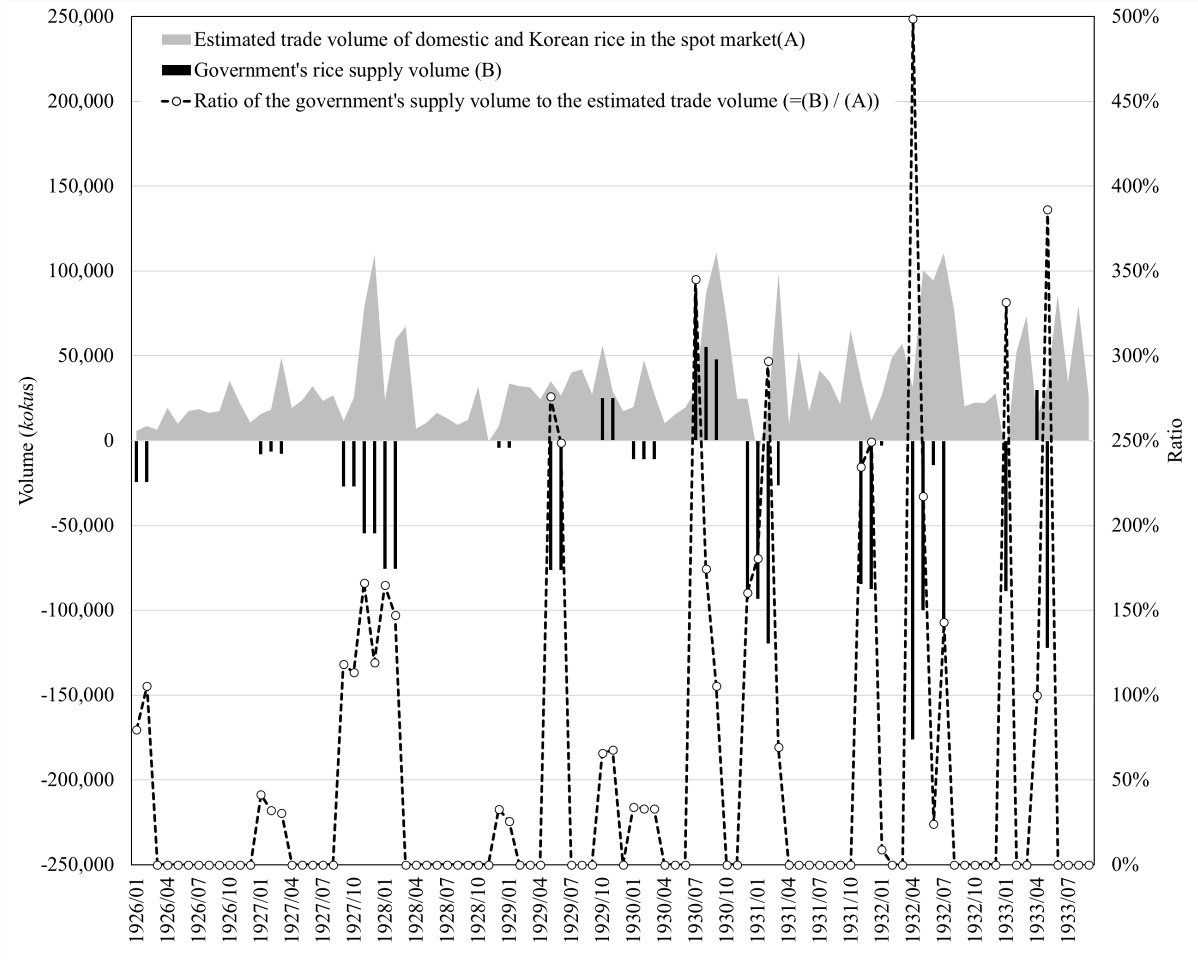


Figure7

Trade volumes and government supply in Osaka's rice spot market

Note: The "estimated trade volume of domestic and Korean rice in the spot market" consists of the estimated consumption volume in Osaka and outflow volume from Osaka. The estimated consumption volume in Osaka is derived using the following formula:

The estimated consumption volume = the stocked volume at the end of the previous month + the inflowing volume – the outflowing volume – the stocked volume at the end of the month

Sources: Ministry of Agriculture and Commerce, Food Bureau 1922–1923, 1925a, 1925b; Ministry of Agriculture and Forestry, Agricultural Bureau 1926–1930; Hasumi 1957; Osaka Chamber of Commerce 1918, 1920a, 1920b, 1922, 1923a, 1923b, 1924–1926; Ota 1938; Tokyo Chamber of Commerce and Industry 1928–1933

These interventions counteracted spot price trends because they attempted to curb price fluctuation. This feature stimulated the deferred price function. The deferred trade strengthened its opposing forces against the government's inducements, and its impact on the spot market militated the spot price trend (Figure A7). Consequently, government intervention under the second and third revised Rice Laws ironically amplified the influence of deferred prices on spot prices. Nevertheless, after enforcing the Rice Control Law, the government expanded the scale of its intervention because Japan registered its largest rice harvest in 1933 (Figures 1, A3, and A4). Therefore, the deferred trade strongly influenced the spot market until 1935 (Figure 6).

The relationship between deferred pricing and spot pricing gradually changed after 1936. According to Figure 6, the effect of spot prices on the change in deferred prices increased, whereas the opposite influence decreased. The February 26 incident in 1936 triggered a structural change in the rice market. This significant historical event drastically transformed Japanese politics and the economy.

6.5. Structural Market Changes during Wartime

The Japanese Kwantung Army in the Liaodong Peninsula, which became Japanese-leased territory due to the Portsmouth Treaty of 1905 after the Russo-Japanese War, caused the Manchurian Incident in September 1931. It invaded Northeast China, and the military obtained political power after the incident (Matsusaka 1996, pp. 103–04). Military action in Manchuria raised arms expenditure, and the number of outstanding government bonds increased. However, the Minister of Finance, Korekiyo Takahashi, planned to reduce arms expenditure to maintain fiscal discipline. Young army officers regarded government leaders as hostile and executed a coup d'état on 26 February 1936 (Berger 1998, pp. 118–20). They assassinated the Finance Minister, and the military greatly strengthened its political power. In this situation, the dealers in the ODRE felt uneasy about the future of Japanese society. They could not predict the future of the rice market, which was susceptible to government intervention, and reduced their trade (Osaka-Dojima Rice Exchange 1936b, p. 7). Furthermore, the Rice Autonomous Management Law was enacted in the same year, and the rice futures market continued to struggle.

The government promulgated and enforced the Rice Autonomous Management Law in 1936 on 28 May and 20 September, respectively. This law boosted its authority to prevent price decreases when rice cultivation experienced bumper crops. Although the government did not apply the law to control rice distribution, rice traders feared that the government would reduce the rice supply because Japan had continuously experienced rich rice harvests since 1936 (Figures A3 and A4). In contrast to the Rice Control Law, which permitted the government to trade only in the spot market, the Rice Autonomous Management Law allowed the government to adjust the rice supply from agricultural areas to distribution hubs throughout the Japanese Empire. If the government invoked the law, its actions would seriously impact rice pricing. Accordingly, dealers in the ODRE were wary of government intervention under the Rice Autonomous Management Law and refrained from active dealings (Osaka-Dojima Rice Exchange 1936b, p. 7).

Under the circumstances of bumper rice crops, dealers who considered the possibility of the government's direct intervention in rice distribution could not predict futures prices, and the futures market's function to provide index prices declined after 1936. The government carefully monitored the spot market to determine whether it had invoked the Rice Autonomous Management Law. Hence, futures market dealers also paid close attention to price movements in the spot market. In its business report in the first half of 1937, the ODRE stated, "Futures prices are stabilized because the spot market is steady" (Osaka-Dojima Rice Exchange 1937b, p. 8). According to this statement, the ODRE recognized that the futures market followed the spot market. Panel B of Figure 6 also shows that the 30DMA-AHDR from spot prices to deferred prices increased in 1936. Thereafter, it frequently exceeded 100 percent, except during the harvest season. That is, the fluctuation in spot prices determined price movement in the futures market at any time other than the harvest season after 1936. This pricing tendency in the futures and spot markets became prominent the following year (Figure 6).

Japan began the Second Sino-Japanese War in July 1937 and reworked its economy to meet its wartime regime. The Japanese military intended to clinch a brief struggle but, instead, perpetuated the war. The government enforced the National Mobilization Law in May 1938 and assumed full authority to operate the wartime economy (Tipton 2016, pp. 144–59). Wartime legislation permitted the government to intervene in the commodity market on a discretionary basis, and wartime controls of the economy threatened the rice futures trade. Consequently, both the number of dealers and the deferred trade volume in the ODRE decreased further (Figure 3). In May 1938, the ODRE mentioned, "The wartime controls of the economy are strengthened, and the dealers refrain from active trade. These factors stabilize rice prices. The futures market is altered to a non-lucrative market, and trade volume shrinks." (Osaka-Dojima Rice Exchange 1938b, pp. 7–8). The volume ratio of the spot trade to the deferred trade increased and remained above ten percent after the National Mobilization Law was enforced in May 1938. The ratio exceeded 25 percent by the end of 1938 (Figure A8). These changes indicated that the futures market had forfeited its significant position in the rice market.

The wartime controls on the economy during the Second Sino-Japanese War after 1938 caused the rice futures market to shrink. The 30DMA-AHDR of spot prices tended to surpass that of deferred prices meaning that the deferred trade failed to maintain its function of generating index prices for the spot trade (Figure 6). The 30DMA-AHDR also indicated that spot prices led to futures prices during the war, in contrast to the theoretical assumption. Nevertheless, the deferred trade provided index prices for the spot trade only during the harvest season (Figures 3 and 6). Until the abolition of all rice exchanges at the end of August 1939, the government allowed dealers to trade in futures, and dealers struggled to predict rice prices before and after the harvest season. The deferred trade initially strengthened its function of generating index prices during the harvest season, and the function partially survived even during wartime.

These seasonal fluctuations in the functions of the deferred and spot markets intensified after 1936 under the Rice Control Law. Furthermore, they escalated during the war. The fluid structure of Osaka's rice market had swung. Under these circumstances, the IRF analyses misidentify that the two markets were separate. They illustrate only the average market structure, but the influences of the deferred and spot prices offset each other (Panels D and E of Figure 4). Accordingly, the IRF analyses capture only the results after offsetting. The difference in assumptions between the IRF and HD analyses causes a distinction in their results.

7. Conclusions

Osaka has a history of more than 300 years in the commodity futures market, and its rice futures trade prospered during the interwar period (Malliaris and Ziemba 2015, p. 13). However, the functions were unstable. Even before 1930, when the government began to severely intervene in the market, the relationship between futures and spot markets fluctuated seasonally. The futures market improved its capacity to supply the index prices of the spot trade during the harvest season when the equilibrium of rice varied heavily. Antithetically, the futures market's function to generate index prices declined at times other than during the harvest season. Furthermore, the government strengthened its control over rice prices after the Great Depression, and the role of the ODRE fluctuated.

The government implemented two measures to adjust rice prices after the depression. The first measure was the government's constant intervention in the spot market, according to the Rice Control Law of 1933. The second was the government's control of the rice supply volume from farming regions to cities, according to the Rice Autonomous Management Law of 1936. The government utilized the first measure to induce rice prices to move in the opposite direction from the market equilibrium. Specifically, although Japan faced bumper crops in 1933, the government continuously bought a tremendous volume of rice in the spot market to raise prices because farmers suffered from plummeting prices after the depression. These political actions, which were contrary to the price trends in response to harvest conditions, boosted the futures market's function, leading spot prices to reflect crop situations. Unlike the first measure, the second reduced the ODRE's function. Rice dealers were afraid of the government's control of the rice supply and held off their trade in the futures market when Japan experienced abundant crops, although the government did not invoke the Rice Autonomous Management Law after 1936. Consequently, the suppression of trades was debased on the function of the ODRE.

After the decline in the ODRE's role, the spot market supplied index prices to the futures market at times other than the harvest season because the reinforcement of the government's capacity to control the rice market distorted the relationship between the futures and spot markets. The wartime economic controls after the outbreak of the Second Sino-Japanese War in 1937 restrained the futures trade and further distorted the rice market. The ODRE lost its role, except during the harvest season, even before its abolition in 1939.

This study employs an HD analysis to investigate high-frequency price data and examines the relationship between the pricing of rice futures and spot markets during the interwar period in Japan. The results show that the relationship between futures and spot pricing had distinct seasonality in response to the rice harvest. The futures market's functions varied seasonally, and the rice market in Osaka sustained this seasonality even after the Great Depression. These seasonal fluctuations fundamentally characterized commodity futures markets. Furthermore, the government extended the scale of its manipulation to control rice prices, and its interventions heavily affected pricing in the futures and spot markets after the depression. The government intervened only in spot markets. In other words, it did not participate in the futures market directly. However, government intervention greatly reduced the futures market's role at times other than during the harvest season. It amplified the seasonal fluctuation of the futures market's functions. Consequently, the futures market functionally swung after the Great Depression.

Scholars in economics and economic history have considered commodity exchange as a crucial part of the commodity market in modern times. Many commodity exchanges collect disseminated information to generate index prices (Goss 1986, p. 2); they now list not only agricultural products, but also metals, industrial materials, and financial commodities (Johnson 2009, p. 313). However, their primary listed goods until the 1960s were agricultural products such as grain (Carlton 1984, pp. 245–46). These agricultural products, including rice, exhibit seasonal price fluctuations. Accordingly, the pricing and functions of many commodity exchanges may vary seasonally, as with the ODRE. In such a case, economic historians must re-evaluate the role of the commodity futures market. Specifically, they must downgrade their assessment of the futures market's functions when the government frequently manipulated the commodity market after the Great Depression. This study requires further research to reassess the functions of the futures market. However, it has three limitations.

The first concerns the causal relationship between futures market pricing and government intervention. This study does not investigate the causal relationship directly because daily statistical data on the Japanese government's interventions are unavailable. This limitation requires further investigation to discover the related historical documents. The second considers the causes of seasonal fluctuations in futures market pricing. The Japanese government forbade rice exchanges from concluding futures contracts for over three months, whereas Western countries have permitted contracts for more than half a year. Rice dealers in Japan could not hedge their long-term risk of price volatility, even though they continued to desire that the government allow more extended contracts in the futures market after the 1900s (Tanaka 1910, pp. 277–78; Nagamitsu 1924, pp. 120–21). Accordingly, this point demands further study to investigate how the government regulation of contract terms affected the performance of the futures market. The third covers the period and objects in the analysis. This study examines Japan's rice futures market between 1925 and 1939. This limitation necessitates future research studies, using high-frequency data, focusing on other commodity futures markets globally and before 1925.

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Appendices

Table A1

Regular holiday closures of the ODRE (November 1925–August 1939)

Date	Reason (remark)	Japanese name
1–3 Jan.	New Year holidays	*Shinnen kyūgyō*
5 Jan.	New Year's party	*Shinnen enkai*
10 Jan.	Imamiya Ebisu Shrine ritual (This holiday was newly set in 1938.)	*Dotonbori ebisu*
11 Feb.	Empire Day	*Kigen setsu*
Spring equinox	Imperial ceremony of ancestor worship formerly held on the vernal equinox (Approximately 22 March)	*Shunki kōreisai*
3 Apr.	Ceremony of the Imperial Household to honor the mythical First Emperor Jinmu	*Jinmu Tennō sai*
29 Apr.	Emperor Showa's birthday (This holiday was newly set in 1927 because Emperor Showa succeeded to the throne from Emperor Taisho, who died on 25 December 1926.)	*Tenchō setsu*
25 Jul.	Osaka Tenmangu Shrine ritual (The exchange opened its market on 25 July from 1928 to 1932.)	*Tenjin sai*
30 Jul.	Anniversary of the demise of Emperor Meiji (This holiday was abolished in 1927 because of the demise of Emperor Taisho, an heir to the Imperial Throne from Emperor Meiji, in 1926.)	*Meiji Tennō sai*
31 Aug.	Emperor Taisho's birthday (This holiday was abolished in 1927 because of the demise of Emperor Taisho.)	*Tenchō setsu*
Autumn equinox	Imperial ceremony of ancestor worship formerly held on the autumnal equinox (Approximately 24 September)	*Shūki kōreisai*
17 Oct.	Annual ceremony of offering the year's new rice harvest by the emperor	*Kanname sai*
31 Oct.	Holiday in lieu of Emperor Taisho's birthday (This holiday was abolished in 1927 because of the demise of Emperor Taisho.)	*Tenchō setsu shukujitsu*
3 Nov.	Emperor Meiji's birthday (This holiday was newly set in 1927.)	*Meiji setsu*

Table A1 (Continued)

Regular holiday closures of the ODRE (November 1925–August 1939)

Date	Reason (remark)	Japanese name
23 Nov.	Annual ceremony of offering to the Imperial Ancestor and the Deities (This holiday was not set in 1915 and 1928 because the government held the *Daijō sai* (the great ceremony of offering to the Imperial Ancestor and the Deities by the newly enthroned His Majesty the Emperor) as a substitute for this holiday.)	*Niiname sai*
5 Dec.	Anniversary of the demise of Emperor Taisho (This holiday was newly set in 1927.)	*Taisho Tennō sai*
27–31 Dec.	Year-end holidays (The exchange suspended its operation on 26 December as the year-end holiday in 1938 and operated its market temporarily on 28 December 1926.)	*Nenmatsu kyūgyō*

Table A2

Temporal national holiday closures of the ODRE (November 1925–August 1939)

Date	Reason (remark)	Japanese name
10 Jun. 1926	State funeral of Sunjong (the abdicated second Emperor of Imperial Korea)	*Li daiō denka kokusō*
22 Oct. 1926	Ceremony of the addition of the former 98th Emperor Chokei in an imperial line	*Chōkei Tennō shinkoku sai*
25–27 Dec. 1926	The period of national mourning for the demised Emperor Taisho	*Gotaisō*
7–8 Feb. 1927	The Rites of the Imperial Funeral	*Taisō rei*
10 Nov. 1928	Ceremonies of the Accession to the Throne	*Sokui rei*
14 Nov. 1928	Great ceremony of offering to the Imperial Ancestor and the Deities by the newly enthroned His Majesty the Emperor	*Oname sai*
16 Nov. 1928	Ceremony of the grand banquet	*Daikyō kai*
4 Jun. 1929	Emperor's visit to Osaka	*Tennō gyōkei*
2 Oct. 1929	Ceremony of renewing the Ise Jingu Shrine	*Jingū shikinen sai*
27 Apr. 1932	The special ceremony of the Yasukuni Shrine with the attendance of the Emperor and Empress	*Yasukuni Jinja rinji taisai*
14 Nov. 1932	Special military review	*Dai-kanpei shiki*
27 Apr. 1933	The special ceremony at the Yasukuni Shrine	*Yasukuni Jinja rinji taisai*
27 Apr. 1934	The special ceremony at the Yasukuni Shrine	*Yasukuni Jinja rinji taisai*
5 Jun. 1934	State Funeral of Heihachiro Togo (the Fleet Admiral)	*Togo Heihachiro kokusō*
5 Nov. 1935	Ceremony of renewing the Atsuta Jingu Shrine	*Atsuta Jingū senza sai*
29 Oct. 1936	Fleet review	*Kankan shiki*
27 Apr. 1937	The special ceremony at the Yasukuni Shrine	*Yasukuni Jinja rinji taisai*
26 Apr. 1938	The special ceremony at the Yasukuni Shrine	*Yasukuni Jinja rinji taisai*
19 Oct. 1938	The grand ceremony of the Yasukuni Shrine	*Yasukuni Jinja taisai*
25 Apr. 1939	The special ceremony at the Yasukuni Shrine	*Yasukuni Jinja rinji taisai*

Table A3

Temporary trade suspensions of the ODRE (November 1925–August 1939)

Period	Type of contract	Reason
22 Apr.–13 May 1927	All	The government ordered the exchange to stop the trade as a part of the debt moratorium of the financial crisis.
3–4 Oct. 1930	All	Due to the stormy situation of the trade.
15–16 Dec. 1931	All	Due to the stormy situation of the trade.
16 May 1932	All	Due to the May 15 Incident, a coup attempt. The culprits, including some naval officers, assassinated the sitting prime minister, Tsuyoshi Inukai.
21 Sep. 1934	All	Due to the typhoon hitting Osaka
25–29 Sep. 1934	Nearby	The exchange could not deliver physical rice to settle the nearby contract due to the destruction of rice warehouses by the typhoon, which hit Osaka on 24 September 1934.
26–29 Feb. 1936	All	Due to the February 26 Incident, a coup attempt. The culprits, who mainly consisted of young army officers, assassinated four key government officials such as Korekiyo Takahashi, the sitting financial minister, and Makoto Saito, the former prime minister.

Table A4

Descriptive statistics and unit root test results of the first difference in the natural log of the futures and spot prices

	First period 2 November 1925–29 June 1931				Second period 1 July 1931–3 October 1932			
	Deferred	Second-nearest	Nearby	Spot	Deferred	Second-nearest	Nearby	Spot
Descriptive statistics								
Mean	-0.000	-0.000	-0.000	-0.001	0.000	0.000	0.000	0.000
Median	-0.000	-0.000	0.000	0.000	-0.000	-0.001	-0.001	0.000
Maximum	0.057	0.060	0.075	0.081	0.095	0.099	0.120	0.212
Minimum	-0.126	-0.152	-0.187	-0.104	-0.058	-0.061	-0.065	-0.047
Std. Dev.	0.011	0.011	0.013	0.007	0.015	0.015	0.016	0.014
N	1,517	1,517	1,517	1,517	351	351	351	351
Unit root test results								
ADF	-7.678***	-7.174***	-13.05***	-7.297***	-16.42***	-16.90***	-17.53***	-18.66***
Lags	16	18	7	14	0	0	0	0
PP	-34.58***	-34.50***	-34.52***	-36.04***	-16.42***	-16.86***	-17.51***	-18.81***
Bandwidth	8	4	14	20	0	3	5	8

Table A4 (Continued)

Descriptive statistics and unit root test results of the first difference in the natural log of the futures and spot prices

	Third period 4 October 1932–30 October 1933				Fourth period 1 November 1933–19 September 1936			
	Deferred	Second-nearest	Nearby	Spot	Deferred	Second-nearest	Nearby	Spot
Descriptive statistics								
Mean	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001
Median	-0.001	-0.001	-0.001	0.000	0.000	0.000	0.000	0.000
Maximum	0.042	0.057	0.055	0.138	0.065	0.041	0.078	0.117
Minimum	-0.030	-0.028	-0.028	-0.037	-0.056	-0.042	-0.047	-0.027
Std. Dev.	0.009	0.009	0.010	0.010	0.006	0.006	0.006	0.006
N	298	298	298	298	792	792	792	792
Unit root test results								
ADF	-9.776***	-9.827***	-15.85***	-15.12***	-19.66***	-25.67***	-24.91***	-14.16***
Lags	3	3	0	0	1	0	0	2
PP	-14.63***	-14.39***	-15.80***	-15.09***	-24.39***	-25.69***	-24.98***	-26.09***
Bandwidth	10	11	7	3	4	7	5	6

Table A4 (Continued)

Descriptive statistics and unit root test results of the first difference in the natural log of the futures and spot prices

	Fifth period 21 September 1936–19 August 1939				All periods 2 November 1925–19 August 1939			
	Deferred	Second-nearest	Nearby	Spot	Deferred	Second-nearest	Nearby	Spot
Descriptive statistics								
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	0.038	0.034	0.026	0.021	0.095	0.099	0.120	0.212
Minimum	-0.042	-0.033	-0.088	-0.018	-0.126	-0.152	-0.187	-0.104
Std. Dev.	0.005	0.005	0.007	0.003	0.009	0.009	0.011	0.007
N	803	803	803	803	3,761	3,761	3,761	3,761
Unit root test results								
ADF	-11.38***	-26.04***	-9.686***	-11.23***	-12.85***	-9.952***	-10.34***	-11.91***
Lags	5	0	9	5	16	35	30	16
PP	-24.43***	-26.01***	-27.06***	-25.64***	-54.16***	-54.62***	-55.52***	-59.26***
Bandwidth	1	11	13	6	12	7	1	25

Notes: "*N*," "ADF," "Lags," "PP," and "Bandwidth" denote the number of observations, augmented Dickey–Fuller test statistics with a time trend and a constant, lag order selected by the Akaike information criterion, Phillips–Perron test statistics, and Newey–West bandwidth by using the Bartlett kernel, respectively. "***" means significant at the 1 percent level.

Table A5

Johansen's trace test results

	First period 2 November 1925–29 June 1931			Second period 1 July 1931–3 October 1932			Third period 4 October 1932–30 October 1933		
	Eigen-value	Test statistics	Critical Value	Eigen-value	Test statistics	Critical value	Eigen-value	Test statistics	Critical value
None	0.0597	161.52	54.682	0.1012	62.648	54.682	0.0888	64.783	54.682
At Most 1	0.0259	68.726	35.458	0.0390	25.949	35.458	0.0656	37.529	35.458
At Most 2	0.0181	29.235	19.937	0.0257	12.248	19.937	0.0531	17.653	19.937
At Most 3	0.0011	1.6595	6.6349	0.0095	3.2893	6.6349	0.0057	1.6739	6.6349

	Fourth period 1 November 1933–19 September 1936			Fifth period 21 September 1936–19 August 1939			All periods 2 November 1925–19 August 1939		
	Eigen-value	Test statistics	Critical value	Eigen-value	Test statistics	Critical value	Eigen-value	Test statistics	Critical value
None	0.0508	80.723	54.682	0.0797	102.91	54.682	0.0587	326.86	54.682
At Most 1	0.0306	39.758	35.458	0.0364	36.982	35.458	0.0154	102.20	35.458
At Most 2	0.0137	15.383	19.937	0.0080	7.5183	19.937	0.0107	43.959	19.937
At Most 3	0.0058	4.5939	6.6349	0.0014	1.1222	6.6349	0.0009	3.5044	6.6349

Notes: This table presents the results of Johansen's (1991) trace tests. The "Critical Value" is the critical value at the 1 percent level for each test.

Table A6

Chi-squared test statistics of the lag exclusion Wald test

(A) First period (2 November 1925–29 June 1931)

	Deferred	Second-nearest	Nearby	Spot	Joint
Lag 1	264.55 (0.000)	326.95 (0.000)	263.90 (0.000)	951.77 (0.000)	1047.7 (0.000)
Lag 2	92.286 (0.000)	130.41 (0.000)	117.04 (0.000)	412.89 (0.000)	490.86 (0.000)
Lag 3	85.549 (0.000)	121.59 (0.000)	104.42 (0.000)	288.72 (0.000)	349.38 (0.000)
Lag 4	51.267 (0.000)	76.935 (0.000)	65.007 (0.000)	177.26 (0.000)	230.71 (0.000)
Lag 5	49.554 (0.000)	58.842 (0.000)	52.984 (0.000)	134.25 (0.000)	165.93 (0.000)
Lag 6	48.339 (0.000)	52.567 (0.000)	56.900 (0.000)	107.45 (0.000)	132.07 (0.000)
Lag 7	29.207 (0.000)	34.511 (0.000)	31.578 (0.000)	65.822 (0.000)	87.716 (0.000)
Lag 8	15.827 (0.003)	21.137 (0.000)	28.890 (0.000)	46.378 (0.000)	68.202 (0.000)
Lag 9	9.6069 (0.048)	9.0184 (0.061)	14.503 (0.006)	24.953 (0.000)	44.526 (0.000)
Lag 10	15.742 (0.003)	16.158 (0.003)	6.5176 (0.164)	13.223 (0.010)	43.322 (0.000)
Lag 11	13.060 (0.011)	10.571 (0.032)	5.0547 (0.282)	11.536 (0.021)	25.761 (0.058)

(B) Second period (1 July 1931–3 October 1932).

	Deferred	Second-nearest	Nearby	Spot	Joint
Lag 1	166.29 (0.000)	159.27 (0.000)	194.24 (0.000)	262.12 (0.000)	836.30 (0.000)
Lag 2	96.417 (0.000)	92.860 (0.000)	105.17 (0.000)	127.88 (0.000)	361.61 (0.000)
Lag 3	51.317 (0.000)	51.673 (0.000)	55.129 (0.000)	84.468 (0.000)	200.50 (0.000)
Lag 4	30.174 (0.000)	30.922 (0.000)	30.055 (0.000)	30.612 (0.000)	102.76 (0.000)
Lag 5	17.258 (0.002)	19.859 (0.001)	23.303 (0.000)	24.116 (0.000)	78.032 (0.000)
Lag 6	9.0032 (0.061)	8.0971 (0.088)	10.368 (0.035)	15.488 (0.004)	64.421 (0.000)
Lag 7	3.9669 (0.411)	4.3786 (0.357)	3.6096 (0.461)	5.3451 (0.254)	26.932 (0.042)

(C) Third period (4 October 1932–30 October 1933)

	Deferred	Second-nearest	Nearby	Spot	Joint
Lag 1	81.798 (0.000)	21.813 (0.000)	76.135 (0.000)	63.321 (0.000)	432.85 (0.000)
Lag 2	52.434 (0.000)	14.951 (0.005)	56.069 (0.000)	38.460 (0.000)	226.24 (0.000)
Lag 3	20.588 (0.000)	6.5506 (0.162)	25.713 (0.000)	16.309 (0.003)	107.78 (0.000)
Lag 4	23.643 (0.000)	11.098 (0.026)	17.673 (0.001)	7.6389 (0.106)	62.927 (0.000)
Lag 5	10.332 (0.035)	4.4966 (0.343)	5.3165 (0.256)	2.9147 (0.572)	30.292 (0.017)

Table A6 (Continued)

Chi-squared test statistics of the lag exclusion Wald test

(D) Fourth period (1 November 1933–19 September 1936)

	Deferred	Second-nearest	Nearby	Spot	Joint
Lag 1	439.00 (0.000)	287.31 (0.000)	357.56 (0.000)	279.79 (0.000)	1057.4 (0.000)
Lag 2	257.90 (0.000)	171.79 (0.000)	176.09 (0.000)	126.15 (0.000)	511.01 (0.000)
Lag 3	154.23 (0.000)	100.26 (0.000)	106.97 (0.000)	59.993 (0.000)	285.26 (0.000)
Lag 4	87.886 (0.000)	54.876 (0.000)	59.551 (0.000)	28.018 (0.000)	178.39 (0.000)
Lag 5	54.264 (0.000)	30.832 (0.000)	27.931 (0.000)	14.429 (0.006)	108.24 (0.000)
Lag 6	34.255 (0.000)	19.443 (0.001)	31.922 (0.000)	15.486 (0.004)	66.707 (0.000)
Lag 7	15.903 (0.003)	10.448 (0.034)	12.090 (0.017)	1.7980 (0.773)	26.274 (0.050)

(E) Fifth period (21 September 1936–19 August 1939)

	Deferred	Second-nearest	Nearby	Spot	Joint
Lag 1	517.99 (0.000)	590.16 (0.000)	161.10 (0.000)	28.541 (0.000)	1420.8 (0.000)
Lag 2	285.18 (0.000)	276.71 (0.000)	63.423 (0.000)	28.358 (0.000)	665.10 (0.000)
Lag 3	155.96 (0.000)	162.65 (0.000)	34.236 (0.000)	36.875 (0.000)	403.50 (0.000)
Lag 4	129.11 (0.000)	130.31 (0.000)	24.126 (0.000)	31.912 (0.000)	316.57 (0.000)
Lag 5	62.651 (0.000)	88.550 (0.000)	18.336 (0.001)	55.935 (0.000)	258.29 (0.000)
Lag 6	67.057 (0.000)	73.227 (0.000)	19.247 (0.001)	26.652 (0.000)	170.93 (0.000)
Lag 7	44.426 (0.000)	32.091 (0.000)	10.759 (0.029)	16.946 (0.000)	109.28 (0.000)
Lag 8	38.696 (0.000)	21.950 (0.000)	6.8863 (0.142)	2.4896 (0.647)	59.519 (0.000)
Lag 9	19.661 (0.001)	12.116 (0.017)	8.5583 (0.073)	2.8675 (0.580)	29.760 (0.019)

Table A6 (Continued)

Chi-squared test statistics of the lag exclusion Wald test

(F) All periods (2 November 1925–19 August 1939)

	Deferred	Second-nearest	Nearby	Spot	Joint
Lag 1	1071.6 (0.000)	1251.5 (0.000)	1077.2 (0.000)	2696.2 (0.000)	2952.8 (0.000)
Lag 2	509.13 (0.000)	619.35 (0.000)	561.99 (0.000)	1347.1 (0.000)	1524.3 (0.000)
Lag 3	380.84 (0.000)	460.08 (0.000)	423.23 (0.000)	840.82 (0.000)	1003.1 (0.000)
Lag 4	253.91 (0.000)	321.05 (0.000)	293.58 (0.000)	502.72 (0.000)	657.64 (0.000)
Lag 5	198.53 (0.000)	235.60 (0.000)	229.44 (0.000)	386.48 (0.000)	513.10 (0.000)
Lag 6	165.01 (0.000)	192.13 (0.000)	211.22 (0.000)	305.91 (0.000)	426.98 (0.000)
Lag 7	115.67 (0.000)	142.95 (0.000)	154.17 (0.000)	227.99 (0.000)	340.46 (0.000)
Lag 8	95.423 (0.000)	121.97 (0.000)	139.28 (0.000)	199.22 (0.000)	311.87 (0.000)
Lag 9	68.785 (0.000)	82.749 (0.000)	100.51 (0.000)	167.14 (0.000)	269.00 (0.000)
Lag 10	63.214 (0.000)	79.133 (0.000)	81.126 (0.000)	136.39 (0.000)	239.74 (0.000)
Lag 11	40.242 (0.000)	54.122 (0.000)	64.405 (0.000)	107.72 (0.000)	194.31 (0.000)
Lag 12	30.201 (0.000)	43.041 (0.000)	55.415 (0.000)	84.977 (0.000)	167.80 (0.000)
Lag 13	30.921 (0.000)	45.175 (0.000)	60.615 (0.000)	89.527 (0.000)	178.52 (0.000)
Lag 14	22.904 (0.000)	39.584 (0.000)	66.615 (0.000)	78.254 (0.000)	162.83 (0.000)
Lag 15	9.4795 (0.050)	17.908 (0.001)	30.965 (0.000)	38.301 (0.000)	106.98 (0.000)
Lag 16	18.295 (0.001)	18.060 (0.001)	25.329 (0.000)	37.656 (0.000)	88.073 (0.000)
Lag 17	10.659 (0.031)	10.253 (0.036)	13.007 (0.011)	9.6028 (0.048)	54.204 (0.000)
Lag 18	5.8747 (0.209)	6.1402 (0.189)	3.2900 (0.511)	5.8450 (0.211)	24.510 (0.079)

Note: Numbers in parentheses are p-values.

Table A7

VEC estimations

(A) First period (2 November 1925–29 June 1931)

	Cointegration equation			
	Equation 1	Equation 2	Equation 3	
$y_{1,t-1}$	1.0000	0.0000	0.0000	
$y_{2,t-1}$	0.0000	1.0000	0.0000	
$y_{3,t-1}$	0.0000	0.0000	1.0000	
$y_{4,t-1}$	-0.7692 [0.0805]	-0.9668 [0.0773]	-1.0289 [0.0694]	
Constant	-0.0000	-0.0001	-0.0001	
	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Cointegration Equation 1	-1.2924 [0.2013]	-0.4074 [0.2128]	-0.8037 [0.2507]	-0.2149 [0.1232]
Cointegration Equation 2	0.6491 [0.2681]	-0.1515 [0.2834]	1.5978 [0.3339]	0.4018 [0.1641]
Cointegration Equation 3	0.0722 [0.1588]	-0.1342 [0.1678]	-1.6048 [0.1977]	0.1576 [0.0972]
$\Delta y_{1,t-1}$	0.4747 [0.1928]	0.6045 [0.2038]	0.9965 [0.2402]	0.3189 [0.1180]
$\Delta y_{1,t-2}$	0.4084 [0.1835]	0.5030 [0.1940]	0.8412 [0.2286]	0.3136 [0.1123]
$\Delta y_{1,t-3}$	0.4169 [0.1735]	0.5487 [0.1834]	0.7741 [0.2161]	0.3478 [0.1062]
$\Delta y_{1,t-4}$	0.4088 [0.1623]	0.6373 [0.1716]	0.8785 [0.2121]	0.3310 [0.0993]
$\Delta y_{1,t-5}$	0.4946 [0.1502]	0.6744 [0.1589]	0.9048 [0.1871]	0.4058 [0.0919]
$\Delta y_{1,t-6}$	0.4666 [0.1364]	0.5821 [0.1442]	0.8121 [0.1699]	0.3904 [0.0835]
$\Delta y_{1,t-7}$	0.2831 [0.1205]	0.3625 [0.1273]	0.5234 [0.1500]	0.2845 [0.0737]
$\Delta y_{1,t-8}$	0.2468 [0.1038]	0.3625 [0.1273]	0.5234 [0.1500]	0.2845 [0.0737]
$\Delta y_{1,t-9}$	0.2191 [0.0863]	0.2369 [0.0912]	0.3963 [0.1074]	0.2059 [0.0528]
$\Delta y_{1,t-10}$	0.1820 [0.0612]	0.1320 [0.0647]	0.1532 [0.0762]	0.0862 [0.0374]
$\Delta y_{2,t-1}$	-0.7004 [0.2564]	-0.9776 [0.2710]	-1.6344 [0.3193]	-0.3785 [0.1569]
$\Delta y_{2,t-2}$	-0.8262 [0.2439]	-1.0331 [0.2579]	-1.5631 [0.3038]	-0.4823 [0.1493]
$\Delta y_{2,t-3}$	-0.6782 [0.2303]	-0.9516 [0.2435]	-1.3581 [0.2868]	-0.4392 [0.1410]
$\Delta y_{2,t-4}$	-0.6219 [0.2152]	-1.0092 [0.2274]	-1.4067 [0.2679]	-0.4043 [0.1317]
$\Delta y_{2,t-5}$	-0.5130 [0.1995]	-0.8444 [0.2109]	-1.2028 [0.2485]	-0.3996 [0.1221]
$\Delta y_{2,t-6}$	-0.5333 [0.1792]	-0.7663 [0.1894]	-1.2146 [0.2232]	-0.4341 [0.1097]
$\Delta y_{2,t-7}$	-0.3520 [0.1565]	-0.5360 [0.1654]	-0.8280 [0.1949]	-0.3548 [0.0958]
$\Delta y_{2,t-8}$	-0.3650 [0.1326]	-0.4984 [0.1402]	-0.8323 [0.1652]	-0.3989 [0.0812]
$\Delta y_{2,t-9}$	-0.2553 [0.1075]	-0.3305 [0.1136]	-0.5804 [0.1339]	-0.2689 [0.0658]
$\Delta y_{2,t-10}$	-0.2392 [0.0737]	-0.2207 [0.0779]	-0.2308 [0.0917]	-0.0898 [0.0451]
$\Delta y_{3,t-1}$	-0.7004 [0.2564]	-0.9776 [0.2710]	-1.6344 [0.3193]	-0.3785 [0.1569]
$\Delta y_{3,t-2}$	-0.8262 [0.2439]	-1.0331 [0.2579]	-1.5631 [0.3038]	-0.4823 [0.1493]
$\Delta y_{3,t-3}$	-0.6782 [0.2303]	-0.9516 [0.2435]	-1.3581 [0.2868]	-0.4392 [0.1410]
$\Delta y_{3,t-4}$	-0.6219 [0.2152]	-1.0092 [0.2274]	-1.4067 [0.2679]	-0.4043 [0.1317]
$\Delta y_{3,t-5}$	-0.5130 [0.1995]	-0.8444 [0.2109]	-1.2028 [0.2485]	-0.3996 [0.1221]
$\Delta y_{3,t-6}$	0.0135 [0.0997]	0.1498 [0.1054]	0.3483 [0.1241]	-0.0040 [0.0610]
$\Delta y_{3,t-7}$	-0.0062 [0.0873]	0.1173 [0.0923]	0.2592 [0.1088]	0.0327 [0.0534]
$\Delta y_{3,t-8}$	0.0781 [0.0730]	0.1770 [0.0771]	0.3396 [0.0909]	0.1412 [0.0447]

Table A7 (Continued)

VEC estimations

(A) First period (2 November 1925–29 June 1931) (continued)

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
$\Delta y_{3,t-9}$	0.0205 [0.0567]	0.0965 [0.0599]	0.2126 [0.0706]	0.0647 [0.0347]
$\Delta y_{3,t-10}$	0.0415 [0.0392]	0.0835 [0.0415]	0.1032 [0.0489]	0.0074 [0.0240]
$\Delta y_{4,t-1}$	-0.4083 [0.1008]	-0.6824 [0.1065]	-0.7960 [0.1255]	-0.5697 [0.0617]
$\Delta y_{4,t-2}$	-0.2047 [0.0994]	-0.5022 [0.1051]	-0.5790 [0.1238]	-0.4794 [0.0609]
$\Delta y_{4,t-3}$	-0.2875 [0.0976]	-0.5644 [0.1031]	-0.5837 [0.1215]	-0.4478 [0.0597]
$\Delta y_{4,t-4}$	-0.2432 [0.0958]	-0.4688 [0.1013]	-0.4798 [0.1194]	-0.3786 [0.0587]
$\Delta y_{4,t-5}$	-0.3003 [0.0934]	-0.4605 [0.0988]	-0.4863 [0.1163]	-0.3353 [0.0572]
$\Delta y_{4,t-6}$	-0.3160 [0.0901]	-0.4037 [0.0952]	-0.4284 [0.1122]	-0.3023 [0.0551]
$\Delta y_{4,t-7}$	-0.1883 [0.0850]	-0.2914 [0.0898]	-0.3030 [0.1058]	-0.2236 [0.0520]
$\Delta y_{4,t-8}$	-0.1039 [0.0774]	-0.2914 [0.0898]	-0.3030 [0.1058]	-0.2236 [0.0520]
$\Delta y_{4,t-9}$	-0.0521 [0.0661]	-0.1015 [0.0698]	-0.1322 [0.0823]	-0.0959 [0.0404]
$\Delta y_{4,t-10}$	-0.0816 [0.0504]	-0.1263 [0.0533]	-0.0733 [0.0628]	-0.0468 [0.0309]
Constant	0.0000 [0.0003]	0.0000 [0.0003]	0.0000 [0.0003]	0.0000 [0.0002]
$\bar{R}^2$	0.4666	0.4586	0.4580	0.4646

(B) Second period (1 July 1931–3 October 1932)

	Cointegration equation
	Equation 1
$y_{1,t-1}$	1.0000
$y_{2,t-1}$	-3.6427 [0.6714]
$y_{3,t-1}$	0.7764 [0.6502]
$y_{4,t-1}$	1.6324 [0.2113]
Constant	-0.0002

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Cointegration Equation 1	0.2536 [0.1049]	0.3129 [0.1070]	0.2907 [0.1120]	-0.4760 [0.0939]
$\Delta y_{1,t-1}$	-0.7157 [0.2572]	0.0270 [0.2622]	0.1763 [0.2746]	0.8845 [0.2303]
$\Delta y_{1,t-2}$	-0.6958 [0.3136]	-0.0512 [0.3197]	-0.0254 [0.3348]	0.5085 [0.2807]
$\Delta y_{1,t-3}$	-0.0220 [0.3310]	0.4483 [0.3374]	0.6054 [0.3534]	1.3423 [0.2963]
$\Delta y_{1,t-4}$	-0.0185 [0.3301]	0.3664 [0.3365]	0.3102 [0.3524]	0.8963 [0.2955]
$\Delta y_{1,t-5}$	0.4646 [0.2959]	0.7802 [0.3016]	0.7403 [0.3159]	0.9098 [0.2649]
$\Delta y_{1,t-6}$	0.0380 [0.2422]	0.2132 [0.2469]	0.3007 [0.2585]	0.5798 [0.2168]
$\Delta y_{2,t-1}$	0.7479 [0.4427]	0.1108 [0.4513]	1.0340 [0.4726]	-1.6238 [0.3963]
$\Delta y_{2,t-2}$	0.6069 [0.4700]	0.0308 [0.4791]	0.8458 [0.5018]	-1.4336 [0.4208]
$\Delta y_{2,t-3}$	-0.0060 [0.4539]	-0.4975 [0.4627]	0.0922 [0.4846]	-1.7713 [0.4063]
$\Delta y_{2,t-4}$	0.0235 [0.4251]	-0.4031 [0.4334]	0.2074 [0.4539]	-0.9503 [0.3806]
$\Delta y_{2,t-5}$	-0.3480 [0.3678]	-0.5909 [0.3749]	-0.1893 [0.3926]	-0.8534 [0.3292]
$\Delta y_{2,t-6}$	-0.0665 [0.2737]	-0.1966 [0.2790]	-0.0319 [0.2922]	-0.4653 [0.2450]
$\Delta y_{3,t-1}$	-0.2671 [0.1914]	-0.2860 [0.1951]	-1.3698 [0.2043]	0.1790 [0.1713]
$\Delta y_{3,t-2}$	-0.1150 [0.2609]	-0.1157 [0.2660]	-0.9961 [0.2786]	0.4142 [0.2336]
$\Delta y_{3,t-3}$	-0.0116 [0.2889]	0.0628 [0.2945]	-0.6914 [0.3084]	0.0609 [0.2586]

Table A7 (Continued)

VEC estimations

(B) Second period (1 July 1931–3 October 1932) (continued)

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
$\Delta y_{3,t-4}$	-0.0146 [0.2861]	0.0607 [0.2917]	-0.4806 [0.3055]	-0.1226 [0.2562]
$\Delta y_{3,t-5}$	-0.1125 [0.2574]	-0.1370 [0.2624]	-0.5087 [0.2748]	-0.1969 [0.2305]
$\Delta y_{3,t-6}$	-0.0122 [0.1780]	-0.0026 [0.1814]	-0.2353 [0.1900]	-0.1502 [0.1593]
$\Delta y_{4,t-1}$	-0.5294 [0.1535]	-0.6110 [0.1565]	-0.5291 [0.1639]	-0.3499 [0.1374]
$\Delta y_{4,t-2}$	-0.5367 [0.1415]	-0.6094 [0.1443]	-0.5267 [0.1511]	-0.3765 [0.1267]
$\Delta y_{4,t-3}$	-0.5851 [0.1297]	-0.6288 [0.1323]	-0.5658 [0.1385]	-0.3245 [0.1161]
$\Delta y_{4,t-4}$	-0.4796 [0.1206]	-0.5102 [0.1229]	-0.4522 [0.1287]	-0.1820 [0.1079]
$\Delta y_{4,t-5}$	-0.3117 [0.1035]	-0.3311 [0.1056]	-0.3115 [0.1105]	-0.0825 [0.0927]
$\Delta y_{4,t-6}$	-0.1354 [0.0740]	-0.1449 [0.0754]	-0.1484 [0.0790]	-0.0234 [0.0662]
Constant	0.0000 [0.0008]	0.0000 [0.0008]	0.0001 [0.0009]	-0.0001 [0.0007]
$\bar{R}^2$	0.3909	0.4064	0.4244	0.5403

(C) Third period (4 October 1932–30 October 1933)

	Cointegration equation	
	Equation 1	Equation 2
$y_{1,t-1}$	1.0000	0.0000
$y_{2,t-1}$	0.0000	1.0000
$y_{3,t-1}$	-0.6348 [0.0716]	-0.1575 [0.1283]
$y_{4,t-1}$	0.0517 [0.0683]	-0.0846 [0.1224]
Constant	0.0000	-0.0003

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Cointegration Equation 1	-0.5105 [0.3590]	0.1579 [0.3821]	1.1544 [0.4319]	-0.7695 [0.4275]
Cointegration Equation 2	-0.7529 [0.1955]	-1.1685 [0.2081]	-1.4009 [0.2352]	0.0190 [0.2328]
$\Delta y_{1,t-1}$	-0.0611 [0.3367]	0.1787 [0.3583]	-0.4042 [0.4050]	1.1088 [0.4009]
$\Delta y_{1,t-2}$	-0.1025 [0.3001]	0.0492 [0.3194]	-0.2332 [0.3610]	0.8838 [0.3573]
$\Delta y_{1,t-3}$	0.1049 [0.2417]	0.1225 [0.2573]	-0.0475 [0.2908]	0.6953 [0.2878]
$\Delta y_{1,t-4}$	0.0242 [0.1691]	-0.0181 [0.1800]	-0.0646 [0.2035]	0.2546 [0.2014]
$\Delta y_{2,t-1}$	0.5892 [0.2124]	0.2002 [0.2261]	1.1687 [0.2556]	-0.0845 [0.2530]
$\Delta y_{2,t-2}$	0.6870 [0.2111]	0.4328 [0.2247]	1.1561 [0.2539]	0.1539 [0.2514]
$\Delta y_{2,t-3}$	0.4033 [0.1919]	0.2755 [0.2042]	0.7536 [0.2308]	0.0667 [0.2285]
$\Delta y_{2,t-4}$	0.1763 [0.1485]	0.1176 [0.1580]	0.3217 [0.1786]	0.0613 [0.1768]
$\Delta y_{3,t-1}$	-0.4230 [0.1897]	-0.1354 [0.2019]	-0.6525 [0.2282]	-0.4260 [0.2259]
$\Delta y_{3,t-2}$	-0.4667 [0.1683]	-0.2299 [0.1791]	-0.7436 [0.2025]	-0.4473 [0.2004]
$\Delta y_{3,t-3}$	-0.3665 [0.1382]	-0.1786 [0.1471]	-0.5489 [0.1662]	-0.2499 [0.1645]
$\Delta y_{3,t-4}$	-0.2294 [0.0944]	-0.1099 [0.1004]	-0.3085 [0.1135]	-0.1471 [0.1124]
$\Delta y_{4,t-1}$	-0.1525 [0.0641]	-0.2484 [0.0797]	-0.2941 [0.0771]	-0.8668 [0.0763]
$\Delta y_{4,t-2}$	-0.1874 [0.0749]	-0.2484 [0.0797]	-0.3019 [0.0901]	-0.7188 [0.0892]
$\Delta y_{4,t-3}$	-0.0911 [0.0740]	-0.0979 [0.0788]	-0.1331 [0.0890]	-0.4798 [0.0881]
$\Delta y_{4,t-4}$	-0.0240 [0.0598]	-0.0238 [0.0637]	-0.0281 [0.0720]	-0.2425 [0.0713]

Table A7 (Continued)

VEC estimations

(C) Third period (4 October 1932–30 October 1933) (continued).

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Constant	0.0000 [0.0005]	0.0000 [0.0005]	0.0000 [0.0006]	0.0000 [0.0006]
$\bar{R}^2$	0.4076	0.4182	0.4530	0.3870

(D) Fourth period (1 November 1933–19 September 1936)

	Cointegration equation	
	Equation 1	Equation 2
$y_{1,t-1}$	1.0000	0.0000
$y_{2,t-1}$	0.0000	1.0000
$y_{3,t-1}$	-33.358 [3.2077]	-21.802 [2.0731]
$y_{4,t-1}$	27.572 [3.1095]	17.802 [2.0096]
Constant	-0.0021	-0.0014

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Cointegration Equation 1	-0.5823 [0.1274]	0.1853 [0.1142]	-0.3117 [0.1232]	-0.3285 [0.1289]
Cointegration Equation 2	0.9172 [0.1974]	-0.2675 [0.1770]	0.5109 [0.1909]	0.4854 [0.1997]
$\Delta y_{1,t-1}$	-0.2565 [0.1227]	-0.0509 [0.1100]	0.4097 [0.1187]	0.4380 [0.1241]
$\Delta y_{1,t-2}$	-0.3042 [0.1173]	-0.1214 [0.1052]	0.2667 [0.1134]	0.3284 [0.1186]
$\Delta y_{1,t-3}$	-0.2923 [0.1090]	-0.0898 [0.0978]	0.2205 [0.1054]	0.2498 [0.1103]
$\Delta y_{1,t-4}$	-0.3053 [0.0978]	-0.1549 [0.0877]	0.1013 [0.0945]	0.1917 [0.0989]
$\Delta y_{1,t-5}$	-0.2287 [0.0834]	-0.1212 [0.0748]	0.0631 [0.0806]	0.1562 [0.0844]
$\Delta y_{1,t-6}$	-0.1239 [0.0616]	-0.0516 [0.0552]	0.0027 [0.0596]	0.0259 [0.0623]
$\Delta y_{2,t-1}$	-0.8093 [0.1851]	-0.6794 [0.1659]	-0.4217 [0.1790]	-0.4133 [0.1872]
$\Delta y_{2,t-2}$	-0.7027 [0.1714]	-0.5890 [0.1537]	-0.3815 [0.1657]	-0.3394 [0.1734]
$\Delta y_{2,t-3}$	-0.4775 [0.1554]	-0.3984 [0.1393]	-0.2510 [0.1503]	-0.3142 [0.1572]
$\Delta y_{2,t-4}$	-0.2782 [0.1349]	-0.2130 [0.1210]	-0.0964 [0.1305]	-0.1569 [0.1365]
$\Delta y_{2,t-5}$	-0.1693 [0.1096]	-0.1319 [0.0982]	-0.0275 [0.1061]	-0.1048 [0.1108]
$\Delta y_{2,t-6}$	0.0160 [0.0751]	-0.0042 [0.0673]	0.0728 [0.0726]	-0.0247 [0.0759]
$\Delta y_{3,t-1}$	0.5842 [0.1097]	0.3906 [0.0983]	-0.1706 [0.1061]	-0.3212 [0.1110]
$\Delta y_{3,t-2}$	0.5160 [0.1066]	0.3669 [0.0956]	-0.1108 [0.1031]	-0.2899 [0.1079]
$\Delta y_{3,t-3}$	0.3768 [0.1013]	0.2104 [0.0908]	-0.1613 [0.0980]	-0.2280 [0.1025]
$\Delta y_{3,t-4}$	0.3472 [0.0918]	0.2091 [0.0823]	-0.0937 [0.0888]	-0.1878 [0.0929]
$\Delta y_{3,t-5}$	0.2368 [0.0786]	0.1531 [0.0705]	-0.0878 [0.0760]	-0.1306 [0.0795]
$\Delta y_{3,t-6}$	0.0339 [0.0561]	0.0211 [0.0503]	-0.0867 [0.0542]	-0.0965 [0.0567]
$\Delta y_{4,t-1}$	-0.3181 [0.0766]	-0.3868 [0.0687]	-0.4987 [0.0741]	-0.4948 [0.0775]
$\Delta y_{4,t-2}$	-0.2218 [0.0732]	-0.3010 [0.0656]	-0.3828 [0.0708]	-0.3854 [0.0740]
$\Delta y_{4,t-3}$	-0.1987 [0.0687]	-0.2570 [0.0616]	-0.2902 [0.0664]	-0.2509 [0.0695]
$\Delta y_{4,t-4}$	-0.1369 [0.0628]	-0.1774 [0.0563]	-0.2313 [0.0607]	-0.1811 [0.0635]
$\Delta y_{4,t-5}$	-0.0725 [0.0532]	-0.0912 [0.0477]	-0.0962 [0.0515]	-0.1227 [0.0539]
$\Delta y_{4,t-6}$	-0.0764 [0.0392]	-0.0823 [0.0351]	-0.1103 [0.0379]	-0.0969 [0.0396]
Constant	-0.0000 [0.0002]	-0.0000 [0.0002]	0.0000 [0.0002]	-0.0000 [0.0002]
$\bar{R}^2$	0.3901	0.4138	0.4070	0.4321

Table A7 (Continued)

VEC estimations

(E) Fifth period (21 September 1936–19 August 1939)

	Cointegration equation			
	Equation 1	Equation 2		
$y_{1,t-1}$	1.0000	0.0000		
$y_{2,t-1}$	0.0000	1.0000		
$y_{3,t-1}$	-0.7258 [0.1407]	-1.3416 [0.0853]		
$y_{4,t-1}$	-2.0722 [0.2990]	-0.0183 [0.1811]		
Constant	0.0003	0.0001		
	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Cointegration Equation 1	0.2173 [0.1050]	0.3148 [0.1144]	0.2824 [0.1415]	0.4701 [0.0512]
Cointegration Equation 2	-0.2419 [0.1426]	0.0161 [0.1553]	0.9846 [0.1921]	-0.5059 [0.0696]
$\Delta y_{1,t-1}$	-0.9241 [0.1212]	-0.0328 [0.1319]	-0.1802 [0.1632]	-0.3533 [0.0591]
$\Delta y_{1,t-2}$	-0.7303 [0.1312]	0.0556 [0.1428]	-0.0673 [0.1767]	-0.3204 [0.0640]
$\Delta y_{1,t-3}$	-0.5770 [0.1352]	0.0814 [0.1472]	-0.0722 [0.1822]	-0.2563 [0.0660]
$\Delta y_{1,t-4}$	-0.4539 [0.1342]	0.1393 [0.1461]	-0.0752 [0.1807]	-0.3202 [0.0654]
$\Delta y_{1,t-5}$	-0.1645 [0.1299]	0.3555 [0.1414]	0.1340 [0.1750]	-0.1513 [0.0634]
$\Delta y_{1,t-6}$	-0.0990 [0.1200]	0.2851 [0.1307]	0.1174 [0.1617]	-0.1298 [0.0586]
$\Delta y_{1,t-7}$	-0.1064 [0.1027]	0.1485 [0.1118]	0.0622 [0.1383]	-0.0212 [0.0501]
$\Delta y_{1,t-8}$	-0.2250 [0.0718]	-0.1140 [0.0782]	-0.0764 [0.0967]	-0.0314 [0.0350]
$\Delta y_{2,t-1}$	0.1959 [0.1549]	-1.0933 [0.1687]	-0.7262 [0.2087]	0.4891 [0.0756]
$\Delta y_{2,t-2}$	0.0175 [0.1667]	-1.0476 [0.1815]	-0.6051 [0.2246]	0.4576 [0.0813]
$\Delta y_{2,t-3}$	0.0268 [0.1698]	-0.8913 [0.1849]	-0.3933 [0.2287]	0.4811 [0.0828]
$\Delta y_{2,t-4}$	-0.0785 [0.1673]	-0.8776 [0.1821]	-0.3226 [0.2254]	0.5030 [0.0816]
$\Delta y_{2,t-5}$	-0.2278 [0.1613]	-0.9390 [0.1757]	-0.3864 [0.2173]	0.4253 [0.0787]
$\Delta y_{2,t-6}$	-0.2838 [0.1488]	-0.8086 [0.1620]	-0.4134 [0.2005]	0.3024 [0.0726]
$\Delta y_{2,t-7}$	-0.1768 [0.1257]	-0.4755 [0.1369]	-0.2253 [0.1693]	0.1400 [0.0613]
$\Delta y_{2,t-8}$	0.0512 [0.0822]	-0.0957 [0.0895]	-0.0414 [0.1107]	0.0419 [0.0401]
$\Delta y_{3,t-1}$	-0.1650 [0.1377]	0.2678 [0.1499]	0.4043 [0.1855]	-0.3024 [0.0671]
$\Delta y_{3,t-2}$	-0.0913 [0.1290]	0.2301 [0.1405]	0.2823 [0.1738]	-0.2460 [0.0629]
$\Delta y_{3,t-3}$	-0.1305 [0.1182]	0.1462 [0.1287]	0.1357 [0.1593]	-0.2711 [0.0577]
$\Delta y_{3,t-4}$	-0.0862 [0.1074]	0.1384 [0.1170]	0.1023 [0.1447]	-0.2386 [0.0524]
$\Delta y_{3,t-5}$	-0.0105 [0.0950]	0.1743 [0.1035]	0.1294 [0.1280]	-0.2261 [0.0464]
$\Delta y_{3,t-6}$	0.0357 [0.0800]	0.1765 [0.0871]	0.1096 [0.1077]	-0.1543 [0.0390]
$\Delta y_{3,t-7}$	0.0506 [0.0620]	0.1445 [0.0675]	0.1028 [0.0835]	-0.0658 [0.0302]
$\Delta y_{3,t-8}$	0.0346 [0.0399]	0.0886 [0.0434]	0.1013 [0.0537]	-0.0033 [0.0195]
$\Delta y_{4,t-1}$	0.3815 [0.2032]	0.5672 [0.2212]	0.5865 [0.2737]	-0.0450 [0.0991]
$\Delta y_{4,t-2}$	0.3452 [0.1885]	0.5292 [0.2052]	0.3724 [0.2539]	-0.1448 [0.0919]
$\Delta y_{4,t-3}$	0.3248 [0.1742]	0.4749 [0.1897]	0.2917 [0.2347]	-0.0244 [0.0850]
$\Delta y_{4,t-4}$	0.1011 [0.1591]	0.2140 [0.1732]	0.1586 [0.2143]	-0.0317 [0.0776]
$\Delta y_{4,t-5}$	0.0558 [0.1445]	0.1538 [0.1573]	0.1810 [0.1946]	0.0206 [0.0705]
$\Delta y_{4,t-6}$	-0.1356 [0.1256]	-0.0725 [0.1367]	0.0442 [0.1692]	-0.0786 [0.0613]
$\Delta y_{4,t-7}$	-0.0671 [0.1023]	0.0283 [0.1114]	0.1359 [0.1378]	-0.0547 [0.0499]

Table A7 (Continued)

VEC estimations

(E) Fifth period (21 September 1936–19 August 1939) (continued)

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
$\Delta y_{4,t-8}$	-0.0024 [0.0738]	0.0507 [0.0803]	0.0916 [0.0994]	-0.0266 [0.0360]
Constant	0.0000	-0.0000	-0.0000	0.0000
$\bar{R}^2$	0.3941	0.4423	0.4875	0.5366

(F) All periods (2 November 1925–19 August 1939)

	Cointegration equation		
	Equation 1	Equation 2	Equation 3
$y_{1,t-1}$	1.0000	0.0000	0.0000
$y_{2,t-1}$	0.0000	1.0000	0.0000
$y_{3,t-1}$	0.0000	0.0000	1.0000
$y_{4,t-1}$	-0.6172 [0.0600]	-0.7209 [0.0529]	-0.8429 [0.0416]
Constant	-0.0000	-0.0000	-0.0000

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
Cointegration Equation 1	-1.0301 [0.1671]	0.0785 [0.1727]	-0.3857 [0.1985]	-0.3843 [0.1328]
Cointegration Equation 2	0.4268 [0.2219]	-0.6117 [0.2293]	1.2203 [0.2635]	0.6345 [0.1763]
Cointegration Equation 3	0.0773 [0.1441]	-0.1364 [0.1489]	-1.7698 [0.1711]	0.2761 [0.1145]
$\Delta y_{1,t-1}$	0.2079 [0.1619]	0.0965 [0.1673]	0.5475 [0.1922]	0.5254 [0.1286]
$\Delta y_{1,t-2}$	0.1602 [0.1563]	0.0374 [0.1615]	0.4798 [0.1856]	0.4919 [0.1242]
$\Delta y_{1,t-3}$	0.1945 [0.1510]	0.1012 [0.1560]	0.5073 [0.1793]	0.5658 [0.1200]
$\Delta y_{1,t-4}$	0.1808 [0.1458]	0.1505 [0.1507]	0.5604 [0.1731]	0.5312 [0.1158]
$\Delta y_{1,t-5}$	0.2839 [0.1405]	0.2439 [0.1452]	0.6428 [0.1669]	0.5920 [0.1117]
$\Delta y_{1,t-6}$	0.2388 [0.1352]	0.1842 [0.1398]	0.6042 [0.1606]	0.5701 [0.1075]
$\Delta y_{1,t-7}$	0.1563 [0.1296]	0.0652 [0.1340]	0.4543 [0.1539]	0.5007 [0.1030]
$\Delta y_{1,t-8}$	0.1265 [0.1242]	-0.0025 [0.1284]	0.3961 [0.1475]	0.4630 [0.0987]
$\Delta y_{1,t-9}$	0.0798 [0.1185]	-0.0478 [0.1224]	0.3547 [0.1407]	0.4370 [0.0941]
$\Delta y_{1,t-10}$	0.0001 [0.1124]	-0.1420 [0.1162]	0.2126 [0.1335]	0.3747 [0.0893]
$\Delta y_{1,t-11}$	-0.0902 [0.1055]	-0.2094 [0.1090]	0.1299 [0.1253]	0.3289 [0.0838]
$\Delta y_{1,t-12}$	-0.0306 [0.0976]	-0.1393 [0.1009]	0.1752 [0.1159]	0.3111 [0.0776]
$\Delta y_{1,t-13}$	-0.0182 [0.0886]	-0.1184 [0.0916]	0.1981 [0.1053]	0.2702 [0.0704]
$\Delta y_{1,t-14}$	0.0027 [0.0783]	-0.0725 [0.0809]	0.2255 [0.0930]	0.2648 [0.0622]
$\Delta y_{1,t-15}$	-0.0193 [0.0674]	-0.0761 [0.0697]	0.1961 [0.0801]	0.1941 [0.0536]
$\Delta y_{1,t-16}$	-0.0134 [0.0553]	-0.0138 [0.0571]	0.2234 [0.0656]	0.1703 [0.0439]
$\Delta y_{1,t-17}$	-0.0002 [0.0391]	-0.0271 [0.0404]	0.0900 [0.0465]	0.0745 [0.0311]
$\Delta y_{2,t-1}$	-0.4584 [0.2150]	-0.4685 [0.2222]	-1.1595 [0.2553]	-0.5897 [0.1708]
$\Delta y_{2,t-2}$	-0.5525 [0.2077]	-0.5277 [0.2147]	-1.1347 [0.2467]	-0.6238 [0.1651]
$\Delta y_{2,t-3}$	-0.4721 [0.2005]	-0.5012 [0.2073]	-1.0462 [0.2381]	-0.6144 [0.1593]
$\Delta y_{2,t-4}$	-0.4605 [0.1931]	-0.5666 [0.1996]	-1.0919 [0.2294]	-0.5376 [0.1535]
$\Delta y_{2,t-5}$	-0.4380 [0.1855]	-0.5185 [0.1917]	-1.0064 [0.2203]	-0.5259 [0.1474]
$\Delta y_{2,t-6}$	-0.4265 [0.1782]	-0.4740 [0.1841]	-1.0435 [0.2116]	-0.5320 [0.1416]

Table A7 (Continued)

VEC estimations

(F) All periods (2 November 1925–19 August 1939) (continued)

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
$\Delta y_{2,t-7}$	-0.3360 [0.1707]	-0.3460 [0.1764]	-0.8621 [0.2027]	-0.4814 [0.1357]
$\Delta y_{2,t-8}$	-0.3711 [0.1629]	-0.3512 [0.1384]	-0.8761 [0.1935]	-0.5434 [0.1295]
$\Delta y_{2,t-9}$	-0.2972 [0.1552]	-0.2405 [0.1604]	-0.7563 [0.1842]	-0.4996 [0.1233]
$\Delta y_{2,t-10}$	-0.2367 [0.1466]	-0.1506 [0.1515]	-0.5515 [0.1740]	-0.4125 [0.1165]
$\Delta y_{2,t-11}$	-0.0968 [0.1370]	-0.0215 [0.1416]	-0.4094 [0.1627]	-0.3633 [0.1088]
$\Delta y_{2,t-12}$	-0.1606 [0.1264]	-0.0851 [0.1307]	-0.4272 [0.1501]	-0.3585 [0.1005]
$\Delta y_{2,t-13}$	-0.1574 [0.1138]	-0.1129 [0.1176]	-0.4122 [0.1352]	-0.3322 [0.0904]
$\Delta y_{2,t-14}$	-0.1384 [0.0996]	-0.1049 [0.1029]	-0.4037 [0.1182]	-0.3138 [0.0791]
$\Delta y_{2,t-15}$	-0.0940 [0.0845]	-0.0455 [0.0873]	-0.2721 [0.1003]	-0.2053 [0.0671]
$\Delta y_{2,t-16}$	-0.0918 [0.0679]	-0.0754 [0.0701]	-0.2758 [0.0806]	-0.1855 [0.0539]
$\Delta y_{2,t-17}$	0.0176 [0.0462]	0.0506 [0.0478]	-0.0799 [0.0549]	-0.0329 [0.0367]
$\Delta y_{3,t-1}$	-0.0086 [0.1392]	0.2466 [0.1439]	0.7824 [0.1653]	-0.2559 [0.1106]
$\Delta y_{3,t-2}$	0.1012 [0.1341]	0.3314 [0.1386]	0.7619 [0.1592]	-0.1644 [0.1066]
$\Delta y_{3,t-3}$	0.0184 [0.1284]	0.2542 [0.1327]	0.6291 [0.1525]	-0.2049 [0.1021]
$\Delta y_{3,t-4}$	0.0495 [0.1226]	0.2790 [0.1267]	0.6494 [0.1456]	-0.1818 [0.0975]
$\Delta y_{3,t-5}$	-0.0360 [0.1167]	0.1760 [0.1206]	0.5137 [0.1386]	-0.2166 [0.0927]
$\Delta y_{3,t-6}$	-0.0067 [0.1109]	0.1697 [0.1146]	0.5275 [0.1317]	-0.1596 [0.0881]
$\Delta y_{3,t-7}$	-0.0028 [0.1051]	0.1636 [0.1087]	0.4946 [0.1248]	-0.1112 [0.0835]
$\Delta y_{3,t-8}$	0.0848 [0.0993]	0.2327 [0.1026]	0.5609 [0.1179]	-0.0103 [0.0789]
$\Delta y_{3,t-9}$	0.0561 [0.0935]	0.1888 [0.0967]	0.4984 [0.1111]	-0.0121 [0.0743]
$\Delta y_{3,t-10}$	0.0793 [0.0875]	0.1939 [0.0905]	0.4388 [0.1039]	-0.0215 [0.0695]
$\Delta y_{3,t-11}$	0.0784 [0.0810]	0.1638 [0.0837]	0.3766 [0.0962]	0.0094 [0.0643]
$\Delta y_{3,t-12}$	0.0980 [0.0741]	0.1721 [0.0765]	0.3444 [0.0879]	0.0133 [0.0588]
$\Delta y_{3,t-13}$	0.1099 [0.0663]	0.2090 [0.0686]	0.3222 [0.0788]	0.0326 [0.0527]
$\Delta y_{3,t-14}$	0.1410 [0.0582]	0.2123 [0.0601]	0.3099 [0.0691]	0.0475 [0.0462]
$\Delta y_{3,t-15}$	0.1227 [0.0488]	0.1682 [0.0504]	0.2182 [0.0579]	0.0416 [0.0388]
$\Delta y_{3,t-16}$	0.0641 [0.0379]	0.0788 [0.0392]	0.1311 [0.0451]	0.0359 [0.0301]
$\Delta y_{3,t-17}$	-0.0195 [0.0257]	-0.0036 [0.0266]	0.0547 [0.0305]	0.0008 [0.0204]
$\Delta y_{4,t-1}$	-0.3705 [0.0703]	-0.5982 [0.0727]	-0.9281 [0.0835]	-0.5792 [0.0559]
$\Delta y_{4,t-2}$	-0.2930 [0.0691]	-0.5218 [0.0714]	-0.8300 [0.0820]	-0.5495 [0.0549]
$\Delta y_{4,t-3}$	-0.3250 [0.0679]	-0.5317 [0.0701]	-0.8142 [0.0806]	-0.5089 [0.0539]
$\Delta y_{4,t-4}$	-0.2913 [0.0667]	-0.4777 [0.0690]	-0.7569 [0.0792]	-0.4542 [0.0530]
$\Delta y_{4,t-5}$	-0.2790 [0.0654]	-0.4406 [0.0676]	-0.7225 [0.0776]	-0.4240 [0.0519]
$\Delta y_{4,t-6}$	-0.2565 [0.0638]	-0.3919 [0.0660]	-0.6719 [0.0758]	-0.4075 [0.0507]
$\Delta y_{4,t-7}$	-0.2044 [0.0619]	-0.3371 [0.0640]	-0.5947 [0.0735]	-0.3793 [0.0492]
$\Delta y_{4,t-8}$	-0.1951 [0.0599]	-0.2990 [0.0619]	-0.5586 [0.0711]	-0.3635 [0.0476]
$\Delta y_{4,t-9}$	-0.1341 [0.0577]	-0.2353 [0.0596]	-0.4829 [0.0685]	-0.3388 [0.0458]
$\Delta y_{4,t-10}$	-0.1286 [0.0553]	-0.2238 [0.0572]	-0.4394 [0.0657]	-0.3113 [0.0440]
$\Delta y_{4,t-11}$	-0.1042 [0.0526]	-0.1743 [0.0544]	-0.3871 [0.0625]	-0.2952 [0.0418]
$\Delta y_{4,t-12}$	-0.0720 [0.0499]	-0.1466 [0.0515]	-0.3437 [0.0592]	-0.2350 [0.0396]
$\Delta y_{4,t-13}$	-0.1006 [0.0468]	-0.1679 [0.0484]	-0.3614 [0.0556]	-0.2408 [0.0372]

Table A7 (Continued)

VEC estimations

(F) All periods (2 November 1925–19 August 1939) (continued)

	Error correction			
	$\Delta y_{1,t}$	$\Delta y_{2,t}$	$\Delta y_{3,t}$	$\Delta y_{4,t}$
$\Delta y_{4,t-13}$	-0.1006 [0.0468]	-0.1679 [0.0484]	-0.3614 [0.0556]	-0.2408 [0.0372]
$\Delta y_{4,t-14}$	-0.1312 [0.0433]	-0.1897 [0.0447]	-0.3752 [0.0514]	-0.2289 [0.0344]
$\Delta y_{4,t-15}$	-0.0573 [0.0389]	-0.0925 [0.0402]	-0.2312 [0.0461]	-0.1634 [0.0309]
$\Delta y_{4,t-16}$	-0.0538 [0.0326]	-0.0694 [0.0337]	-0.1550 [0.0387]	-0.1346 [0.0259]
$\Delta y_{4,t-17}$	-0.0399 [0.0239]	-0.0589 [0.0247]	-0.1031 [0.0283]	-0.0644 [0.0190]
Constant	0.0000 [0.0002]	0.0000 [0.0002]	0.0000 [0.0002]	0.0000 [0.0001]
$\bar{R}^2$	0.4492	0.4549	0.4625	0.4836

Note: $\bar{R}^2$ denotes the adjusted R-squared value and standard errors are in parentheses.

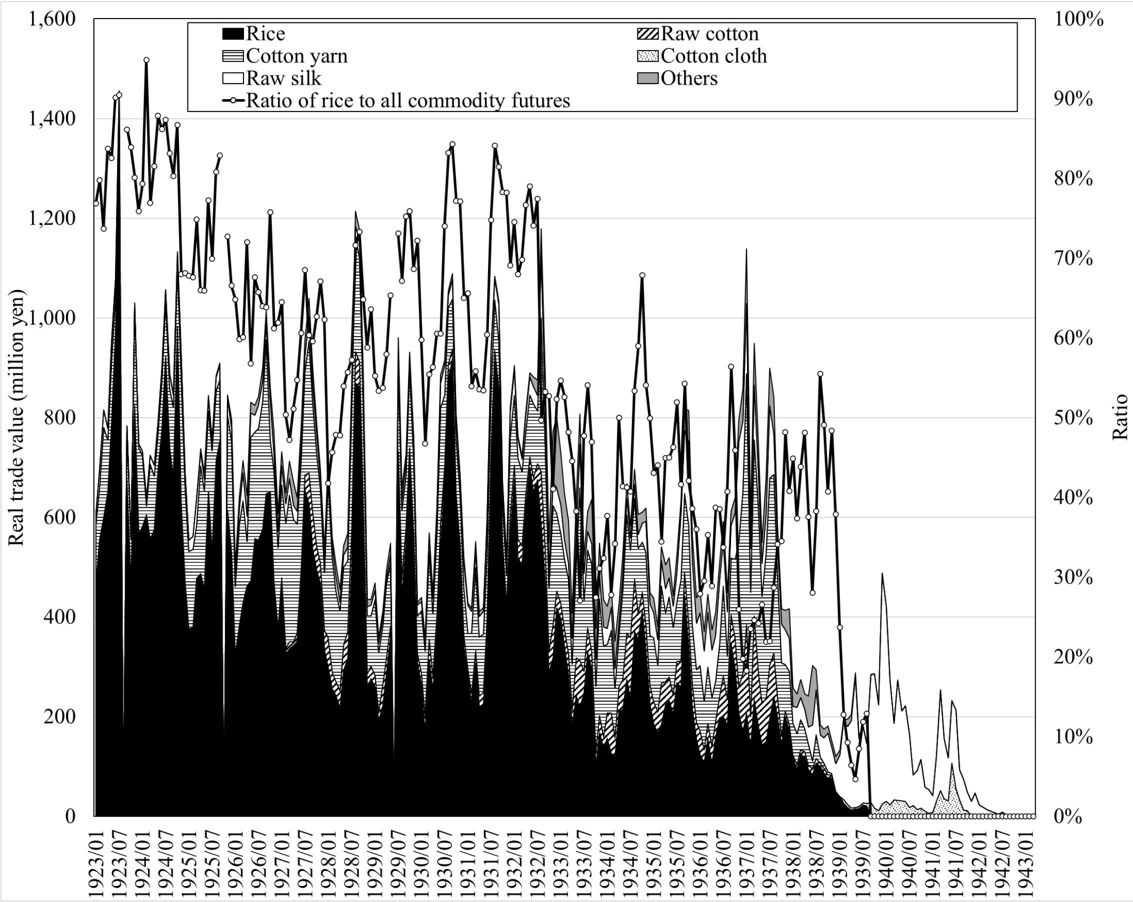


Figure A1

Real value of the futures trade in Japan's commodity exchanges

Note: There are no dates for August 1923, October 1925, or June 1929 because of the lack of data.

Sources: Bank of Japan, Research and Statistics Department 1987, pp. 24–25; Tokyo Stock Exchange, Investigation Department 1923–1929, 1930a, 1930b, 1931–1943 (monthly series).

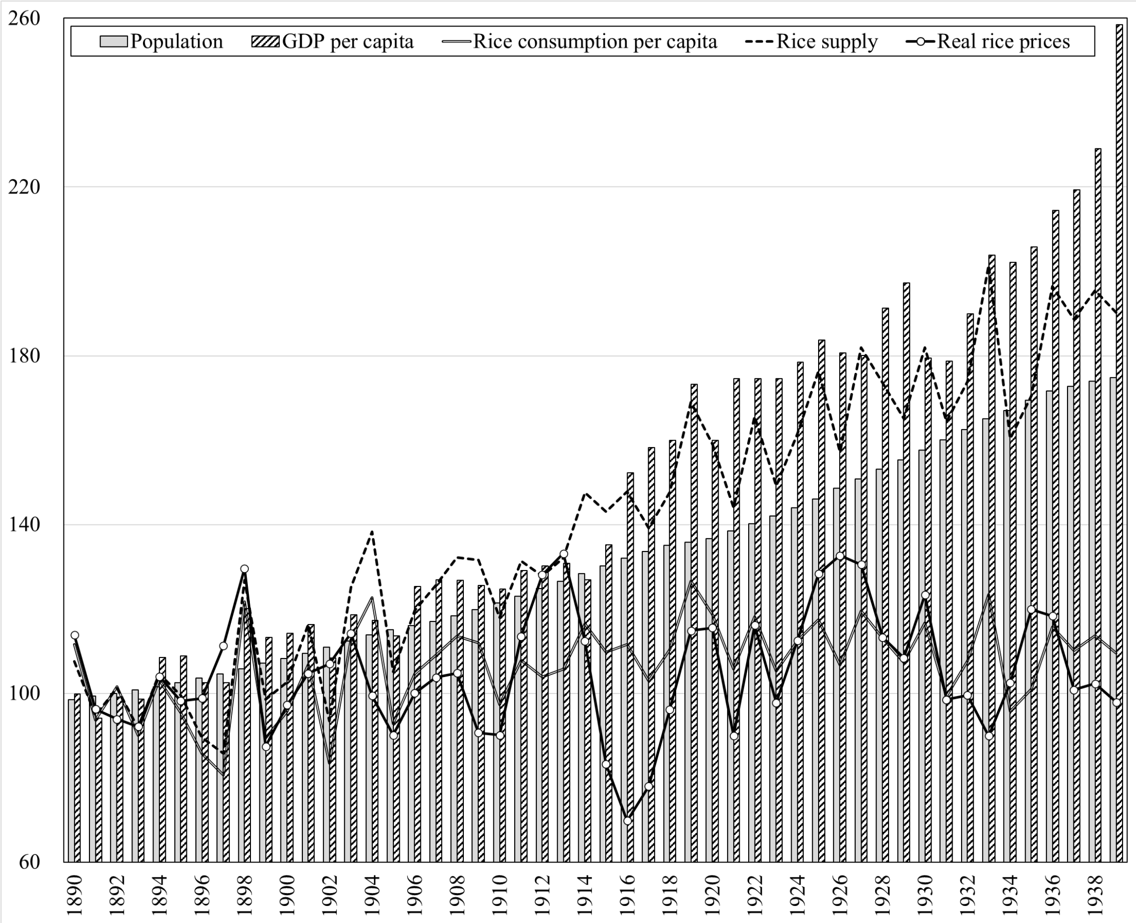


Figure A2

Indices of rice supply and demand in Japan.

Note: These indices are based on the average data from 1890 to 1894.

Sources: Bank of Japan, Statistics Department 1966, pp. 12–13; Bank of Japan, Research and Statistics Department 1987, pp. 24–25; Fukao et al. 2017a, p. 276; 2017b, p. 282; Ministry of Agriculture and Commerce, Food Control Bureau 1944, pp. 50–51, 54; Ministry of Agriculture and Forestry, Economy of Agriculture and Forestry Bureau, Statistical Investigation Unit 1955, pp. 160–61; Sasaki 1937, pp. 347–48, 350, 352–60, and 365–74.

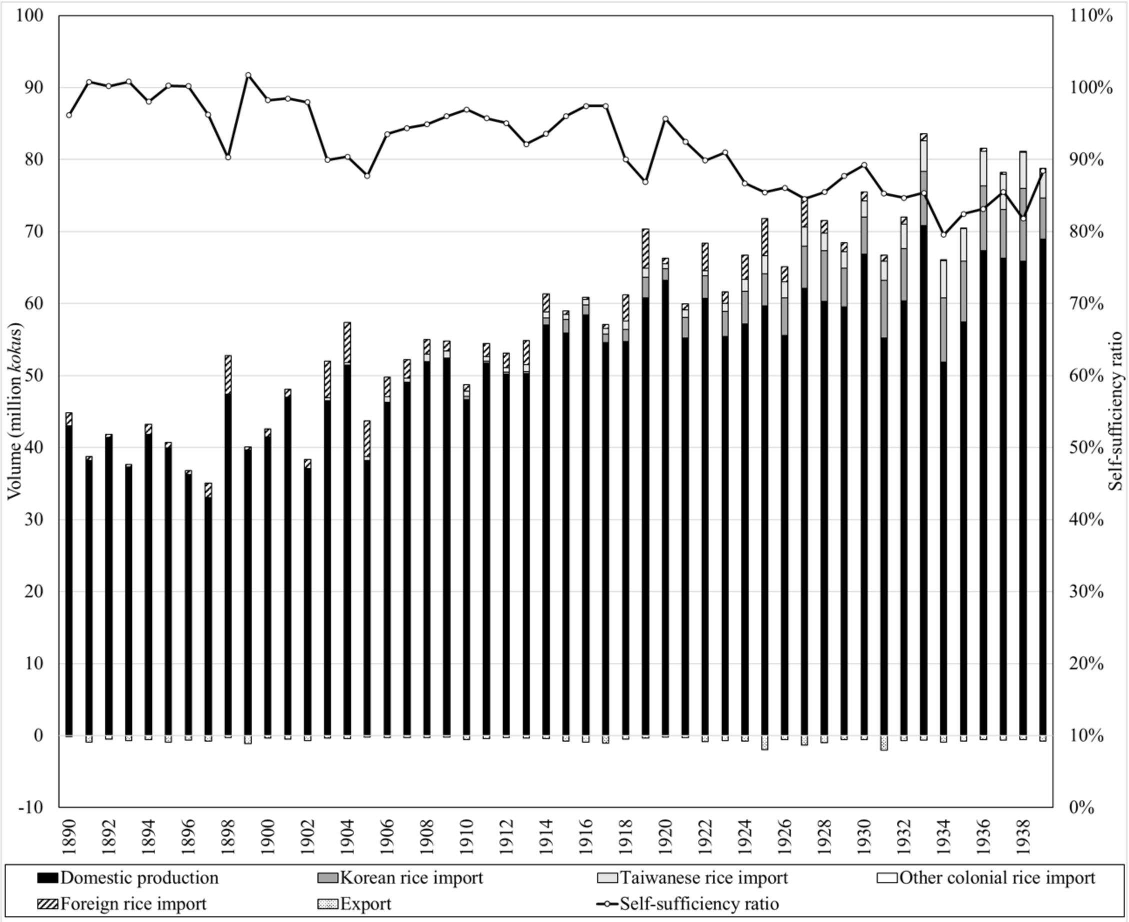


Figure A3

Rice supply volume

Note: The "*koku*" is a standard unit of measurement in Japanese agriculture. One *koku* is equal to 180.39 liters and is roughly equivalent to 150 kg.

Sources: Ministry of Agriculture and Commerce, Food Control Bureau 1944, pp. 50–51; Ministry of Agriculture and Forestry, Economy of Agriculture and Forestry Bureau, Statistical Investigation Unit 1955, pp. 160–61; Toyo Keizai Shimpo Sha 1935, pp 484–85, 592–93.

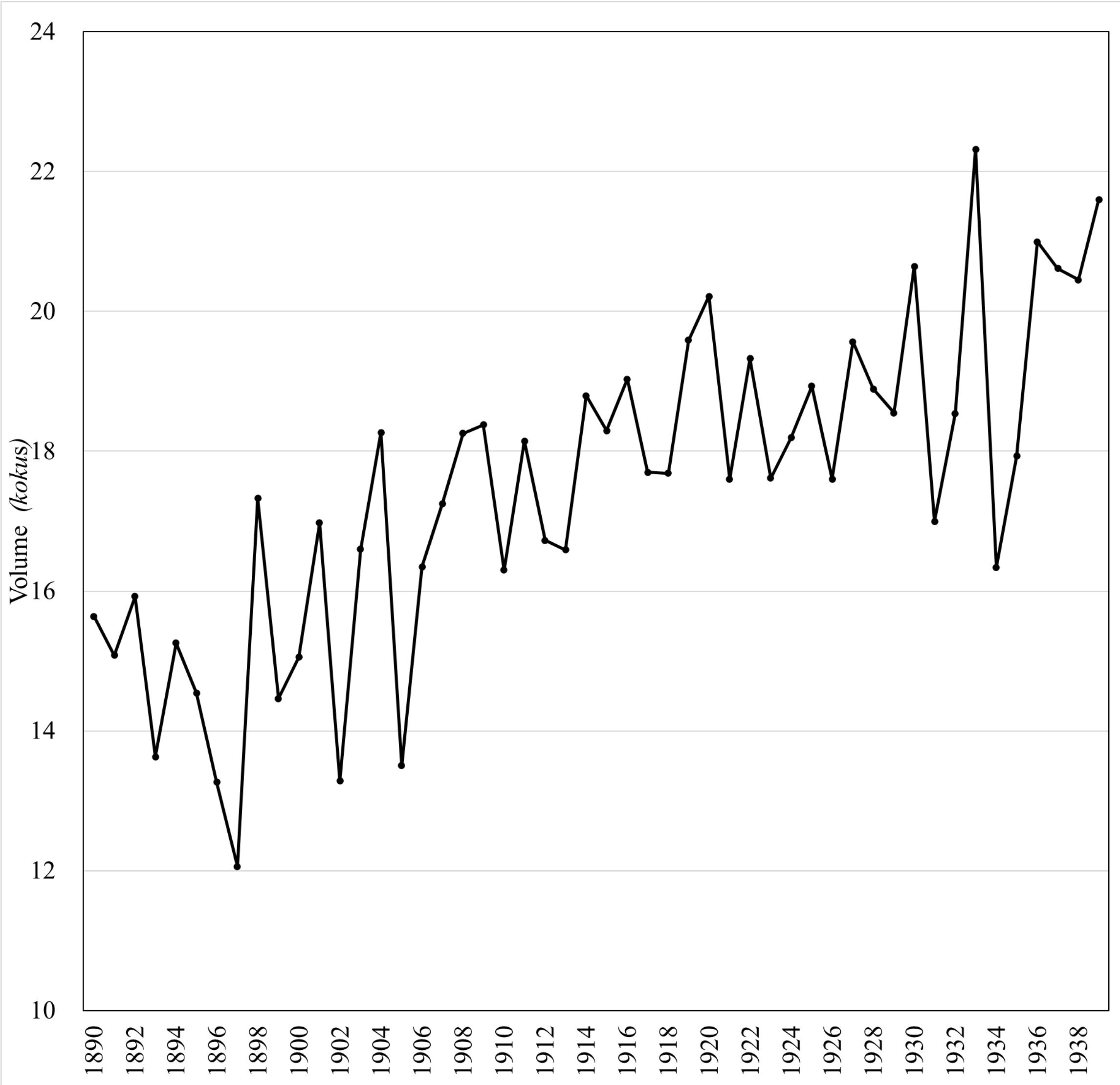


Figure A4

Production volume per hectare of rice paddies

Sources: Nippon Agricultural Research Institute 1981, p. 706; Ministry of Agriculture and Commerce, Food Control Bureau 1944, pp. 1, 50–51.

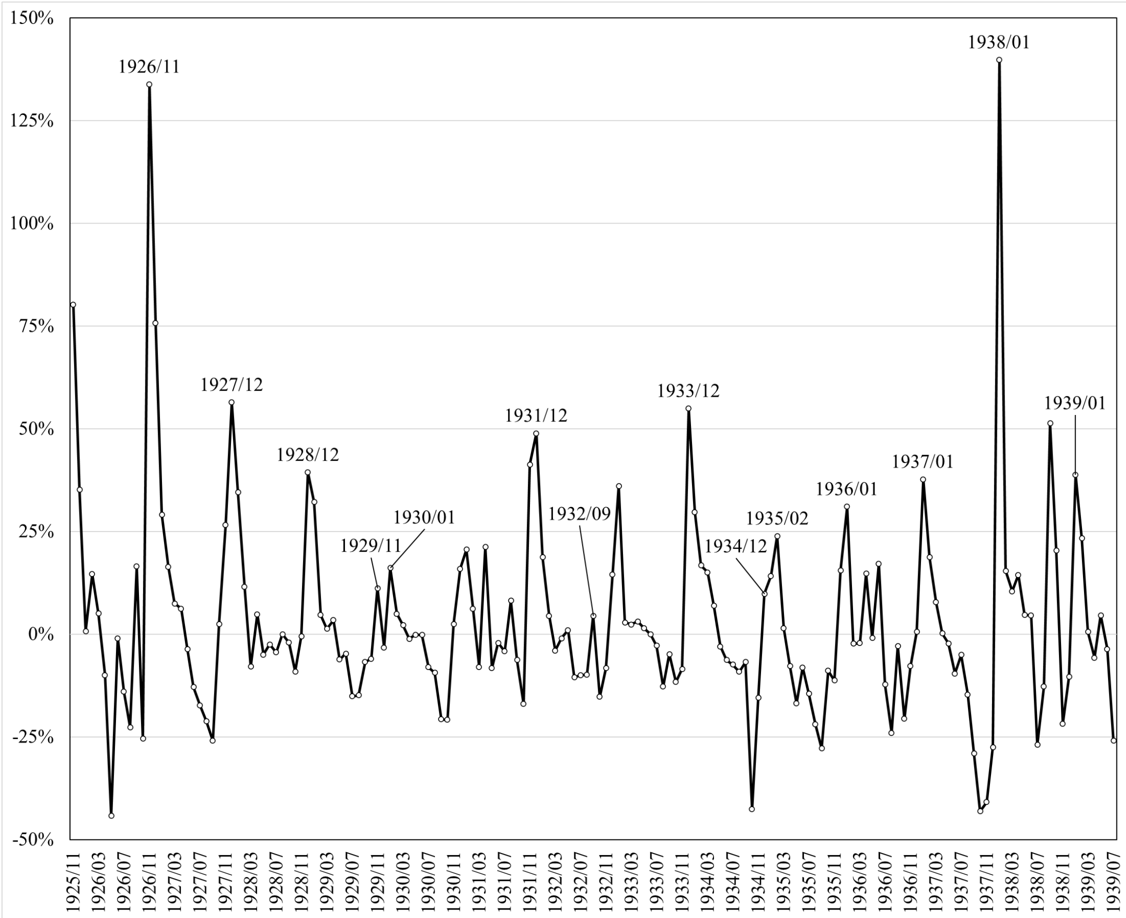


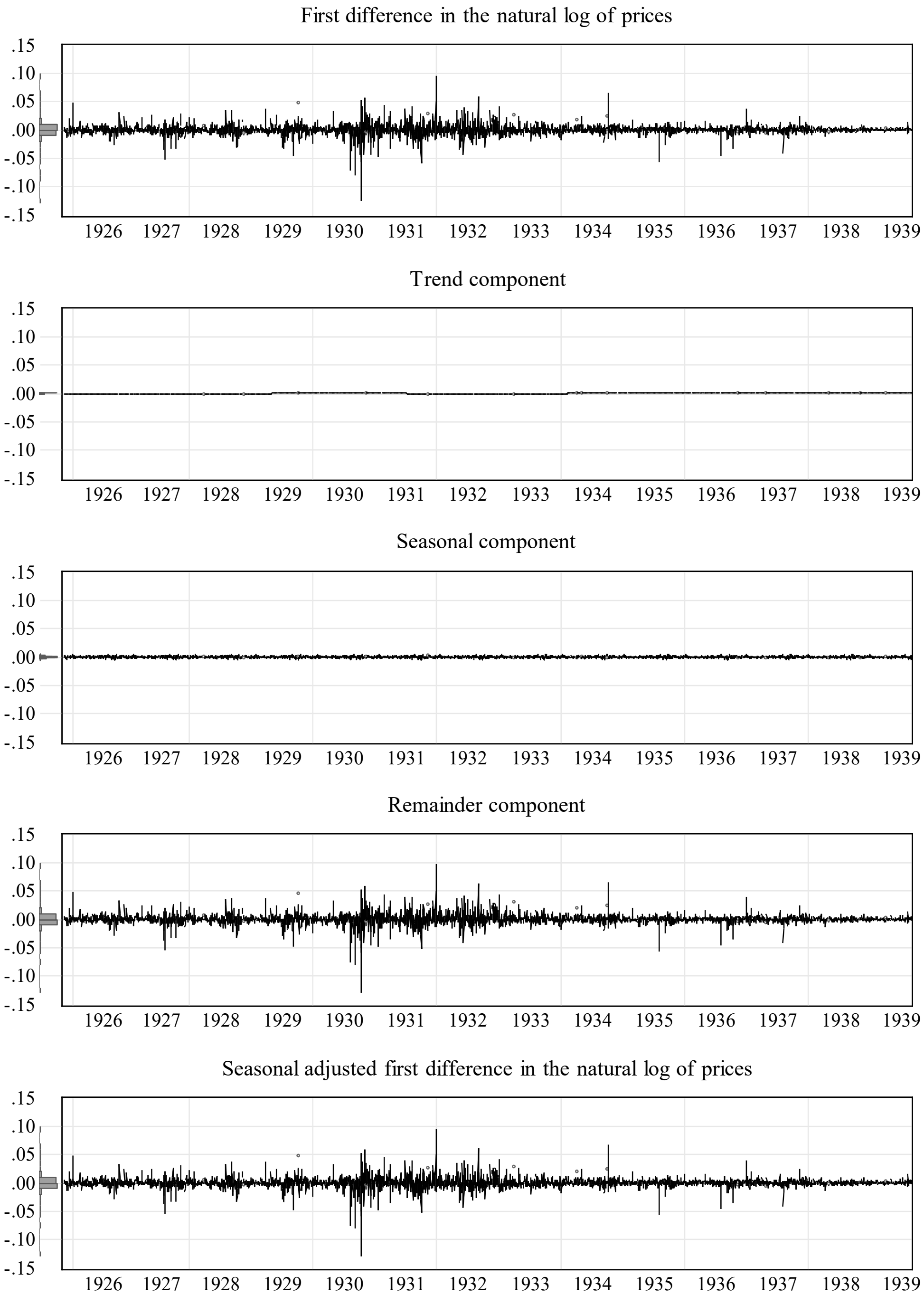
Figure A5

Monthly percentage changes in stocked domestic and Korean rice volumes in Osaka

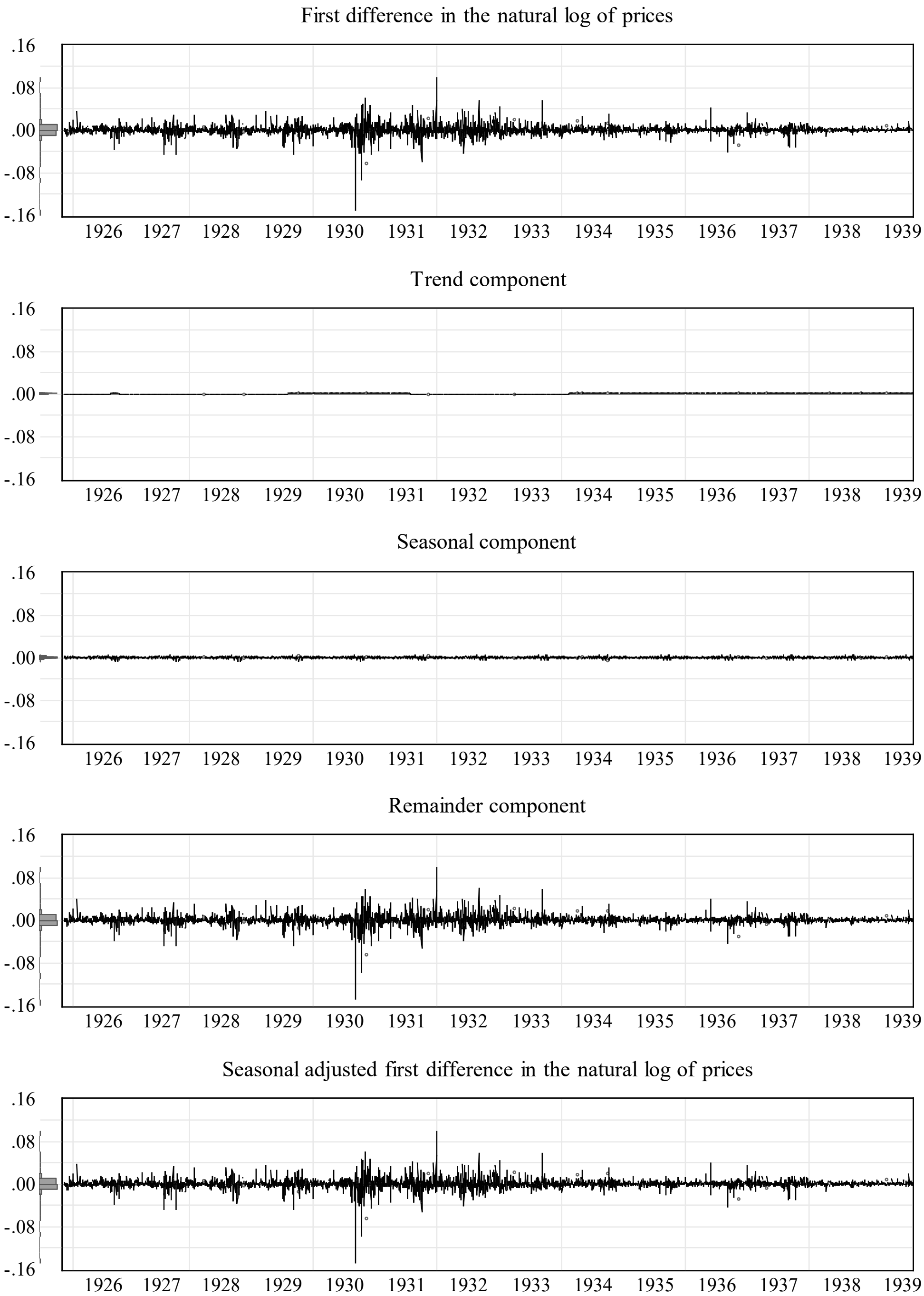
Note: This figure indicates the year and month in which the ratio peaked.

Sources: Osaka-Dojima Rice Exchange 1925a, 1926b, 1927b (semi-annual series); Osaka-Dojima Rice Exchange 1928–1935; 1936a, 1937a, 1938a, 1939 (monthly series).

(A) Deferred

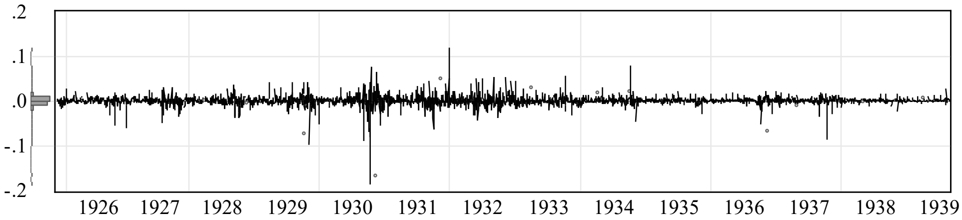

First difference in the natural log of prices
.15 .10 .05 .00 -.05 -.10 -.15
1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939
Trend component
.15 .10 .05 .00 -.05 -.10 -.15
1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939
Seasonal component
.15 .10 .05 .00 -.05 -.10 -.15
1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939
Remainder component
.15 .10 .05 .00 -.05 -.10 -.15
1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939
Seasonal adjusted first difference in the natural log of prices
.15 .10 .05 .00 -.05 -.10 -.15
1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936 1937 1938 1939

(B) Second-nearest

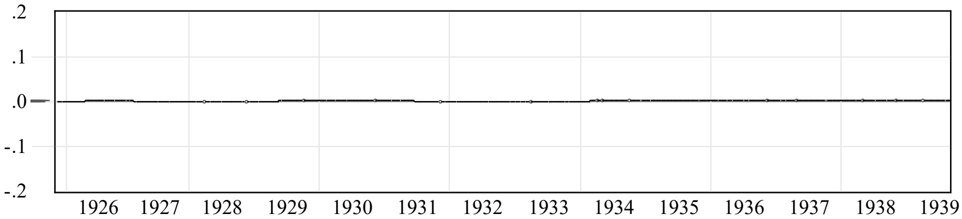


(C) Nearby

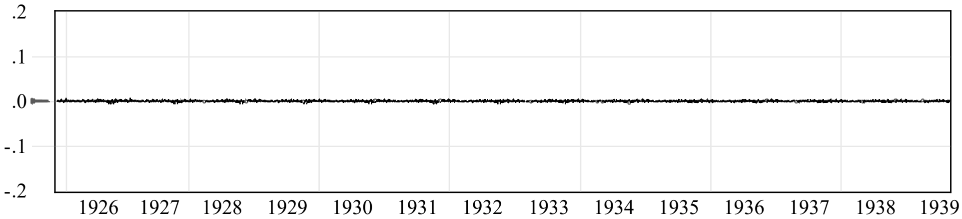
First difference in the natural log of prices



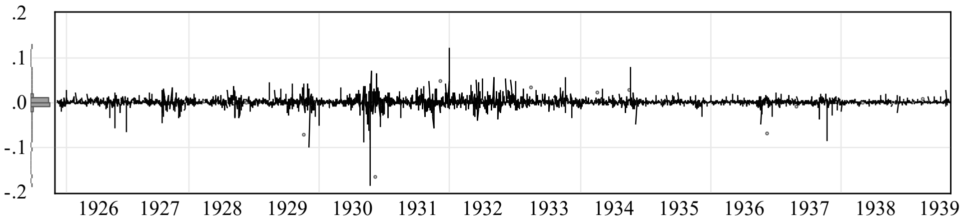
Trend component



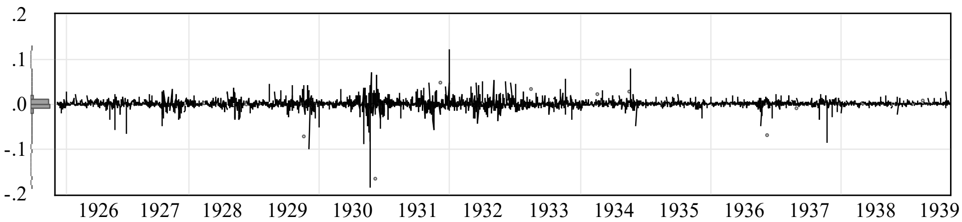
Seasonal component



Remainder component



Seasonal adjusted first difference in the natural log of prices



(D) Spot

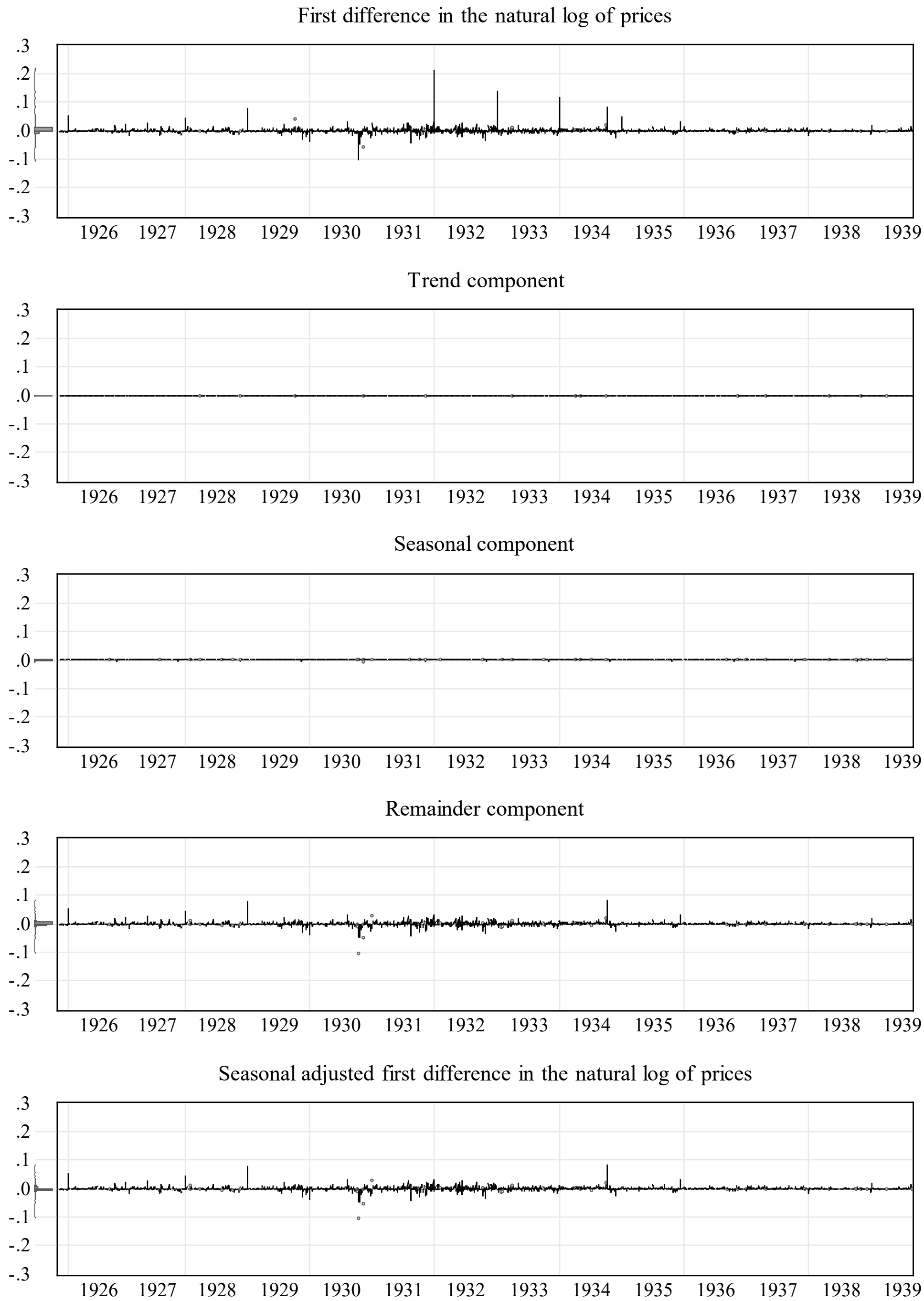


Figure A6

Results of the STL decomposition

Note: The numbers of observations in each cycle of the seasonal component, smoothing parameter for the low-pass filter, smoothing parameter for the trend component, and smoothing parameter for the seasonal component are 272, 273, 437, and 23, respectively.

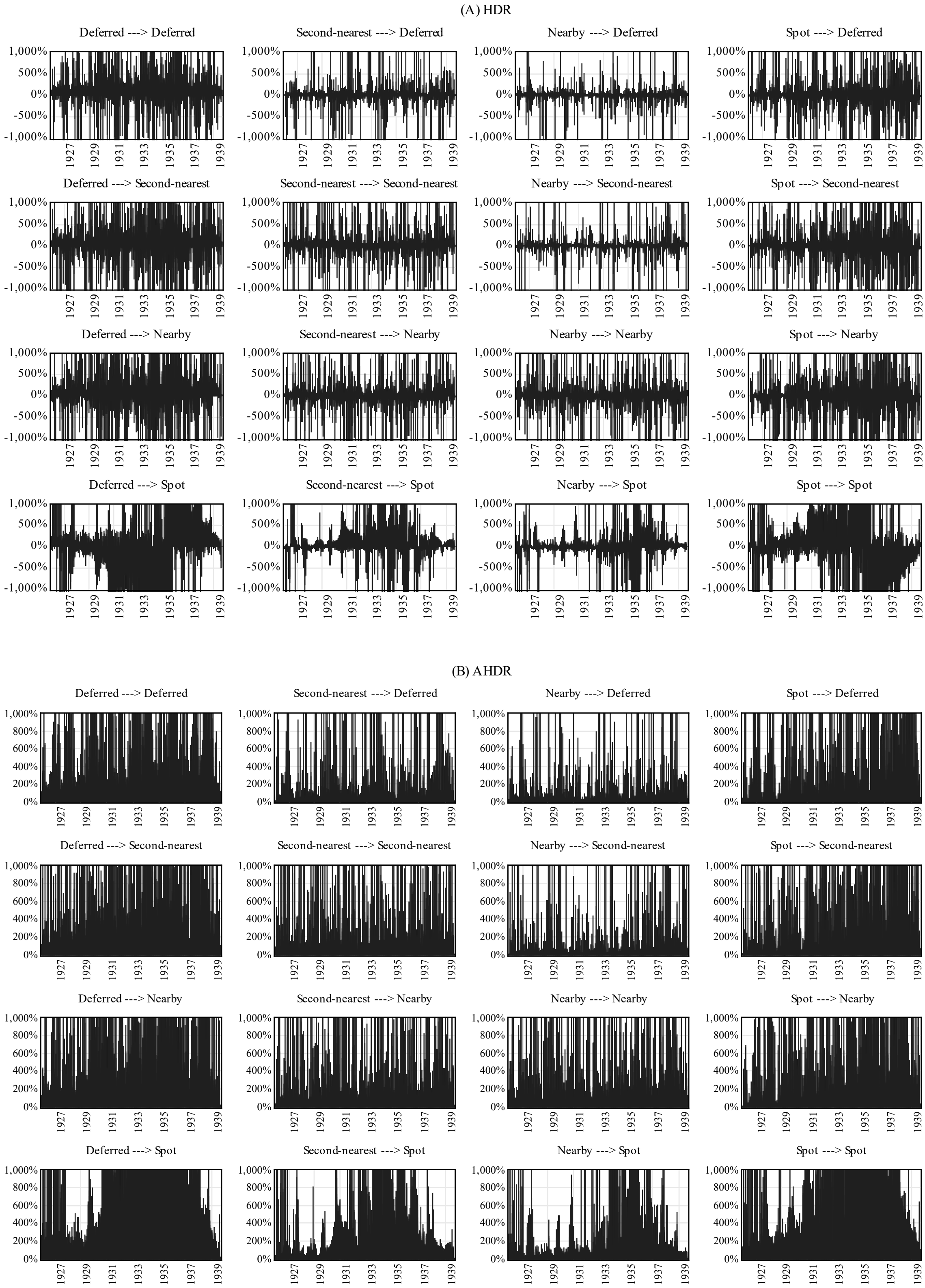


Figure A7

HDRs and AHDRs of the rice futures and spot markets in Osaka

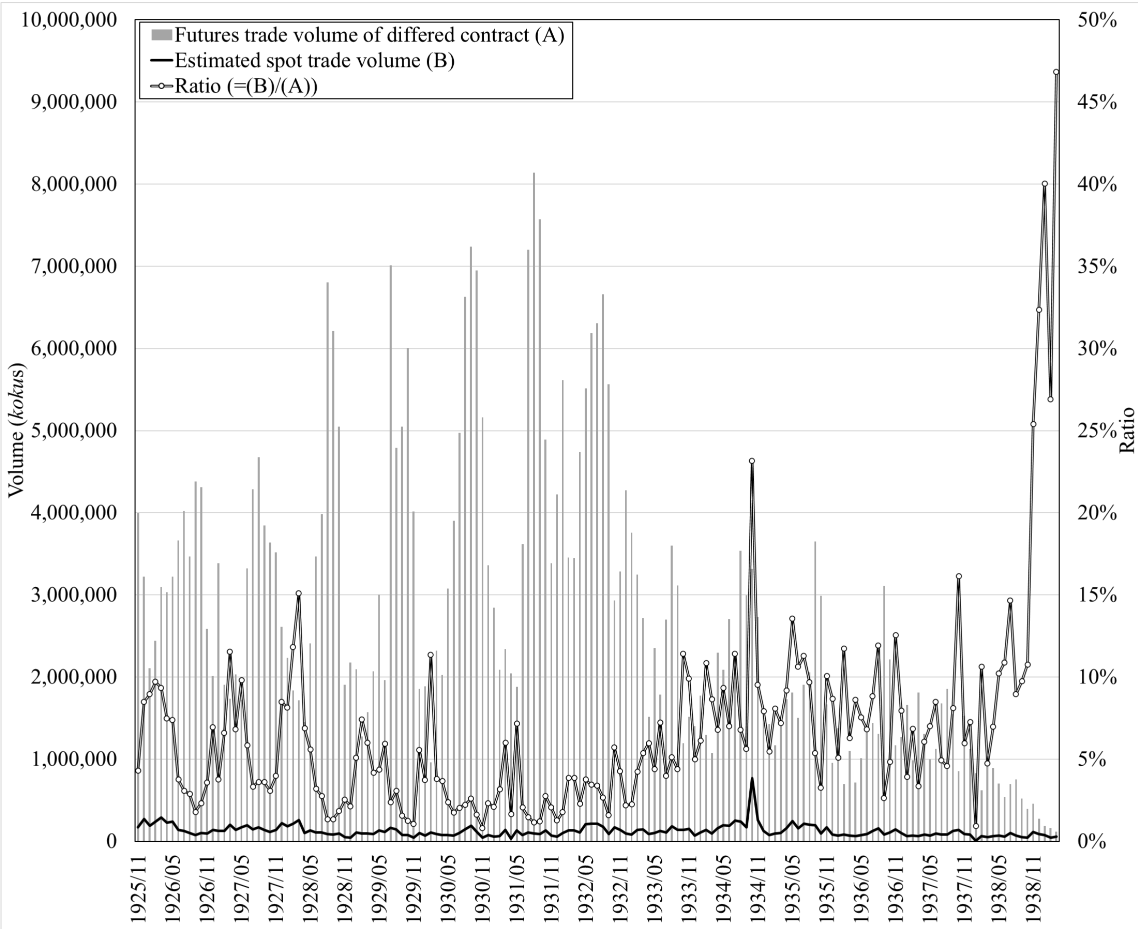


Figure A8

Trade volumes of the futures (deferred contracts) and spot markets in Osaka

Notes: See Figure 7.

Sources: Osaka Chamber of Commerce 1926; Osaka-Dojima Rice Exchange 1925a, 1926a, 1927a, 1928–35, 1936a, 1937a, 1938a, 1939; Tokyo Chamber of Commerce and Industry 1926–1940.