AUTOPSY OF A MARKET FAILURE:
THE DOJIMA JAPANESE RICE FUTURES IN THE EARLY 21st CENTURY

BY

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THESIS

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ABSTRACT

We investigate the Osaka Dojima Exchange (ODEX) Japanese rice futures market to identify the reasons underlying its failure. In 2021 the Japanese government did not authorize permanent listing of the contract citing the limited participation of handlers and ODEX decided to terminate trading. We evaluate a wide range of market characteristics that influence the success of a commodity futures market. We conclude that the spot market did not meet the requirements for the futures market to be successful. The futures market was further unable to provide some of its most relevant functions effectively. The use of the futures contracts essentially as a forward contract did not facilitate the success of the market either. Coupled with all these issues, political opposition and regulatory uncertainty led to the failure of the market by mid-2021.

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TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Considered as one of the origins of modern futures markets in the world, the Dojima rice futures market in Osaka, Japan has its roots in the 17th century during the Japanese Tokugawa Shogunate period (1603-1867). After the Meiji Restoration (1868), the Japanese government halted trading in Dojima, but the market soon restarted and operated until 1939 when it was closed due to World War II. After the war, local futures industries' (brokers, futures commission merchants, etc.) efforts to resume rice futures trading ran into government opposition. Authorities prioritized rice spot market regulation over futures trading, to control the supply and prices of a staple food in the country. Trading resumed on August 8, 2011, 72 years later from the last trade, both at the Tokyo Grain Exchange (TGE) and the Osaka Dojima Exchange (ODEX) under a temporary two-year period authorized by the Japanese Ministry of Agriculture, Forestry and Fisheries (MAFF). In the past, the MAFF usually authorized three-year trial periods for other commodity futures markets under the Japanese Commodity Futures Act. However, the MAFF took a cautious stance for rice and limited the period to two years. Caution reflected the opposition from some local politicians who did not regard futures trading of a staple food favorably.

The TGE and the ODEX were initially optimistic regarding the success of rice futures contracts, given the local commodity industry tradition of trading rice futures. The exchanges expected the contracts' prices would become benchmark prices for rice, given the lack of a transparent marketplace where rice prices were discovered. However, contrary to the initial expectations, the rice futures market suffered from low trading volume, on the order of 958 contracts per day from 2011 to 2013, aggregated across the two exchanges (table 1 in appendix A). This figure was less than 40% of the trading volume of imported corn futures contracts traded at the TGE at that time. In 2013, the TGE was dissolved due to financial difficulties, but the ODEX took over the TGE rice contract and became the only exchange to seek the permanent listing of rice futures in the country.

By law, at the end of a trial period the exchange can either file for the shift to permanent listing or extension of temporary listing to continue trading. Permanent filing requires justification from the exchange based on both liquidity and the participation of handlers who facilitate production and distribution of the underlying commodity. However, neither the law nor the relevant regulatory body, the MAFF, have established specific thresholds to qualify for permanent listing. Table 1 in appendix A classifies the ODEX rice futures trading over time by subperiods characterized by ODEX filings either for extension or permanent listing, provides information on the MAFF decisions and summary statistics on trading volume by subperiod. ODEX filings were for all rice derivatives traded in the exchange. Daily trading volume of all rice futures did not exceed 1,548 contracts during the first three temporary listing periods, which did not satisfy MAFF's liquidity requirements for permanent listing.

In 2017, in the context of a shrinking commodity futures market in Japan and after MAFF denied one request for rice permanent listing, the ODEX decided to adopt a new trading system. Starting in 2018, the exchange abandoned the traditional batch trading system "Itayose," and adopted an order-driven continuous trading system featuring an open limit order book similar to the U.S and European commodity futures markets. The ODEX expected that the new trading system would improve market access, and market liquidity (ODEX Aug 15, 2018). Consistent with the ODEX expectations, during the 2019-2021 temporary trading period, daily trading volume increased to 2,554 contracts.

In July 2021, the ODEX filed for the third time for permanent listing, but MAFF concluded that the market still did not meet the legal requirements for permanent trading. This left ODEX with only one option to continue trading: to seek approval for another extension. However, the rice futures had already undergone four temporary extension approvals by 2021, the most in Japanese commodity futures markets history. In addition, some local politicians were lobbying for a denial of further extensions as they considered these were not in line with the objective of the law. The Agricultural and Forestry committee of the ruling Liberal Democratic Party of Japan (LDP) had issued several statements on rice futures temporary listing in the past, which reflected a negative stance on temporary listing authorizations (see, for example, LDP 2019).

The ODEX decided to delist rice futures by 2023.[1] The MAFF's minister held a press conference on August 10, 2021 and offered three reasons for the denial of the rice futures permanent listing: 1) the number of handlers trading in the market had stayed the same, 2) handlers' intentions to use futures contracts had been decreasing, and 3) most trading volume was concentrated on Niigata-Koshihikari, the main rice futures contract. Local media reported that the opposition from the Japan Agricultural Cooperatives (JA) Group, the largest rice distributor in the country, and the LDP, the ruling party in Japan, were related to the MAFF decision (e.g., Nikkei August 6, 2021; Asahi Shimbun July 31, 2021). Figure 1 in appendix A shows the open interest (average between long and short positions) over time by trader category in Niigata-Koshihikari futures, which started trading in October 2016. The dark blue area represents handlers' open interest. Open interest by market-makers, investment trusts (labeled as commodity pools), investors, brokers who are not members of ODEX, and oversea brokers are vertically stacked on top of handlers' open interest. Handlers' open interest fluctuated throughout the period of analysis,

[1] Most of the contracts ended trade in June 2022. Rice export futures contract will end in November 2023.

hit a peak of 2,383 contracts in March 2020 and fell thereafter. In August 2021, at the final stage of trading, it returned to a level around 500 contracts, similar to the open interest when the contract was launched. This is consistent with MAFF statement that handlers' participation did not increase in the market. However, MAFF did not support its decision and statements with empirical evidence.

The objective of this research is to assess the reasons underlying low participation of handlers in the Niigata-Koshihikari futures market, which MAFF pointed out as a key reason for disapproval of permanent trading. Working (1970) identifies four necessary conditions for a successful futures market. First, handlers should use futures contracts as a temporary substitute for the physical commodity to hedge the risk of future cash price changes. This requires an active spot market with price variability, and homogeneity of the underlying commodity to ensure fungibility (e.g., Brorsen and Fofana 2001; Leuthold 1994; Wang, J and X. Wang 2022). It also requires the futures market to effectively provide two of its most important functions: price discovery and hedging (e.g., Garbade and Silver 1983; Tomek and Gray 1970). Second, there should be a balanced equilibrium between speculators and hedgers (e.g., Bollman, Garcia and Thompson 2003; Gray 1966; Working 1970), so that the latter can effectively use the contract for hedging purposes (Gray 1978). Third, transactions costs should be low, which in turn requires sufficient market depth (Bessembinder and Seguin 1993; Irwin and Sanders 2012). Fourth, the market should have government and regulatory recognition. We study all these conditions and summarize our findings, through a regression analysis to identify the factors that are significantly correlated with handlers' participation in the market.

Results suggest that the rice spot market did not meet the necessary characteristics for a successful futures market. Lack of spot market activity and low fungibility of the underlying commodity did not help the futures market. We find the spot market price was disconnected from ODEX futures contract price, with the latter failing to provide price discovery and hedging opportunities. Other issues related to the performance of the ODEX contract relate to the futures contract being essentially used as a forward contract. After the system transitioned to continuous trading, transactions costs and volume increased, but open interest declined. We identify uncertainty regarding trading authorization and political opposition as another reason underlying the failure of the Dojima rice futures contract. Our regression analysis points towards the use of the futures contract as a forward contract and the policy uncertainty as the most relevant reasons motivating the failure of the market.

CHAPTER 2: BACKGROUND

In this section we describe the main characteristics of both the Japanese rice spot market and the Dojima rice futures market to provide context to our analysis.

2.1. *Japanese rice spot market*

Rice is the most significant agricultural commodity produced in Japan. Rice gross agricultural output reached 1.6 trillion JPY (11 billion USD) in 2020, representing roughly one-fifth of the country's agricultural output (MAFF 2021). A key rice market player is the JA Group that is exempt from the Japanese Anti-Trust Act and holds the largest market share in upstream rice distribution (40.1% in the 2020 crop year according to MAFF 2022). JA Group traces its origins to, among others, a government-controlled association of farmers called *Nogyokai* formed during World War II to distribute food. Rationing and government-controlled rice distribution through the JA Group continued through the food shortage era from 1945 to 1967. After 1967, coinciding with a rice surplus era (Kako 2006), the JA Group maintained its monopolistic position in upstream rice distribution, while promoting acreage reduction to cooperate with the government's rice price support policy.

To ensure food self-sufficiency, the government also isolated the Japanese rice spot market from global trade. This resulted in market prices being essentially determined by domestic factors and largely disconnected from international market conditions. Imports of rice were basically banned until the Uruguay Round Agreement of the World Trade Organization in 1993, which established a minimum access scheme (MA) to import rice. In 1999, the MA shifted to a tariff rate quota for imports, but due to the high tariff rate over the quota, rice imports have equaled the quota amount of 770 thousand metric tons each year (MAFF 2022).

Domestic markets have been slowly deregulated and liberalized since the late 1960s. The enforcement of the Food Law in 1995 and its amendment in 2004 were instrumental in pushing the deregulation of rice distribution in Japan. The amendment in 2004 finalized the deregulation giving farmers and merchants full freedom to trade rice. While before the enforcement of the Food Law, the JA Group market share in rice upstream distribution was around 95% (Ozawa 2014), after the law the share declined by more than half, reaching about 40% in 2020 (MAFF 2022).

In 1969 the government revised the food standards and approved rice differentiation by variety and region. Since then, the rice spot market has become highly fragmented with the creation of over 900 rice types branded according to variety and geographic origin (MAFF 2022). The most famous brand of rice is Niigata-Koshihikari, a short-sized grain rice for food produced in Niigata prefecture that only accounts for roughly 5.6%[2] of total rice production. Rice branding has resulted in price differentiation, even within the same rice variety across the geography. This has allowed the JA Group to maintain a strong influence on the rice price through its 47 prefectural subsidiaries which compete in a fragment of the overall rice market against small competitors (Taie 2015).

In 2018, MAFF eliminated planting acreage reduction—which had been maintained for roughly half a century— to improve farmer competitiveness. However, this policy change was accompanied by a subsidized program that encourages rice production for feed instead of rice for food, which constitutes another form of supply control policy (Homma 2018). The current rice spot market does not have an organized central market with publicly observable prices. Handlers trade rice either directly or through brokers in a few private marketplaces or over the counter (OTC). Local newspapers and private agencies report the "market spot price (*Shichuu-Souba*)" usually on a weekly basis. The JA Group has its own selling price (*Aitai Kakaku*) that is essentially

[2] This figure is estimated from a planted acreage report released by *Beikoku-antei-kyokyu-kakuho-shien-kikou* [Rice supply organization of Japan] (2022).

based on rice production costs and is reported by MAFF monthly. While the spot market price reflects domestic supply and demand conditions, the JA Group selling price is mainly used for long-term contracts. Figure 2 in appendix A presents the evolution of the weekly spot price, the daily nearby futures price and the monthly JA Group selling price over the period from October 2016 to August 2021. Despite differences in price frequency measurement, the plot suggests that the spot and nearby futures prices experience relevant volatility and are relatively intertwined over the sample period, with some substantial deviations over short periods (e.g. 2019 and 2020). In contrast, the JA Group price displays a more stable pattern, appears disconnected from the other two prices and is usually larger. The latter questions whether JA Group actually sells rice at the reference price (Ozawa 2014).[3] The apparent disconnect between the market spot/futures price and the JA Group price is consistent with the group's standpoint on the futures market. In 2011, the JA Group opposed the futures market due to the inconsistency with the MAFF's supply control policy, the rice spot market being still immature and the concern of speculation in the futures market (JA com May 13, 2011). The group's stance basically did not change through the period of rice futures listing.

Since local consumers place a value on the freshness and good taste of rice, the Japanese rice spot price has a crop year differential. Both the spot price and JA Group's selling price are defined based on the new crop year. Any old crop remaining in the market at the end of crop year is priced at a discount from the new crop, which may discourage the storage of rice in Japan and limit arbitrage across crop years. Figure 2 in appendix A shows the apparent disconnect between the nearby and the most-deferred futures contract price. There is little data on how much old crop prices are discounted. *Beikoku data bank*, a rice data provider, reported the old crops of Niigata-

[3] The actual JA Group selling price is said to be kept secret.

Koshihikari being 1,200 JPY/60kg cheaper compared to the new crops in September 2020. The crop year differential was applied to the futures market as well. When the old crop was delivered at the maturity of the new crop contract, the seller was imposed a 1,500 JPY/60kg discount[4] on the old crop relative to the new crop.

2.2. *Japanese rice futures market*

The ODEX rice futures market had five different[5] contracts representing different rice varieties, geographical indications, and usages as of 2021, with the main contract being the Niigata-Koshihikari rice futures. Niigata-Koshihikari futures was launched on October 21, 2016, and it soon became the most widely traded contract in the rice futures market with an average volume share of 78% after October 2016 and up to August 2021. Its price quotation was in Japanese Yen (JPY) per 60 kg and the contract unit was 1.5 metric tons. The ODEX adopted a small contract size to attract speculators. Market participants could close their positions in the futures market either through physical delivery at maturity, or by offsetting their futures positions in the market.[6] There were six listed contracts: nearby (first), second, third, fourth, fifth and the most deferred (sixth) contract.[7] The contracts' delivery months were February, April, June, August, October, and December with October being the new crop contract. Each contract month had a trading period of one year.

A characteristic of the Japanese rice futures market was the most deferred contract position being the most highly traded, which contrasts with the U.S. and European futures markets, where

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[4] The crop year differential was applied to the October, December, and February contracts, but not to April, June, and August contracts. While the differential was not announced until 1.5 months before the maturity of the contract, it remained constant throughout the listing period.

[5] Other than Niigata-Koshihikari, the ODEX listed Akita-Komachi futures, Miyagi-Hitomebore futures, rice for export futures, and rice for restaurant (called Tokyo Kome) futures contracts.

[6] Table 8 in appendix B shows each listed contract and corresponding crop year from 10/21/2016 to 08/06/2021.

[7] In October 2016, the Niigata-Koshihikari contract started trading with three listed contracts. After the launch, the exchange added a new contract every two months, reaching six contracts in April 2017.

the nearby contract is usually the most active, but is rather common in Japan's commodity futures markets. In the case of the Niigata-Koshihikari futures, the most deferred contract accounted for more than 60% of the trading volume from October 2016 to August 2021 on average (figure 3 in appendix A).[8] On the other hand, open interest showed a pattern that clearly contrasts with trading volume. Figure 4 in appendix A illustrates open interest by contract position. To elaborate the figure, we roll the contracts when the nearby expires. Then, all contracts move one step closer to expiration, with the former second to sixth contracts becoming the current nearby to fifth contract, and the most deferred contract becoming the current sixth contract (see table 8 in appendix B). The nearby (second-deferred) contract month accounted for 10.9% (16.2%) of total open interest, while only 0.5% (0.8%) of trading volume. This suggests that a number of open positions were often held to expiration and delivery. The average Niigata-Koshihikari futures physical delivery ratio was 37%[9] of the maximum open interest over the contract's life period, which contrasts with a rough 10% in U.S. grain futures reported by Peck and Williams (1992). On average, the number of contracts settled with physical delivery on the first day of a contract delivery month, expressed as a percent of open interest on that day, reaches over 90% in the Niigata-Koshihikari futures (figure 5 in appendix A), which implies that if handlers remained in the market until the delivery month, most of their positions were settled with physical delivery.

2.3. *Itayose and continuous trading system*

Until 2018, the ODEX rice futures market traded under the Itayose system, a traditional market structure in Japanese commodity futures markets analogous to batch trading where bids

[8] By the 1910s, the most deferred rice contract represented roughly 70% of trading volume at Dojima (Ito et al 2018). At that time, the most deferred contract was three months ahead.

[9] The number includes exchange of futures for physical (EFP, a private agreement between two parties to offset futures positions with each other in exchange for the physical delivery of underlying assets before maturity).

and asks are collected (batched) over discrete time to determine the best matching price (Aldrich and Vargas 2020). Under Itayose, the day trading session was organized in different auctions. In each session, the exchange posted a non-binding provisional price serving as the starting point for the subsequent price discovery process. In response to the provisional price, individual brokers submitted their buying or selling orders and the exchange adjusted the provisional price until the market cleared. For example, if selling orders were more than buying orders, the exchange lowered the provisional price to equal the orders. When the clearing price was found, the orders placed at that price became bound. Itayose is sometimes called "Walrasian tatonnement auction" by economists (Eaves and Williams 2007), because total bids and asks are matched perfectly by adjusting prices. The rice futures' Itayose trading system had six trading sessions every trading day. The first session started at 9 AM and was followed by subsequent sessions at 10AM, 11AM, 1PM, 2PM and 3PM (the last session). The last session's price was the closing price of the day.

In 2018 the rice futures market shifted to an order-driven continuous trading system like the trading mechanisms used in major U.S and European derivative exchanges. In fact, all Japanese commodity futures markets now use some form of continuous trade, though batch auctions like those in the Itayose system are used in limited circumstances in some markets. Under continuous trading, the exchange did not adjust the price to balance buying and selling orders. Instead, time priority was used to match the orders (Kyle and Lee 2017). For example, a buy order was immediately executed if the matching sell orders existed. If there were more buy orders than matching sell orders, the buy orders placed earlier had a priority to be executed. Unmatched orders had to wait until new sellers came into the market to be executed. Traders could trade any time from 9AM to 3PM.

ODEX decided to end Itayose in order to promote larger trade volume in the futures market. The pros and cons of batch and continuous trading have been discussed widely. Generally, Itayose (batch) auctions offer advantages in terms of reducing volatility and bid-ask-spread (BAS), relative to continuous trading (e.g., Budish Cramton and Shim 2015; Aldrich and Vargas 2020; Huang et al 2021). These advantages come at the cost of low trading volume (only transactions at clearing prices and at limited times are allowed to occur). In contrast, continuous trading enables frequent transactions if the two parties agree (Webb, Muthuswamy and Segara 2007). Under continuous trading, trade volume is usually larger than in Itayose, as price discovery occurs through trade, rather than through an auction. At the cost of larger volatility and transactions costs, price discovery is usually faster in continuous trading than in Itayose.

CHAPTER 3: EVALUATION OF REQUIREMENTS TO PROMOTE A SUCCESSFUL FUTURES MARKET

To shed light on the underlying reasons for the failure of the Niigata-Koshihikari Japanese rice futures market, we evaluate several important conditions for a successful futures market. Specifically, we investigate the activeness and homogeneity of the spot market and the futures' market quality through price discovery, hedging effectiveness, the degree of balance between hedgers & speculators, relative market depth and transactions costs, as well as the regulatory uncertainty's impact on hedger participation. In the next subsection we present the data used for the analysis. We then present our measures and the results.

3.1. *Data*

This research is based on daily ODEX rice futures price data, trading volume, and open interest by trader category.[10] We also use weekly spot market prices. Our sample period covers from October 21, 2016, when Niigata-Koshihikari futures was launched, to August 6, 2021, when MAFF officially turned down the third request for permanent listing. After the MAFF's decision, new contract months were not launched and orders stopped coming into the market, which ended trade in practice.

Regarding the futures market price, we use the daily closing price, except for those days when the contract did not register any transaction, for which we use the daily settlement price instead. The ODEX released settlement prices based on the previous day's transaction prices when a contract month did not have a transaction price on a particular day. When the previous transaction price was unavailable, best ask prices or best bid prices were adopted. While under Itayose there

[10] As opposed to the Commitments of Traders Report of the U.S. Commodity Futures Trading Commission (CFTC) which are made available on a weekly basis, ODEX publishes open interest by trader category daily.

were daily transactions for each individual contract, after the transition there were 70% of the days with no trading in the nearby position. Data are for all 31 contract months traded during the period of analysis (table 8 in appendix B).

Spot market prices were obtained from *Beikoku Data Bank*, a private data company in Japan which collects Japanese cash price data from local brokerage firms. Cash price data before the 2019 crop year are only available on a weekly basis, specifically only the Tuesday price is available. While daily data became available in 2019, we find they usually only change on a weekly basis. Hence, we conduct any analysis requiring spot price data using weekly (Tuesday) prices. When conducting analyses that require matching spot and futures prices, Tuesday close (or settlement) futures prices are used for the whole sample.

We use ODEX daily reported open interest which breaks down market open interest into six trader categories: handlers, market-makers, investors, non-member brokers, commodity investment pools and foreign brokers.[11] Handlers refer to farmers, wholesale merchants, and corporate rice users who trade physical rice. Market-makers are entities who provide liquidity to the market. Proprietary traders, high frequency traders and proprietary trading of futures commission merchants (FCM) belong to this category. Investors mainly refer to retail investors. Non-member brokers include open interests from brokers who don't have an ODEX membership, and thus they order rice futures through the ODEX member brokers. Commodity investment pools and foreign brokers' open interests have been reported zero since the launch of Niigata-Koshihikari futures.

[11] The ODEX used a different daily open interest format during Itayose trading: "Non-Commercials" were used in place of investors, "Commercials" and "Receiving Orders From the Non-FCM Membership" were used in place of handlers.

3.2. *Activeness of the cash market*

To evaluate the activeness of the underlying cash market (ACM), Bekkerman and Tejeda (2017) propose to count how many weeks without a price change occur in the spot market per half a year (26 weeks). The smaller the number, the more active the market is. We derive a single ACM per crop year through the following four steps: 1) we first-difference weekly cash price data for the crop year, 2) generate a rolling window of 26-weeks (from week 2 to week 27, from week 3 to 28, and so forth up to the interval which include last week), 3) count the number of times when the price did not change per each window as in equation (1) below, 4) provide the average for each year.

$$\mathrm{ACM} = \sum_{\tau=k}^{k+25} \mathrm{ACM}_{\tau}\,[\mathrm{P}_{\tau} - \mathrm{P}_{\tau-1} = 0] \quad (1)$$

where $P\tau$ denotes the price on week τ. $\mathrm{ACM}_{\tau}[x_{\tau}]$ is an indicator function taking the value of 1 if the condition in brackets is met. Since the first rolling window contains 26 weeks of price differences, $k = 2, \ldots, 27$ completes the whole year. We then calculate the average ACM across the rolling windows.

Niigata-Koshihikari's ACM averages 17.45 per 26 weeks across the sample years (see table 2 in appendix A), which suggests that more than 67% of the weeks within half a year do not experience any price change. The figure is within the range of values reported by Bekkerman and Tejeda (2017) for apple, rice, and pinto beans in the U.S, which are considered commodities with a rather inactive cash market, but clearly outside the range for corn and soybeans with highly active spot markets (table 2 in appendix A). Niigata-Koshihikari's ACM is not only large but moves within a narrow range which results in low variability of ACM over time. ACM is a measurement of how frequently price change occurs; it cannot gauge the size of the price change. We shed light on the latter by examining the magnitude of Niigata-Koshihikari spot price changes. On average, weekly price changes are 1.57% (249 JPY/60kg) during the sample period, which contrasts with other crops such as U.S. corn futures prices that experienced a weekly average change of 2.56% over the same period. These results suggest a rather stable spot price which may have reduced the need for hedging among handlers. The less active spot price might be associated with the domestic supply control policy, which may have limited price fluctuations.

3.3. *Cash market homogeneity*

To shed further light on the potential demand for hedging through the Niigata-Koshihikari futures contract, we investigate the homogeneity of the Japanese rice spot market. As discussed, Niigata-Koshihikari rice variety represents just 5.6% of Japanese rice production. This limited market share reduced the potential demand for hedging, unless Niigata-Koshihikari prices had been highly connected to other rice varieties, which may have allowed to use the futures contract for cross-hedging.

We study the existence of a long-run equilibrium between the Niigata-Koshihikari spot price and the spot price of another famous brand of rice produced in Akita prefecture, the Akita-Komachi. Akita-Komachi has a 4.7% share in the rice market, similar to the share of Niigata-Koshihikari. Also, data availability for Akita-Komachi allows us to compare the two rice varieties. We first check the order of integration of the prices using the augmented Dicky Fuller (1979) test. Second, following Gonzalo and Lee's (1998) suggestion, we run both Engle and Granger (1987) and Johansen's (1991) cointegration tests. We use the Bayesian Information Criteria (BIC) to select the number of lags of the model underlying each test. Unless both tests confirm cointegration, we consider the pairs of prices as not cointegrated.

To perform the cointegration analysis and given the limited availability of spot price data, we use weekly data. The analysis is based on a rolling window approach with a fixed window size of roughly one year: 50 weeks, which allows observing the dynamics of cointegration over time. A window of 50 weeks is further consistent with the duration of a crop year. The number of increments between rolling windows equal 1 week, which leads to 198 subsamples.

Results of the augmented Dickey-Fuller (ADF) test suggest both price series are integrated of order one, while price returns are stationary. Cointegration is confirmed for only two out of 198 subsamples (1%), which suggests almost no cointegration occurs between Niigata-Koshihikari and Akita-Komachi spot prices (see figure 6 in appendix A). While admittedly a rough indicator for market homogeneity, cointegration results suggest a limited demand for cross-hedging using Niigata-Koshihikari futures contracts.

3.4. *Price discovery*

Price discovery is one of the most important roles of a commodity futures market (Tomek and Gray 1970). Since futures markets can swiftly react to new information, they usually lead cash prices in terms of incorporating new information (Working 1962). If the futures market price does not reflect all available information, the market is not efficient (Fama 1970) and may play a limited role in price discovery. Effective price discovery should result in futures and cash prices being linked by a long-run equilibrium relationship. We study price discovery by assessing cointegration between the Niigata-Koshihikari spot price and the different Niigata-Koshihikari futures contract positions by maturity. To the extent that rice is a storable commodity, prices of different contract maturities should be related (Working 1948, 1949). We adopt the same approach as with the homogeneity test, i.e. we conduct a cointegration analysis based on a 50-week rolling window, resulting in 191 subsamples.[12] We are less interested in the cointegration over the whole period of analysis, as this does not correspond to the duration of a crop year (approximately 50 weeks).[13]

Table 3 in appendix A provides test results. We find only 12.0% of spot and nearby 50-week subsamples to be cointegrated during the Itayose period and 36.21% under continuous trading. Other deferred contract prices show extremely low cointegration with spot prices in both subperiods. The proportion of the fifth and the most deferred contract subsamples that are cointegrated with spot is below 1%. For the second and fourth position, the ratio is zero. While the spot and third deferred contract are cointegrated in 6.667% of the subsamples under Itayose, the number falls to zero under continuous trading. Hence, our results suggest that the rice spot and futures prices are not bonded by an equilibrium parity during most of the time.

The findings that deferred futures positions are not cointegrated with cash prices are inconsistent with rice being a storable commodity, which should facilitate intertemporal prices to be connected through storage costs (Bessler and Covey 1991; Smith 2005; Tomek and Gray 1970). Hu et al (2020) identify stronger cointegration between the futures nearby and deferred contracts in the Chicago Board of Trade (CBOT) corn (storable) futures than in the CME live cattle (non-storable) futures. Over the sample period, there were several good crop years that should have resulted in Niigata-Koshihikari rice inventory buildup,[14] which in turn should have created stronger intertemporal price linkages. While these results may seem puzzling, a possible answer lies in the idiosyncrasies of the rice market in Japan. As discussed, old rice crops are sold at a discounted price both in the cash and futures market. Hence, stocks may not be held into the next

[12] For fourth and fifth deferred position contracts, the number of subsamples is 184 and 176, respectively. This is because these two contracts were launched later as shown in table 8 in appendix B.

[13] We find that the nearby contract is cointegrated with the spot price over the whole sample period, with the second deferred contract being a borderline case (results depend on the cointegration test used). The remaining contracts show no cointegration with the spot price.

[14] According to the MAFF (2016, 2017, 2018, 2019, 2020) crop production index survey, rice crop production was generous for 2016, 2019 and 2020 (which is represented by an index above 100 in each of these years).

crop year. This might explain why virtually almost no-cointegration occurred between cash and futures' deferred position contracts, especially with the most deferred contract which is the most highly traded.

While the lightly traded nearby contract shows some cointegration with spot prices, the proportion of cointegrated subsamples is low. Our results are consistent with Fortenbery and Zapata's (1997) study of cheddar cheese. They attribute limited cointegration to limited arbitrage between cheese spot and futures markets and the low trading volume in the cheese futures market. Further, the reduced number of periods during which spot and rice futures are cointegrated is likely to have kept hedgers away from the futures market as futures cannot be a temporary substitute for cash due to price differences.

3.5. *Hedging effectiveness*

We employ Hedging Effectiveness (HE) measures based on weekly spot and futures price data to quantify the performance of the Niigata-Koshihikari futures as hedging instruments. We assume hedgers use a naïve hedging strategy and thus take a market position that offsets their cash positions over a 50-week period, coinciding with the rolling windows defined earlier, as well as with the approximate duration of the crop year. We quantify how much risk exposure is reduced through hedging, relative to an unhedged position using the following HE measure (2) adopted in previous literature (e.g., Ederington 1979).

$$\mathrm{HE}_{k+49} = 1 - \frac{\mathrm{Var}(\mathrm{R}_{\mathrm{cash},k}^{k+49} - \mathrm{R}_{\mathrm{futures},k}^{k+49})}{\mathrm{Var}(\mathrm{R}_{\mathrm{cash},k}^{k+49})} \tag{2}$$

where $\mathrm{R}_{\mathrm{cash},k}^{k+49}$ and $\mathrm{R}_{\mathrm{futures},k}^{k+49}$ are the cash and futures returns over the holding period, with $\mathrm{Var}(\mathrm{R}_{\mathrm{cash},k}^{k+49} - \mathrm{R}_{\mathrm{futures},k}^{k+49})$ and $\mathrm{Var}(\mathrm{R}_{\mathrm{cash},k}^{k+49})$ being the variance of the hedged and unhedged portfolio, respectively. The closer the HE is to 1, the larger the proportion of cash price risks offset by the futures contracts. This requires cointegration between cash and futures prices. A HE $= 1$

indicates a perfect hedge where the hedged portfolio experiences zero return variances. In contrast, a HE = 0 suggests that the hedged portfolio has equal amount of risks as the cash position itself, implying that the financial instrument mitigates zero amount of cash price risks. HE measurement can yield negative values as well, which implies the overall risk exposure is increased by taking futures positions. Notice that our measure ignores contract rolling and transaction costs which may result in lower HE.

Table 4 in appendix A reports the HE results. The mean HE across all subsamples is 0.643 for the nearby contract month and 0.261 for the most deferred contract, the most highly traded. These results are consistent with the price discovery results that suggest virtually no cointegration between spot and deferred contracts (from the second to the most deferred). Moreover, 17.895% of the subsamples pairing spot and the most deferred futures price result in negative HE ratios, which indicates risk exposure is greater when the portfolio is hedged with the most deferred contract than when it is left unhedged.

Figure 7 in appendix A presents the HE for the nearby contract positions over time. While the figure shows relatively higher HE values, especially during periods when samples are cointegrated, the thin trading volume at the nearby contract may have discouraged hedgers to participate in the Japanese rice futures market.

3.6. *Market composition*

As discussed earlier, a balance between speculators and hedgers is important for a successful futures market. To measure this balance, Working (1960) proposed the speculation T-index that quantifies speculation in excess of what is necessary to meet hedgers' demand for futures positions. The index is based on the underlying idea that speculators are necessary if they satisfy the hedgers' demand. It is computed by separating the market open interest from hedgers and speculators, and identifying the extent to which speculators' positions exceed hedging demand through the following measure:

$$T_t = \begin{cases} 1 + \frac{SS_t}{HL_t + HS_t} & \text{if } HS_t \geq HL_t \quad \text{or} \\ 1 + \frac{SL_t}{HL_t + HS_t} & \text{if } HS_t < HL_t \end{cases} \tag{3}$$

where t represents day, SS_t and SL_t measure the absolute magnitude of speculators' short and long positions on day t, respectively, HS_t and HL_t represent the absolute magnitude of hedgers' short and long positions, respectively. The index is bounded below by one, meaning the market is perfectly balanced as speculators satisfy exactly the demand from hedgers. Larger index values imply excess speculation in the market. A potential difficulty related to deriving the index concerns the classification of traders' positions into hedgers and speculators, which is not always clear cut.

We calculate the speculative T-index daily. We classify traders into hedgers and speculators as follows. We define hedgers' positions as the sum of handlers and a fraction of market-makers and non-member brokers. Our unconventional decision to include a portion of market-makers as hedgers is justified by the atypical role that they play in our market. Figure 8 in appendix A shows the evolution of handlers, investors, and market-makers' net positions calculated as short minus long positions over the sample period. Notice that market-makers took a completely net flat position under the Itayose era when handlers' net positions were perfectly offset by investors' net positions. Nevertheless, after the transition to continuous trading, handlers' net positions were not exactly balanced by investors and market-makers began to play a balancing role. While during some periods market-makers were complementing investors to balance excess net hedging positions, there were periods during which they helped balance excess net investor positions. Thus, unlike their large size in gross positions (figure 1 in appendix A, orange area), market-makers' net positions were small and only differed from zero during the continuous trading era when they compensated for any disequilibrium in the market, either on the hedging or the speculative side. Admittedly, the data reflect a puzzling picture on the interaction between market participants that implies that market makers were only trading against themselves during Itayose. During continuous trading, they had a balancing role that was relatively minor compared to their total market positions. This suggests that they essentially continued to trade among themselves. Therefore, we conclude that allocating a portion of market-makers' position in the hedgers' category is a more reasonable categorization.

Allocating a portion of market-makers' position raises the question on the appropriate market-makers' open interest that ought to be allocated to hedgers and speculators. This problem also applies to non-member brokers' open interests since it is unclear whether non-member brokers' clients are hedgers or speculators. To solve this problem, we follow Irwin and Sanders (2010) and split market-makers and non-member categories into hedgers and speculator categories in the same proportion that is observable from the sample. Similarly, we define non-hedger positions as the sum of investors, and the corresponding fraction of market-makers and non-member brokers. To allow comparison with other futures markets, we also utilize the weekly CFTC's *Futures-and-Options Combined Reports*, and the weekly open interest report by trader category from the Japan Exchange Group (JPX) and compute the T-index for the CBOT rough rice and the JPX platinum market.[15] The former allows comparison with an oversea market trading a similar commodity and the latter allows comparison with a successful commodity futures market in Japan.

[15] Following the convention in the literature, in the case of CBOT, market makers are assigned to speculators. Given the similarities between JPX and ODEX, we keep the same classification as ODEX. JPX changed the format of the commodity futures open interest report from July 2020. The format before the date is similar to the ODEX. In the new format, we group "proprietary," "security brokers," "financial institutions," "other institutions," and "foreigners" categories into hedgers and non-hedgers following Irwin and Sanders (2010).

Table 5 in appendix A provides the results of the speculative T-index. The Niigata-Koshihikari index is 1.103 on average for the whole sample period which implies that average speculative positions were around 10% greater than the minimum speculation needed to cover the net hedging demand. Compared to the mean value of CBOT rough rice (1.186) and JPX platinum (1.598), the T-index of Niigata-Koshihikari records lower values. The lower bounds of the T-index are 1.0 for the Itayose trading period, and slightly above one (1.034) for the continuous trading period, which suggests there are intervals of no/almost no excess speculation in the market. Figure 9 in appendix A depicts the evolution of the T-index over time. During the Itayose trading period, the T-index initially starts above two, then declines to 1.3 on average until the end of August 2017, when it quickly drops to 1 and stays there until the transition to continuous trading in October 2018. After the transition, the index reaches values close to 1.4 in June 2019 just before the filing for the second permanent listing, but it drops again to values virtually equal to 1 after the MAFF denial. The index registers values around 1.4 during the short-lived spike around August 2020, grows again up to 1.3 in April 2021 and drops gradually thereafter. Figure 12 in appendix B compares the evolution of T-index of Niigata-Koshihikari against the T-index of the CBOT rough rice and the JPX platinum markets. The T-index of Niigata-Koshihikari moves clearly below the JPX platinum's index and generally below the CBOT rice index, suggesting lower degree of speculative activity, especially during the Itayose period.

In summary, the analysis of the composition of traders suggests that excess speculation is relatively low in Niigata-Koshihikari futures. This relates to the fact that in many instances hedgers trade with themselves, which results from the futures contract being essentially used as a forward contract (Working 1970). As discussed in Gray (1978) and Hieronymus (1971), whenever speculation is relatively large, market liquidity and competition between speculators ensures low hedging costs as the risk premium earned by speculators is reduced or eliminated. However, a situation where hedgers trade against other hedgers is likely to increase hedging costs and reduce hedging effectiveness. We shed light on transactions costs in the next subsection.

3.7. *Measurements of transaction costs*

Bessembinder and Seguin (1993) and Irwin and Sanders (2012) point out that a high volume-to-open interest ratio may make the market more volatile when large shocks occur, which in turn is likely to increase transactions costs. We report this ratio by separating between Itayose and continuous trading periods. The average daily trading volume of Niigata-Koshihikari futures grew from 543 contracts during Itayose to 1,912 during continuous trading, while average open interest decreased from 2,799 during Itayose to 2,088 during continuous trading. This resulted in the average daily volume-to-open interest ratio increasing from 0.206 during Itayose to 0.927 during continuous trading (table 6 and figure 10 in appendix A). On a monthly basis, volume-to-open interest ratio was about 4.24 under Itayose and 18.37[16] under continuous. The continuous period monthly figure is substantially above values reported by Irwin and Sanders (2012) on the order of 4.51 for the U.S. corn, and 6.35 for soybean during 2009-2011. As discussed earlier, continuous trading allows traders to transact immediately (Huang et al 2021), which resulted in increased trading volume; nevertheless, increased trading was not accompanied by an increase in the market depth or open interest. This may have increased transactions costs, which we discuss in the following paragraphs.

We approximate transactions costs through the effective BAS of the Niigata-Koshihikari rice futures. Unfortunately, we do not have order book data for the Japanese rice futures market. To approximate the BAS, we use the estimator proposed by Abdi and Ranaldo (2017) which relies

[16] We set Itayose period from Oct 2016 to Oct 2018, and continuous trading period from Nov 2018 to Aug 2021.

on the daily Close, High, and Low prices (CHL) method. Unlike other estimators, CHL does not require an assumption about the magnitude of bid-ask bounces and thus is independent of trade direction. We take a 21-days rolling window approach and calculate the CHL method estimator as follows:

$$CHL_{t+20} = \sqrt{\max\left\{4\,\frac{1}{21}\sum_{t=k}^{k+20}\left(\ln\left(P_{c,t}\right) - \ln\left(\eta_t\right)\right)\left(\ln\left(P_{c,t}\right) - \ln\left(\eta_{t+1}\right)\right), 0\right\}} \quad (4)$$

where k is the first day in the rolling window, ln $(P_{c,t})$ is the day t log closing price, and η_t is the midpoint of day t high and low price. Following Abdi and Ranaldo (2017), we exclude non-transaction days.

Results are presented in table 6 and figure 11 in appendix A. The mean BAS across the different contracts, from the nearby to the most-deferred position traded under Itayose is 0.060% (9.174 JPY/60kg), below one tick size (10 JPY/60kg). After the transition to continuous trading, the mean grew to 0.402% (60.472 JPY/60kg), more than 6 ticks. The increased BAS estimators after the shift from Itayose to continuous trading is consistent with previous literature (Huang et al. 2021). While the Itayose only allows transactions at clearing prices, continuous trading allows transactions at non-clearing prices if two parties agree. The non-clearing prices may reflect limited information and they are more likely to fluctuate than market clearing prices under the batch auction. As a result, the spread tends to grow under continuous trading. Rather, the surprising result in the transaction costs analysis is the BAS for the most deferred contact being larger (0.311% for the whole period, an average of five ticks) than the average from nearby-to-the-most-deferred contracts (0.263%, Table 6 in appendix A). This is clearly inconsistent with other literature (e.g., Frank and Garcia 2011) that finds volume to be negatively correlated with BAS.

3.8. *Regulatory uncertainty*

Establishing a futures market requires support from both the government and the traders who will use the market (Working 1970; Leuthold 1994). Here we focus on the regulatory uncertainty that characterized the market. From its inception, the market traded under temporary authorization and as discussed earlier, MAFF did not authorize any of the three filings for permanent trading. We hypothesize that this is likely to have negatively influenced the market's open interest. In the next subsection we conduct a regression analysis to identify the variables that are correlated with open interest and summarize our findings. We approximate political uncertainty through dummy variables and we find suggestive evidence of the regulatory uncertainty hypothesis.

CHAPTER 4: REGRESSION ANALYSIS

Limited handler open interest was a relevant reason triggering the MAFF to deny permanent listing of the Niigata-Koshihikari futures contract. In this subsection, we conduct a regression analysis to identify which of the aspects characterizing the cash and the futures markets investigated in subsections 3.2 to 3.8, are significantly correlated with handlers' open interest. In addition, we introduce dummy variables that aim at capturing uncertainty related to the transition from Itayose to continuous trading. We also capture the impacts of the Covid19 pandemic and the days when a contract expires using dummy variables defined below. The latter is included to shed further light on the use of the futures contract as a forward contract. The linear regression is specified as follows:

$$\Delta \mathrm{Handlers}'_t = \beta_1 \Delta \mathrm{ACM}_t + \beta_2 \Delta \mathrm{Correlation}_t + \beta_3 \Delta \mathrm{HE}_t + \beta_4 \mathrm{Tindex}_t + \beta_5 \mathrm{CHL}_t + \beta_6 \mathrm{Screening}_i + \beta_7 \mathrm{Transition} + \beta_8 \mathrm{Lockdown}_i + \beta_9\, \mathrm{Delivery} + \mathrm{Constant} \quad (5)$$

where $\Delta\mathrm{Handlers}'_t$, the dependent variable, is the day t change in handlers' open interest (the average between long and short positions is used). We identify the presence of a unit root in handlers' open interest, so we take the first order difference (denoted as Δ) to ensure stationarity. All the right-hand side variables that are preceded by Δ have been first differenced as well for the same reason. ACM_t denotes the activeness of the underlying cash market on day t (subsection 3.2). Since ACM is calculated on a weekly basis, we derive ACM daily by assuming ACM remains constant within each week. This assumption applies to all variables measured weekly. $\mathrm{Correlation}_t$ is the correlation between Niigata-Koshihikari and Akita-Komachi spot price on day t. It relates to the analysis in subsection 3.3 by providing a quantitative measure[17] of the strength

[17] As opposed to a qualitative measure indicating the existence of cointegration or not.

by which the two prices are connected. We generate the correlation every week based on the 50-week rolling window approach. We roll the 50-week subsample one week at a time to generate the correlation up to the end of the sample. Also based on weekly data and the 50-week rolling window (subsection 3.5), $\mathrm{HE_t}$ measures the hedging effectiveness on day t calculated using the nearby futures contract. The $\mathrm{HE_t}$ is also related to the price discovery analysis in subsection 3.4 since a strong connection between cash and futures is required for the futures contract to be an effective hedging instrument. $\mathrm{Tindex_t}$ is the speculative T-index on day t (subsection 3.6). $\mathrm{CHL_t}$ stands for bid-ask spread on day t computed with the Close, High, and Low prices method described earlier (subsection 3.7).

We measure the uncertainty created around the temporary trade authorization granted to the Niigata-Koshihikari rice futures market and the filings to continue trading by the exchange through dummy variables (subsection 3.8). Specifically, we create two dummy variables that measure the impact of the 2019 and 2021 filings for permanent listing, $\mathrm{Screening_i}$, i = 2019 and 2021. Since calculation of cash price correlation and hedging effectiveness implies losing a whole year of data to the rolling window, our sample in the regression analysis covers from October 31, 2017 to August 6, 2021. Therefore, filings before this date are not included in the analysis. We assume that when the deadline to file to continue trading (August 8 of the screening year) approaches, uncertainty in the market increases, which may discourage participation. Visual inspection of the open interest data suggests this is the case. Therefore, we set the starting point of the dummy variable on the day when handlers' open interest begins to show a declining trend before the deadline. For the 2019 screening period, we set the dummy = 1 for the period from January 18, 2019 to August 8, 2019, otherwise the dummy takes the value of 0; for the 2021 screening, the dummy takes the value of 1 from November 10, 2020 to August 8, 2021. The decline of the handlers' open interest starts earlier for the 2021 screening, which is consistent with the market having undergone four temporary extension approvals, a record in the Japanese futures industry. This may have created uncertainties much earlier, relative to the 2019 screening.

We also capture the short-term impacts that the transition from Itayose to continuous trading may have had on market participation. While futures contracts that had not expired before the transition continued trading in the new system, some traders may have preferred to cancel their positions before the transition. Also, after the new period started on October 15, 2018, open interest may have returned to the market. Based on visual inspection of the data, the dummy covers the period from August 30, 2018 through November 12, 2018. We capture the impacts of the Covid-19 pandemic through a series of variables that reflect the lockdown periods ($Lockdown_i$) established by the Japanese government. The Japanese government declared four lockdown periods during the temporary listing of rice futures: from April 7, 2020 to May 25, 2020, January 8, 2021 to March 21, 2021, April 25, 2021 to June 20, 2021, and July 12, 2021 to September 30, 2021. We define four dummy variables covering these periods. Notice that the sample does not include the whole duration of the fourth lockdown and thus it takes the value of 1 from July 12, 2021 up to the end of the sample, on August 6, 2021. Finally, we consider a dummy variable, Delivery, that identifies the days when a contract matures (Delivery =1 on the first day of the contract delivery month). This variable aims at capturing the rather uncommon use of the Niigata-Koshihikari futures contracts as forward contracts (subsection 3.6), which should result in a rather relevant drop in handlers' open interest on contract expiration dates.

Table 7 in appendix A reports the results of the regression analysis. Most dummy variables are statistically significant. The MAFF's screening period dummies are both negative and statistically significant, which is consistent with the uncertainty over authorization of trading negatively influencing handlers' participation. The dummy representing the transition from the Itayose to continuous trading is negative and statistically significant as well, which suggests that uncertainties and technical issues related to a change in trading mechanism resulted in a temporary decline of open interest. The first lockdown dummy has a statistically significant negative sign suggesting a decline in handlers' open interest on the order of 11 contracts. The activity, however, returns with the third lockdown when open interest increases by 10 contracts and does not change afterwards.

Finally, the combination of hedging effectiveness not being statistically significant and the delivery dummy being significant and negative, supports the hypothesis that most handlers used the futures market not as a hedging instrument, but as a forward contract. The delivery variable coefficient suggests that on the day that a contract matures, there is a decline in handlers' open interest on the order of 146 contracts. The average change of handlers' open interest over the sample period is 17 contracts per day in Niigata-Koshihikari futures. Hence maturity has a very large impact on open interest.

CHAPTER 5: CONCLUSION

In this paper, we analyze why the Niigata-Koshihikari futures, the most active contract of the Japanese rice futures market that traded at the ODEX from 2016 to mid-2021, failed. The MAFF approved the filings for temporary rice futures trading presented by the ODEX in 2011 and 2013 before the Niigata-Koshihikari futures was launched. However, it turned down the three filings for permanent trading presented by the exchange afterwards (2017, 2019 and 2021), based on the argument that there was not enough handler participation. The ODEX responded to the third MAFF denial for permanent listing by terminating all rice trading in the exchange. The literature has identified several issues that may trigger failure of a futures market and we find several of them characterized the defunct Niigata-Koshihikari futures market. Specifically, we show the market faced an array of difficulties related to regulatory uncertainty and cash and futures market issues.

Two spot market characteristics may have limited the use of the rice futures market for hedging purposes; an inactive Niigata-Koshihikari spot market characterized by relatively infrequent price changes, as well as little homogeneity in the spot rice market, due to the existence of many rice varieties and little correlation between their prices. While the former may have reduced the need to hedge the Niigata-Koshihikari spot price, the latter is likely to have narrowed the possibility to use the futures contract for cross-hedging. Market concentration regarding rice distribution by the JA group and the opposition of the JA group to the futures market weren't helpful either. We also find that the Niigata-Koshihikari futures failed to perform two of the most relevant functions of a futures market: price discovery and hedging effectiveness. Lack of cointegration between the futures and its underlying price resulting from poor price discovery, led to small average hedging effectiveness, especially for the most highly traded maturities.

While the market, on average, did not suffer from excess speculation, it was characterized by an uncommon interaction between hedgers and speculators resulting from the contract being used as a forward contract, rather than a temporary substitute for buying or selling the commodity in the cash market in the future. The ODEX tried to stimulate participation in the rice futures market by introducing a continuous trading system and phasing out the old Itayose system. While trading volume increased after the transition, open interest declined, resulting in a higher volume-to-open interest ratio, possibly making the market more vulnerable to volatility shocks (Bessembinder and Seguin 1993). The transition also induced larger transaction costs. Results further suggest that uncertainty relative to trading authorization by MAFF also contributed to reduce handler participation. Political opposition to free trading of a staple food possibly drove MAFF decisions.

In summary, the market faced a wide range of issues from the use of futures contracts as forward contracts, a non-active spot market with limited homogeneity, and failure of the futures market to perform price discovery and provide hedging effectiveness. The market was also characterized by an increase in transaction costs after the system transition, and uncertain regulation derived from the political opposition. As discussed, Working (1970) identifies several necessary conditions for a successful futures market: a balanced equilibrium between speculators and hedgers that allows handlers to use the futures contracts as temporary substitutes for the physical commodity, low transactions costs, and government and regulatory recognition. Without these conditions, it was difficult for the oldest futures market in the world to survive.

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APPENDIX A:TABLES AND FIGURES

Table 1. Summary of the ODEX Japanese rice futures temporary listing

Temporary listing period	Daily volume of all rice futures products	Daily volume of Niigata-Koshihikari	Results
2011-2013	958	—	Filing for extension, approved
2013-2015	1149	—	Filing for extension, approved
2015-2017	1548	754	Filing for permanent listing, disapproved→ extension, approved
2017-2019	898	644 (72% of column 1)	Filing for permanent listing, disapproved→ extension, approved
2019-2021	2554	2280 (89% of column 1)	Filing for permanent listing, disapproved→delisting

Note: Adapted from *Kome-Sakimono Torihiki no Genzyo nitsuite* [Current Market Condition of Rice Futures] by MAFF. Daily volume is the average trading volume across of all rice futures contract months measured in number of contracts. Daily volume of all rice futures products includes Niigata-Koshihikari futures' volume. Daily volume of Niigata-Koshihikari during 2015-2017 is volume after October 21, 2016 when the contract was launched. MAFF was the regulatory organism in charge of approving either temporary or permanent listing of the rice futures contracts. A temporary listing authorization (extension) was granted for two years starting on August.

Table 2. Activeness of the Japanese rice cash market and comparison to other commodity markets

Commodity	Mean # weeks without price change	Std. Dev	95% Confidence interval	ACM category
		Japanese rice		
Niigata-Koshihikari	17.45	1.95	[13.62,21.27]	Low
		Bekkerman and Tejeda (2017)		
Apples	17.91	3.14	[11.76,24.06]	Low
Rice	17.44	3.56	[10.45,24.42]	Low
Pinto Beans	17.29	2.70	[12.01,22.57]	Low
Corn	0.35	0.52	[0.00,1.37]	High
Soybeans	0.24	0.42	[0.00,1.06]	High

Note: Japanese rice cash data is from Beikoku Data Bank. ACM is an acronym for activeness of the underlying cash market and is calculated based on weekly data. ACM quantifies the number of weeks without a price change within a 26-week rolling window in a crop year. We calculate the ACM for each crop year from 2016 to 2020, resulting in 123 subsamples of 26-week rolling windows. The table reports the mean ACM across the rolling windows. The 95% confidence interval is calculated as mean ACM±1.96*(standard deviation). Bekkerman and Tejeda (2017) derive ACM measures for different U.S. agricultural products, from January 2007 to September 2012. Their results are reported here for comparison purposes. Categorization of markets in the last column follows Bekkerman and Tejeda (2017). Low (high) ACM values denote active (inactive) cash markets.

Table 3. Summary of cointegration tests between Niigata-Koshihikari spot and futures price (Oct 2016 – Aug 2021)

	Percent of cointegrated subsamples	
Series combination: spot/futures contract	Itayose	Continuous
spot/nearby	12.0%	36.207%
spot/second	0%	0%
spot/third	6.667%	0%
spot/fourth	0%	0%
spot/fifth	0%	0.862%
spot/most deferred	0%	0.862%

Note. The table summarizes Engle and Granger (1987) and Johansen (1991) cointegration tests for spot and different futures contract positions (from the nearby to the most deferred), based on weekly data. We calculate cointegration tests using a rolling window approach. Both tests are calculated for each subsample (Itayose and continuous trading). The total number of subsamples is 191 (75 for Itayose and 116 for continuous) for spot/nearby to third position, 183 (67 for Itayose and 116 for continuous) for spot/fourth position, and 176 (60 for Itayose and 116 for continuous) for spot/fifth position. A subsample containing both Itayose and continuous trading periods is classified depending on where most days lie. The values in the table report the percentage of subsamples for which both tests conclude there is cointegration.

Table 4. Hedging effectiveness (HE) measures (Oct 2016 – Aug 2021)

Hedging contract position	Mean HE across subsamples (in proportion)	Subsamples with negative HE results (in %)
nearby	0.643	6.316%
second	0.146	28.421%
third	0.067	25.789%
most deferred	0.261	17.895%

Note: Hedging contract position indicates which futures contract is used to hedge the cash position. Hedging effectiveness (HE) is calculated assuming a naïve hedging strategy, where the hedger takes a short position in the futures market to fully match their cash position. Numerical values in the second column indicate the proportion of unhedged portfolio variance reduced through hedging. Numerical values in the third column are the percent of subsamples with negative HE results, an indicator that hedging increases portfolio risks rather than reducing them. The number of subsamples is 190, each subsample contains 50 weekly price data.

Table 5. Summary statistics for the speculative T-index of Niigata-Koshihikari rice futures, CBOT rough rice futures and JPX platinum futures (Oct 2016 – Aug 2021)

Products	Mean	Std. Dev.	Min	Max
Niigata-Koshihikari/whole period	1.103	0.121	1.000	2.078
Niigata-Koshihikari/Itayose	1.122	0.150	1.000	2.078
Niigata-Koshihikari/continuous	1.089	0.092	1.034	3.954
CBOT rough rice	1.186	0.068	1.056	1.394
JPX platinum	1.598	0.171	1.319	2.104

Note: Source, adapted from the ODEX, CFTC, and JPX. The T-index is based on daily data for Niigata-Koshihikari and weekly for CBOT rough rice and JPX platinum. The number of samples is 1,170 for Niigata-Koshihikari/whole trading period, 487 for Niigata-Koshihikari/Itayose trading, 683 for Niigata-Koshihikari/continuous trading, 251 for the CBOT rough rice and the JPX platinum futures.

Table 6. Summary statistics for the trade volume, open interest and bid-ask spread for the Niigata-Koshihikari futures market (Oct 2016 to Aug 2021)

	Whole period	Itayose	Continuous
		Volume & Open interest	
Mean daily volume (in number of contracts)	1342	543	1912
Mean daily open interest (in number of contracts)	2384	2799	2088
Mean daily volume-to-open interest ratio (in proportion)	0.627	0.206	0.927
		Bid-ask spread	
CHL (in %), average from nearby to the most deferred contracts	0.263% (39.622 JPY/60kg)	0.060% (9.174)	0.402% (60.472)
CHL (in %), most deferred contract	0.311% (46.526 JPY/60kg)	0.064% (9.605)	0.480% (71.807)

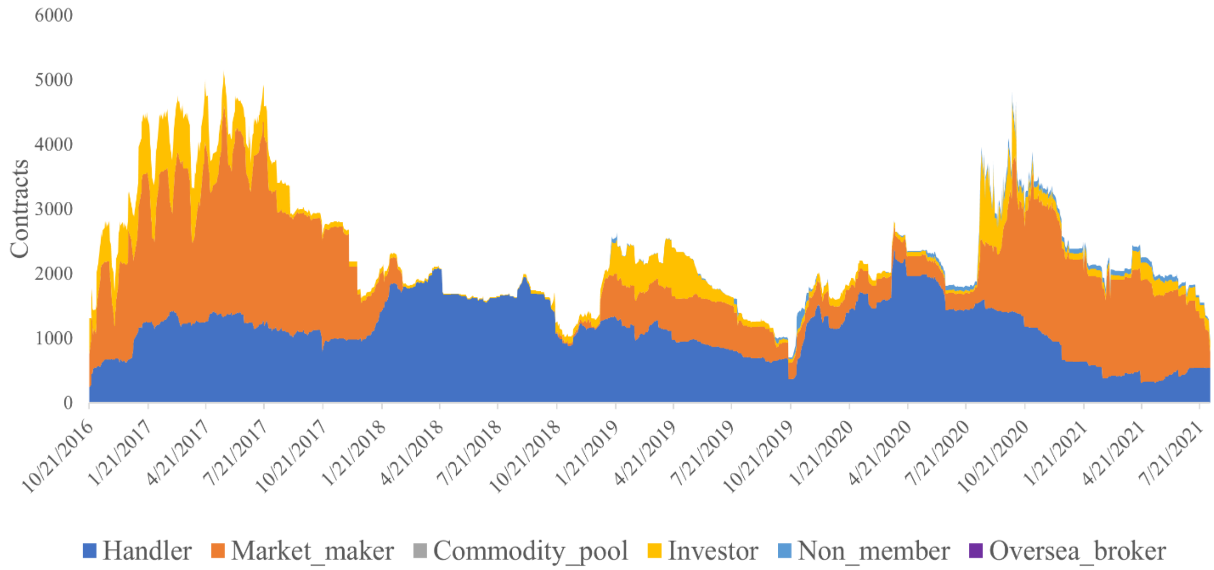
Note: Trading volume and open interest are calculated based on daily data. Sample size is 1,170 (487 for Itayose and 683 for continuous trading period). Volume-to-open interest is calculated based on the daily ratio volume/open interest. CHL is an estimate for the bid-ask spread based on a 21-day rolling window, resulting in 1,149 windows (467 for Itayose and 682 for continuous trading period). Values in parenthesis in the table are expressed in Japanese yen (JPY) per 60kg.

Table 7. Parameter estimates of the ordinary least squares (OLS) regression analysis (Oct 2017 – Aug 2021)

Dependent variable: $\Delta Handlers_t$ (handlers' open interest in first differences)	
Explanatory variable	Coefficient (standard error)
$\Delta \mathrm{ACM_t}$	2.4095 (3.4141)
$\Delta \mathrm{Correlation_t}$	28.1237 (44.7212)
$\Delta \mathrm{HE_t}$	15.2106 (56.2060)
$\mathrm{Tindex_t}$	-15.5645 (9.4815)
$\mathrm{CHL_t}$	-0.0407 (0.0384)
Screening 2019	-5.6175 (2.8298)**
Screening 2021	-7.2702 (2.8355)**
Transition	-26.1168 (6.9268)***
Lockdown 1	-11.3524 (4.6815) **
Lockdown 2	-0.0801 (2.5667)
Lockdown 3	10.0259 (2.9810)***
Lockdown 4	4.0167(2.5317)
Delivery	-146.3161 (22.1719)***
Constant	25.2557 (10.5750)
R-square	0.3313

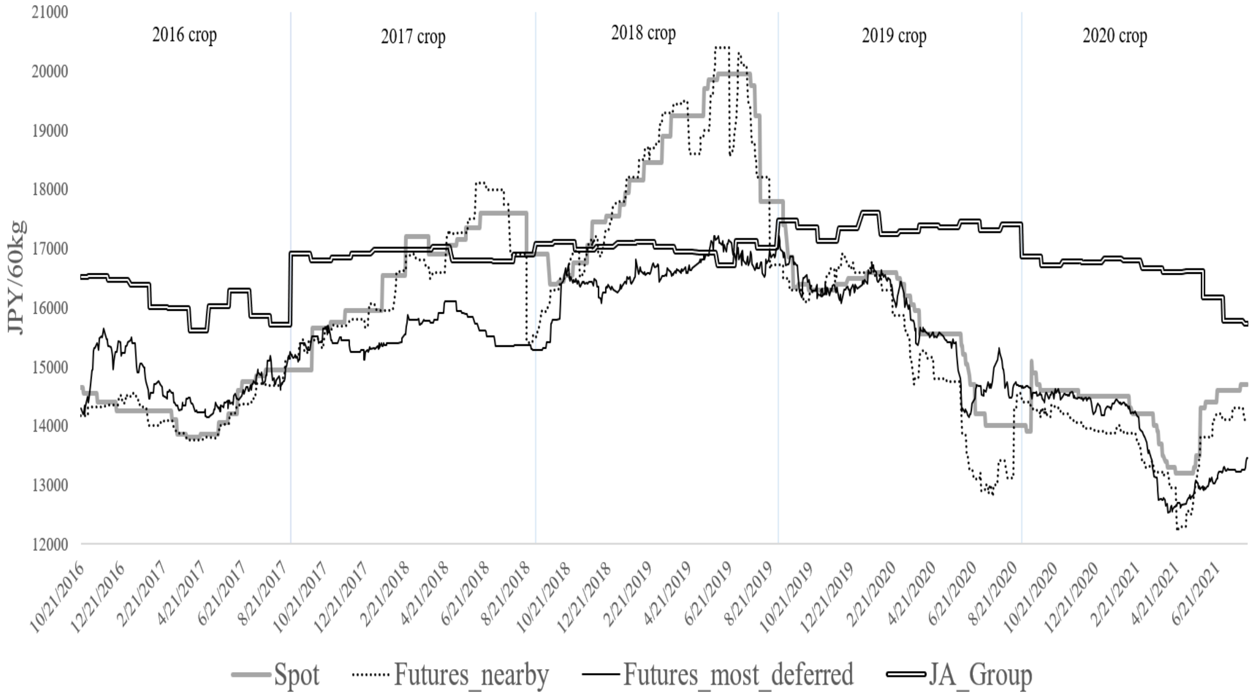
Note: Significance level 1% is denoted by ***, 5% by ** and 10% by *. The number of observations is 915. Δ denotes first-order difference. The dependent variable measures daily handlers' open interest (average of long and short). The explanatory variables are: ACM: activeness of the underlying cash market calculated based on a 26-week rolling window and assumed to be constant within a week; Correlation: correlation between Niigata-Koshihikari and Akita-Komachi spot price based on a 50-week rolling window and assumed to be constant within a week; HE: hedging effectiveness between spot and nearby contract based on a 50-week rolling window and assumed to be constant within a week; T-index: daily speculative T-index; CHL: daily bid-ask spread estimator computed with the CHL method. Screening: dummy variable for the screening period for permanent listing by MAFF (2019 and 2021 represent the screening years); Transition: trading system transition period dummy variable; Lockdown: dummies representing the covid-19 lockdown periods mandated by the government in chronological order. Delivery: contract maturity day dummy variable, which takes the value of 1 on the first day of the contract delivery month.

Figure 1. Daily Niigata-Koshihikari rice futures contact open interest by trader category (Oct 21 2016 – Aug 6 2021)



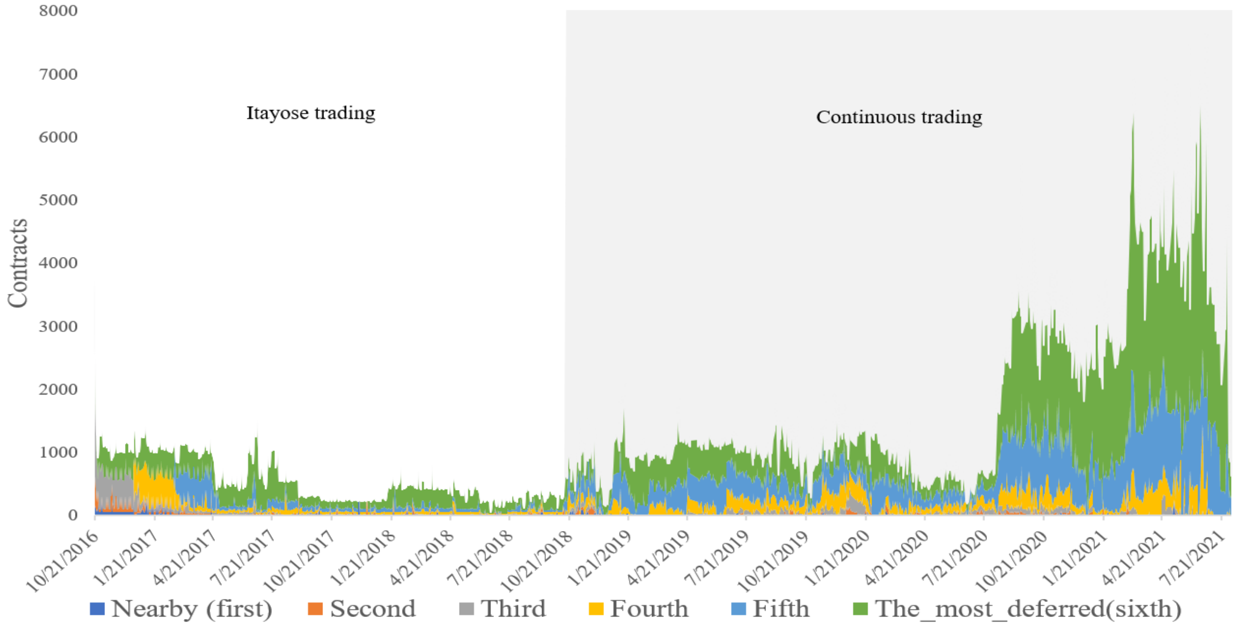
Note: Data are derived from the ODEX daily open interest report. One contract amounts to 1.5 metric tons. The number of contracts corresponds to the average between long and short positions. Handlers include farmers and merchants; Market-makers include mainly the proprietary arm of brokers; Commodity pool includes investment trusts; Non-member includes orders from non-member ODEX brokers; Oversea brokers includes orders from oversea brokers. Non-handler open interest by different categories is vertically stacked on top of handlers' open interest.

Figure 2: Niigata-Koshihikari market spot price (weekly), nearby and the most deferred futures price (daily) and selling price of JA Group (monthly) (Oct 2016 – Aug 2021)



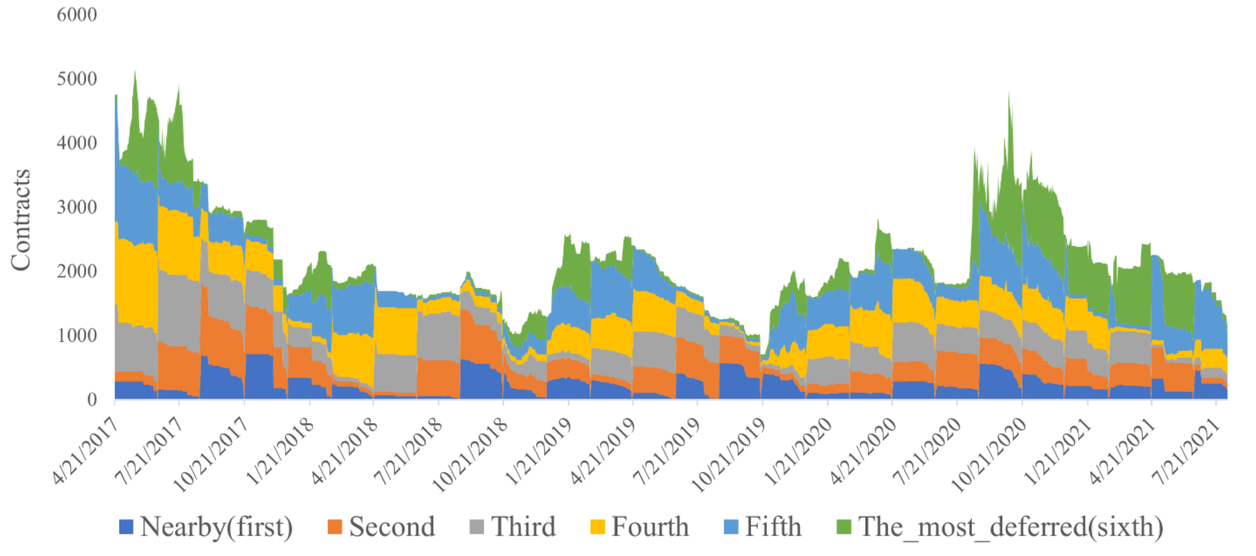
Note: Data sources are Beikoku Data Bank for spot prices, ODEX for futures prices, and MAFF for JA Group price. JA Group price includes tax. All prices are expressed in JPY/60 kg. Each interval between two light blue vertical lines represents an individual crop year.

Figure 3. Daily Niigata-Koshihikari rice futures trading volume by contract position (Oct 2016 – Aug 2021)



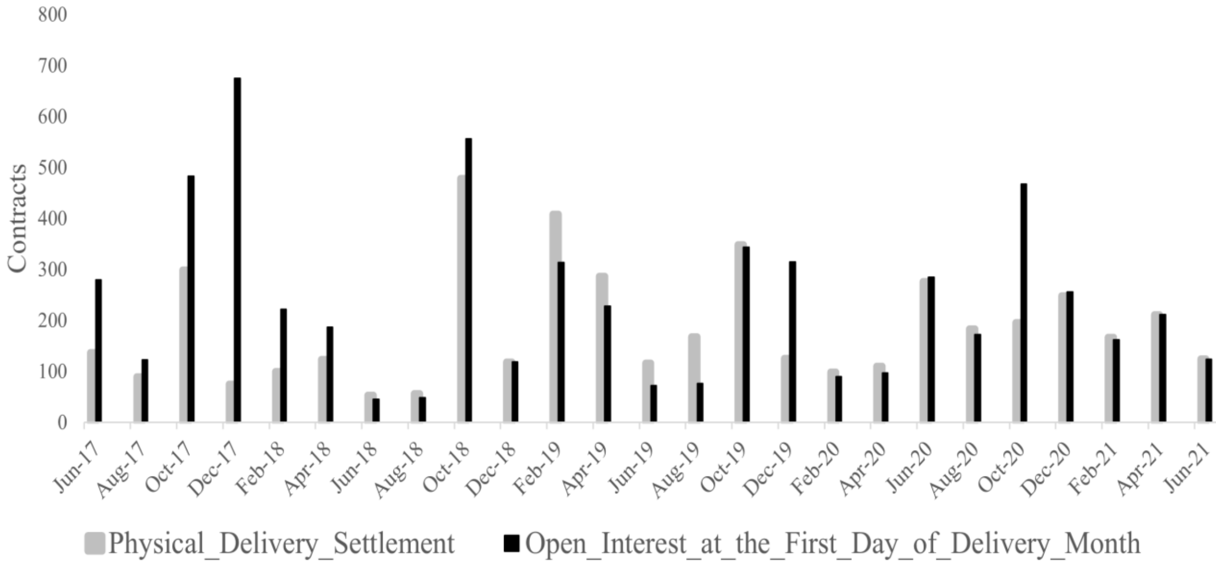
Note: Data source is ODEX. The most deferred contract is the sixth contract after April 21, 2017. Before that date, from October 21, 2016 to December 20, 2016 (December 21, 2016 to February 20, 2017) [February 21, 2017 to April 20, 2017] the most deferred contract is the third (fourth) [fifth] contract. Shaded grey area represents the continuous trading period.

Figure 4. Daily Niigata-Koshihikari rice futures open interest by contract position, daily (Apr 2017 – Aug 2021)



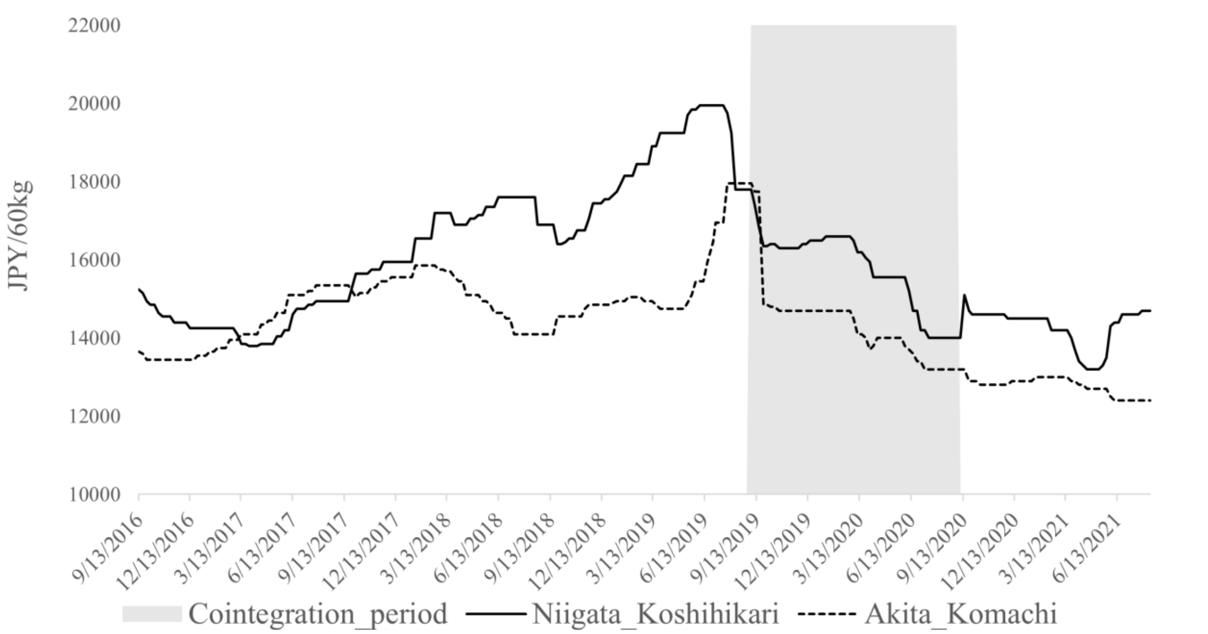
Note: Data source is ODEX.

Figure 5. Number of Niigata-Koshihikari rice futures contracts settled through delivery and open interest of the expiring contract on the first day of the delivery month (Jun 2017 – Jun 2021)



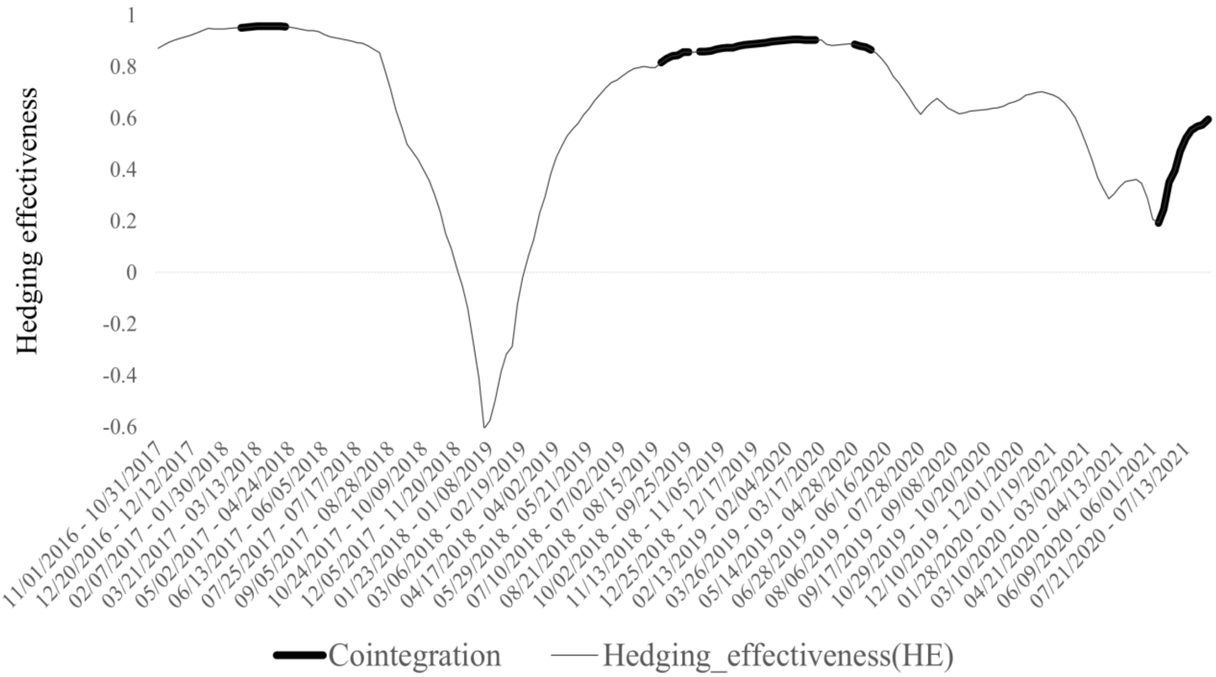
Note: Data source is ODEX. The number of contracts settled through delivery includes exchange for physical (EFP) contracts.

Figure 6. Niigata-Koshihikari & Akita-Komachi spot prices and cointegrated subsamples (Sep 2016 – Aug 2021)



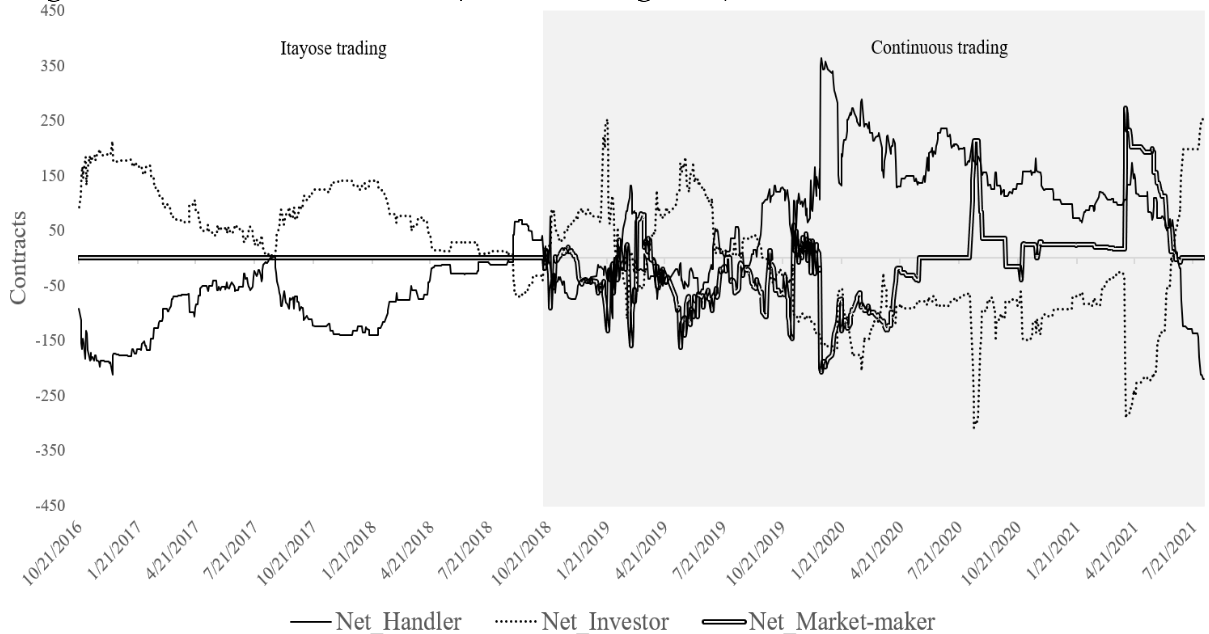
Note: Data source is Beikoku Data Bank. Cointegration between the two prices is measured in rolling windows of 50 weeks. Only two out of 198 subsamples are cointegrated and denoted through the shaded area. Shaded grey area represents cointegration intervals.

Figure 7. Evolution of hedging effectiveness (HE) when Niigata-Koshihikari cash positions are hedged using the nearby futures contract (Oct 2016 – Aug 2021)



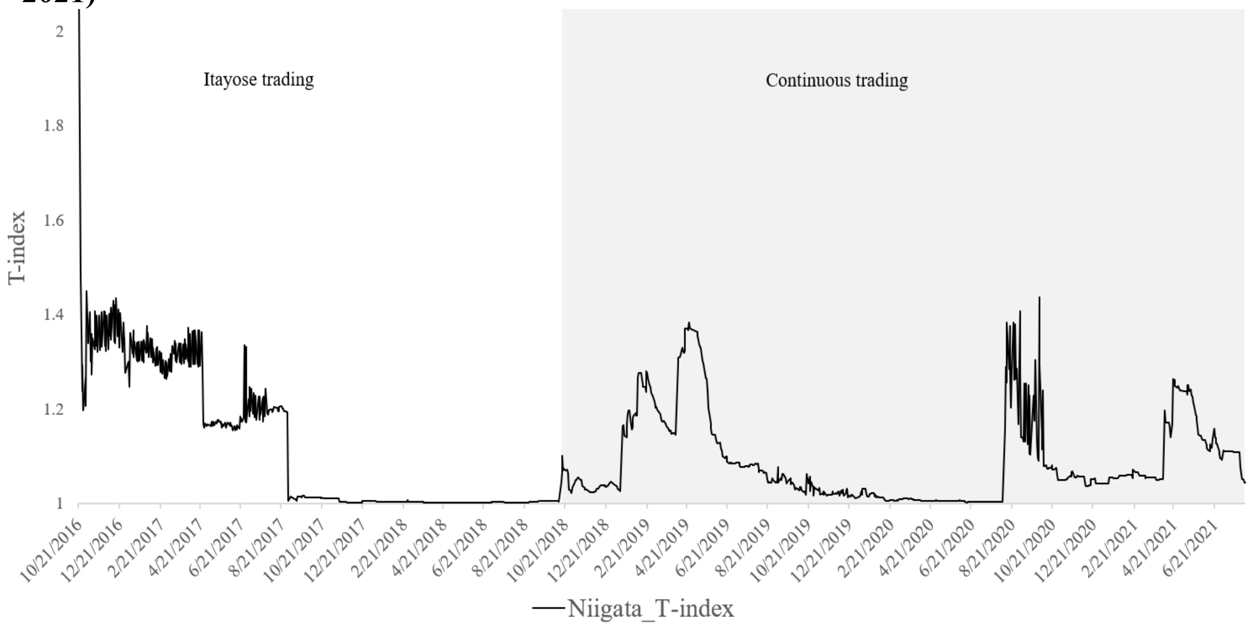
Note: The number of subsamples is 190, each subsample contains 50 weekly price data. Hedging effectiveness (HE) is calculated assuming a naïve hedging strategy, where the hedger takes a short position in the futures market to fully match their cash position. HE is expressed in proportion of unhedged portfolio variance reduced through hedging and depicted through the black continuous line. The thick black line denotes the time intervals when cash and futures prices are cointegrated.

Figure 8. Daily net position of handlers' market-makers' and investors' open interest for Niigata-Koshihikari rice futures (Oct 2016-Aug 2021)



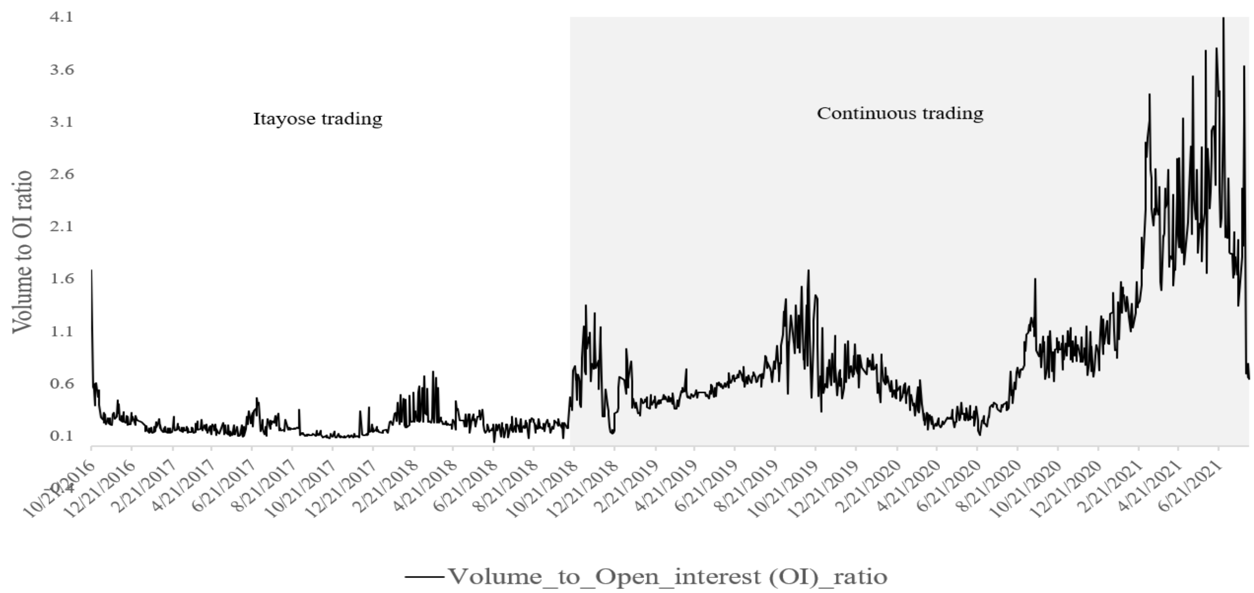
Note: Data source is ODEX. The number of observations is 1170. Shaded grey area represents continuous trading period. We omit the Non-member open interest.

Figure 9. Daily speculative T-index of Niigata-Koshihikari rice futures (Oct 2016 –Aug 2021)



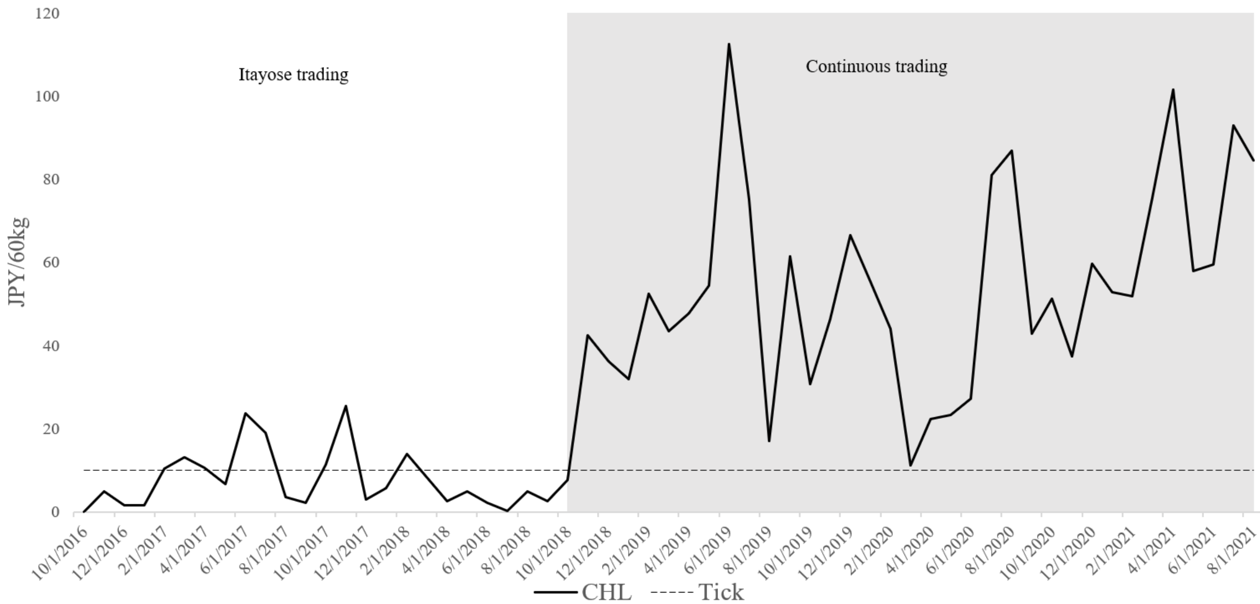
Note: Data source is ODEX. The vertical line (labeled as system transition) marks the date when the market shifted from Itayose to continuous trading. Shaded grey area represents the continuous trading period.

Figure 10. Daily volume to open interest ratio for the ODEX Niigata-Koshihikari rice futures (Oct 2016 – Aug 2021)



Note: Data source is ODEX. The vertical line (labeled as system transition) marks the date when the market shifted from Itayose to continuous trading. Shaded grey area represents the continuous trading period.

Figure 11. Monthly average of the bid-ask spread for Niigata-Koshihikari rice futures with CHL method (Oct 2016 – Aug 2021)



Note: We calculate the monthly average bid-ask spread estimator for Niigata-Koshihikari rice futures market. Reported values are based on CHL method averaged across all contact months and expressed in Japanese yen/60 kg (continuous line). The tick size (10 JPY/60kg) is represented by the dashed line. Shaded grey area represents the continuous trading period.

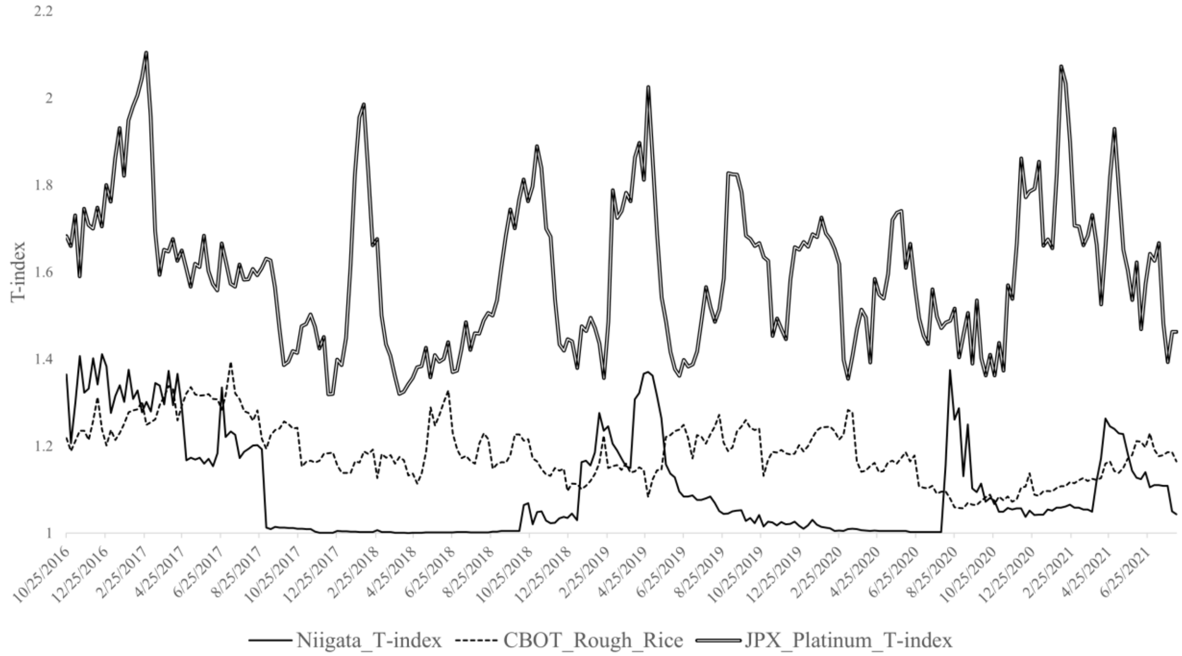
APPENDIX B:SUPPLEMENTARY TABLES AND FIGURES

Table 8. Niigata-Koshihikari rice futures contract months and corresponding crop year table (Oct 21 2016 – Aug 6 2021)

period	Spot	Nearby (1st)	2nd	3rd	4th	5th	The most deferred (6th)
10/21/2016-12/20/2017	2016Crop	2016Crop(2017 Jun)	2016Crop (2017 Aug)	2017Crop (2017 Oct)			
12/21/2016-2/20/2017	2016Crop	2016Crop(2017 Jun)	2016Crop (2017 Aug)	2017Crop (2017 Oct)	2017Crop(2017 Dec)		
2/21/2017-4/20/2017	2016Crop	2016Crop(2017 Jun)	2016Crop (2017 Aug)	2017Crop (2017 Oct)	2017Crop(2017 Dec)	2017Crop(2018 Feb)	
4/21/2017-6/20/2017	2016Crop	2016Crop(2017 Jun)	2016Crop (2017 Aug)	2017Crop (2017 Oct)	2017Crop(2017 Dec)	2017Crop(2018 Feb)	2017Crop(2018 Apr)
6/21/2017-8/18/2017	2016Crop	2016Crop(2017 Aug)	2017Crop (2017 Oct)	2017Crop(2017 Dec)	2017Crop(2018 Feb)	2017Crop(2018 Apr)	2017Crop(2018 Jun)
8/21/2017-10/2/2017	2016Crop	2017Crop(2017 Oct)	2017Crop(2017 Dec)	2017Crop(2018 Feb)	2017Crop(2018 Apr)	2017Crop(2018 Jun)	2017Crop(2018 Aug)
10/3/2017-10/20/2017	2017Crop	2017Crop(2017 Oct)	2017Crop(2017 Dec)	2017Crop(2018 Feb)	2017Crop(2018 Apr)	2017Crop(2018 Jun)	2017Crop(2018 Aug)
10/23/2017-12/20/2017	2017Crop	2017Crop(2017 Dec)	2017Crop(2018 Feb)	2017Crop(2018 Apr)	2017Crop(2018 Jun)	2017Crop(2018 Aug)	2018Crop(2018 Oct)
12/21/2017-2/20/2018	2017Crop	2017Crop(2018 Feb)	2017Crop(2018 Apr)	2017Crop(2018 Jun)	2017Crop(2018 Aug)	2018Crop(2018 Oct)	2018Crop(2018 Dec)
2/21/2018-4/20/2018	2017Crop	2017Crop(2018 Apr)	2017Crop(2018 Jun)	2017Crop(2018 Aug)	2018Crop(2018 Oct)	2018Crop(2018 Dec)	2018Crop(2019 Feb)
4/23/2018-6/20/2018	2017Crop	2017Crop(2018 Jun)	2017Crop(2018 Aug)	2018Crop(2018 Oct)	2018Crop(2018 Dec)	2018Crop(2019 Feb)	2018Crop(2019 Apr)
6/21/2018-8/20/2018	2017Crop	2017Crop(2018 Aug)	2018Crop(2018 Oct)	2018Crop(2018 Dec)	2018Crop(2019 Feb)	2018Crop(2019 Apr)	2018Crop(2019 Jun)
8/21/2018-9/21/2018	2017Crop	2018Crop(2018 Oct)	2018Crop(2018 Dec)	2018Crop(2019 Feb)	2018Crop(2019 Apr)	2018Crop(2019 Jun)	2018Crop(2019 Aug)
9/25/2018-10/19/2018	2018Crop	2018Crop(2018 Oct)	2018Crop(2018 Dec)	2018Crop(2019 Feb)	2018Crop(2019 Apr)	2018Crop(2019 Jun)	2018Crop(2019 Aug)
10/22/2018-12/20/2018	2018Crop	2018Crop(2018 Dec)	2018Crop(2019 Feb)	2018Crop(2019 Apr)	2018Crop(2019 Jun)	2018Crop(2019 Aug)	2019Crop(2019 Oct)
12/21/2018-2/20/2019	2018Crop	2018Crop(2019 Feb)	2018Crop(2019 Apr)	2018Crop(2019 Jun)	2018Crop(2019 Aug)	2019Crop(2019 Oct)	2019Crop(2019 Dec)
2/21/2019-4/19/2019	2018Crop	2018Crop(2019 Apr)	2018Crop(2019 Jun)	2018Crop(2019 Aug)	2019Crop(2019 Oct)	2019Crop(2019 Dec)	2019Crop(2020 Feb)
4/22/2019-6/20/2019	2018Crop	2018Crop(2019 Jun)	2018Crop(2019 Aug)	2019Crop(2019 Oct)	2019Crop(2019 Dec)	2019Crop(2020 Feb)	2019Crop(2020 Apr)
6/21/2019-8/20/2019	2018Crop	2018Crop(2019 Aug)	2019Crop(2019 Oct)	2019Crop(2019 Dec)	2019Crop(2020 Feb)	2019Crop(2020 Apr)	2019Crop(2020 Jun)
8/21/2019-9/24/2019	2018Crop	2019Crop(2019 Oct)	2019Crop(2019 Dec)	2019Crop(2020 Feb)	2019Crop(2020 Apr)	2019Crop(2020 Jun)	2019Crop(2020 Aug)
9/25/2019-10/18/2019	2019Crop	2019Crop(2019 Oct)	2019Crop(2019 Dec)	2019Crop(2020 Feb)	2019Crop(2020 Apr)	2019Crop(2020 Jun)	2019Crop(2020 Aug)
10/21/2019-12/20/2019	2019Crop	2019Crop(2019 Dec)	2019Crop(2020 Feb)	2019Crop(2020 Apr)	2019Crop(2020 Jun)	2019Crop(2020 Aug)	2020Crop(2020 Oct)
12/23/2019-2/20/2020	2019Crop	2019Crop(2020 Feb)	2019Crop(2020 Apr)	2019Crop(2020 Jun)	2019Crop(2020 Aug)	2020Crop(2020 Oct)	2020Crop(2020 Dec)
2/21/2020-4/20/2020	2019Crop	2019Crop(2020 Apr)	2019Crop(2020 Jun)	2019Crop(2020 Aug)	2020Crop(2020 Oct)	2020Crop(2020 Dec)	2020Crop(2021 Feb)
4/21/2020-6/19/2020	2019Crop	2019Crop(2020 Jun)	2019Crop(2020 Aug)	2020Crop(2020 Oct)	2020Crop(2020 Dec)	2020Crop(2021 Feb)	2020Crop(2021 Apr)
6/22/2020-8/20/2020	2019Crop	2019Crop(2020 Aug)	2020Crop(2020 Oct)	2020Crop(2020 Dec)	2020Crop(2021 Feb)	2020Crop(2021 Apr)	2020Crop(2021 Jun)
8/21/2020-9/14/2020	2019Crop	2020Crop(2020 Oct)	2020Crop(2020 Dec)	2020Crop(2021 Feb)	2020Crop(2021 Apr)	2020Crop(2021 Jun)	2020Crop(2021 Aug)
9/15/2020-10/20/2020	2020Crop	2020Crop(2020 Oct)	2020Crop(2020 Dec)	2020Crop(2021 Feb)	2020Crop(2021 Apr)	2020Crop(2021 Jun)	2020Crop(2021 Aug)
10/21/2020-12/18/2020	2020Crop	2020Crop(2020 Dec)	2020Crop(2021 Feb)	2020Crop(2021 Apr)	2020Crop(2021 Jun)	2020Crop(2021 Aug)	2021Crop(2021 Oct)
12/21/2020-2/19/2021	2020Crop	2020Crop(2021 Feb)	2020Crop(2021 Apr)	2020Crop(2021 Jun)	2020Crop(2021 Aug)	2021Crop(2021 Oct)	2021Crop(2021 Dec)
2/22/2021-4/20/2021	2020Crop	2020Crop(2021 Apr)	2020Crop(2021 Jun)	2020Crop(2021 Aug)	2021Crop(2021 Oct)	2021Crop(2021 Dec)	2021Crop(2022 Feb)
4/21/2021-6/18/2021	2020Crop	2020Crop(2021 Jun)	2020Crop(2021 Aug)	2021Crop(2021 Oct)	2021Crop(2021 Dec)	2021Crop(2022 Feb)	2021Crop(2022 Apr)
6/21/2021-8/6/2021	2020Crop	2020Crop(2021 Aug)	2021Crop(2021 Oct)	2021Crop(2021 Dec)	2021Crop(2022 Feb)	2021Crop(2022 Apr)	2021Crop(2022 Jun)

Note: Contract month is in parenthesis. The different crop years are represented by different colors; light green: 2016 crop; green: 2017 crop; light blue: 2018 crop; blue: 2019 crop; light gray: 2020 crop; gray: 2021 crop. For example, 2016 crop (2017 June) means futures contract month is 2017 June and it assumes 2016 crop delivery. Niigata-Koshihikari initially started with three contract months. Crop years are defined based on the Beikoku Data Bank.

Figure 12. Weekly Speculative T-Index for CBOT rough rice, JPX platinum and ODEX Niigata Koshihikari rice futures (Oct 2016 – Aug 2021)



Note: Data sources are CFTC, JPX, and ODEX.