Efficiency of the Dojima rice futures market in Tokugawa-period Japan

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Received 21 May 1998; accepted 20 December 1999

Abstract

Co-integration analysis is applied to historical data (1760–1864) from the world’s first well-established futures market, in rice at Dojima (in Osaka, Japan). The market shows a strong seasonal character. The summer market was strongly characterized by producers’ hedging behavior, and may be called a “commodity-oriented futures market”. On the other hand, the spring and autumn markets in the middle of Tokugawa era were “financial” markets, characterized by the unbiasedness hypothesis from the theory of rational expectations. © 2001 Elsevier Science B.V. All rights reserved.

JEL classification: G13; N25

Keywords: Futures market; Market efficiency; Cointegration; Osaka

1. Introduction

In Tokugawa-period Japan (1603–1867), the rice trading center was Osaka, a city called the “kitchen for the country”. It was there that clan governments (Han) across the land shipped much of the rice they collected as land tax in lieu of cash. In Dojima, the site of the rice trading activities, a rice futures market

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continuously operated. Standard textbooks on futures markets (e.g., Duffie, 1989; Blank et al., 1991) identify the Dojima rice market as “the world’s first well-established futures market”, and the Chicago Commodity Exchange Handbook explicitly states that futures trading originated in Osaka.

During the past 50 years, this rice market has been well-investigated in Japan, and in English literature, Schaede (1989) offers an excellent description of it. Schaede has also identified the Dojima rice market as a futures market by examining the following criteria: (1) only exchange members can participate in the market; (2) contracts traded are standardized; (3) for each position, a “good-faith” money has to be deposited at the clearinghouse; (4) trading is not bilateral, but the clearinghouse enters each transaction as a third party and guarantees the fulfillment of all contracts; (5) the contract runs for a certain trading period and open positions are reassessed daily in accordance with price fluctuations; and (6) positions dissolved before the end of the trading period are cleared by cash settlement. Schaede has concluded that the market practices generally satisfied these criteria.

Inspite of careful examination of institutional setup of the market, Schaede, as well as many studies in Japan, have not analyzed it quantitatively because of the lack of reliable data. A recent paper by Ito (1993), however, has used standard techniques of present-day economics, i.e., he demonstrated that the Dojima rice market failed to satisfy the “unbiasedness” condition of the rational expectations test. In fact, Ito concluded that the market cannot be deemed to have consisted of participants who were using information effectively, and thus it was not “efficient”; a conclusion based on the fact that (i) the futures price in the market on average failed to predict the spot price accurately, and (ii) the stock of rice at the time of forecasting had a strong correlation with the ex post forecast error. This suggests that, contrary to the high degree of institutional perfection attributed to the market by the existing studies, the market was considerably limited in its ability to process information.

On the other hand, when considering the period’s patterns of rice production and transportation, many institutional features seem to justify calling trading operations in the market efficient. It is this contradiction that underlies the purpose of the present paper. That is, to undertake an empirical analysis of the market by taking such features into account, and to demonstrate that rational expectations were indeed at work in providing an effectively operating futures market. The type of study used here is also meaningful in that, provided the theoretical constraints existing at the time are properly understood, it shows that standard analytical techniques of modern economics can be used for an analysis of economic phenomena taking place several hundred years ago. Moreover, it can elucidate across time and space our understanding of the universal nature of the market mechanism.

Compared to the present-day economy, which has a complex institutional setup and is subject to frequent violent shocks, the economy in the Tokugawa
era was simpler and changed at a much slower pace; key features allowing us to assume with greater ease how a theoretically conceptualized economic model is supposed to operate. When considering that there exists an extensive time series of quantitative data on the rice trading activities in Dojima, it becomes quite apparent that the market serves as an ideal locus for verifying economic theory, while also offering a unique set of data factually substantiating the theory of a futures market with a level of precision that has not been reached by any other set of empirical data.

Subsequently, a brief overview of the Dojima rice market is presented in Section 2, being followed in Section 3 with a description of a theoretical seasonal pattern of markets emphasizing particular features of the market. Then, after data are described in Section 4, a test of unbiasedness is conducted in Section 5; one which shows that the market followed a very regular seasonal pattern. Finally, more detailed discussions of the summer market are discussed in Section 6, with conclusions being contained in Section 7.

2. The Osaka rice market

In the Tokugawa era, the rice collected as tax by clan governments was shipped to their warehouses in Osaka for sale at the Dojima rice market, and then ultimately for distribution to consumers at large. A clan’s warehouse issued a promissory note called a “rice ticket” promising to deliver a specified amount of warehouse-stocked rice to a particular individual on a specified date. Gradually, as rice tickets began to be transacted as negotiable instruments, an increase occurred in transactions based on purely speculative motives and on transactions in rice tickets for rice not yet shipped to Osaka. Taking note of this reality, the Shogunate government in 1730 issued an official permit to the Dojima rice market ratifying rice futures trading operations which had been going on for some time.1

In addition to tickets for shomai (genuine rice), tickets for choaimai (rice on books) were transacted, with the settlement of deals by the delivery of actual rice being prohibited for choaimai transactions. The exact relationship between the price of shomai, that of choaimai, and the actual market price of rice relative to how “spot” and “futures” prices in present-day futures market are related to each other is rather complicated and cannot be answered in a straightforward manner. However, given that this paper is mainly concerned

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1 Rice trading in the Kitahama market, the predecessor to the Dojima market, is vividly described by Ihara Saikaku (1642–1693), a realistic novelist of the early Tokugawa period, in his Nihon Eitaigura, especially in its first volume, “Namikaze Shizukani Jintsumaru”. (The Jintsumaru, a sea-going merchant ship, has a calm passage.)
with the period when the market remained relatively stable (Miyamoto, 1988), we shall treat transactions in choaimai as similar to those in an ordinary commodity futures market.

Trading in rice futures then, unlike trading in the present-day futures market, was conducted in three seasonal markets, i.e.,

1. The spring market: January 8–April 28 (called “winter trading” along with that in the below autumn market).
2. The summer market: May 7–October 9 (called “summer trading”).
3. The autumn market: October 17–December 24 (called winter trading).

During each seasonal market, the maturation date for rice futures extended only up to the “closing date” of that market. In other words, a speculative deal on spring market rice futures was carried out by forecasting the rice price as of April 28 at the latest, and no deal could be made on rice futures to be delivered at harvest time later in the year or in the following year. In this regard, the rice futures market was radically different from contemporary futures markets, where risks in principle can be hedged against an infinite time horizon through various financial instruments.  

This particular institutional feature of the Dojima market is nevertheless convenient for identifying the motive behind transactions in each season. That is, the summer market seems to have primarily catered to the need for hedging against the risk of an unsatisfactory harvest; whereas the primary function of the autumn market opening shortly after the harvest may have been to facilitate hedging against the risks of shipping harvested rice to Osaka and determining the quantity that would actually be shipped. The spring market, on the other hand, can reasonably be characterized as the market for transactions of

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2 For further details on the institutional aspects of the Dojima rice market, see Shimamoto (1953), Miyamoto (1988, especially Chapter 3), Shade (1989), Susuki, (1940), Suzuki, (1935), and Wakita, (1996). In characterizing the rice market as a financial securities market, Shimamoto attaches importance not to “futures”, but to “spot” rice or Shomai. To be sure, the shomai price and the current price were not necessarily identical, especially toward the end of the Tokugawa era. However, the discrepancy between the two was due to the fact that shomai transactions were carried out as trades of rice tickets, which were often issued in excess of the amount of rice actually stored in the clan governments’ warehouses. It should be noted, moreover, that with the passage of time, the duration between the issuing of rice tickets and the actual delivery of rice on those tickets gradually extended to one year or more, with the result that rice tickets became characterized increasingly as securities issued by feudal lords, or pieces of collateral put up by them to borrow money in the rice market to finance their budgets. This helps explain the question which Ito (1988) finds puzzling i.e., why the spot and futures prices tended to disagree on the date of maturation of future transactions. This fact also justifies Miyamoto’s attempt to establish a link between the rice ticket price, which reflected pure speculative transactions and the actual market price. Shimamoto emphasizes this latter fact, characterizing the choaimai market as a “gambling market” and the shomai markets as a “securities market”, and arguing that the futures price was connected far more closely with the actual market price than the modern conventional wisdom would suggest. This was because the futures price was formed independently of the behavior of the clan governments.
the rice already stored in Osaka as well as the additional shipments of rice from the colder Hokuriku districts which usually arrived in April.

In any case, it is clear that maintaining a market that can handle a diversity of transactions in futures commodities involves considerable costs; and in fact, no such futures market operates today that handles transactions over an extended time horizon like this. The division of the year into three separate trading seasons is therefore considered a rational means of minimizing both the cost of maintaining the futures market and that of transactions.

3. Theoretical seasonal patterns of futures and spot prices

Considering the existence of seasonal markets in accordance with the production pattern of rice, we are viewing the Dojima rice market not as a financial securities exchange but instead as a commodity futures market in which clan governments were the suppliers and the Osaka rice merchants were the buyers. With this in mind, a question arises as to what sort of relationship must the spot and futures prices satisfy within a commodity futures market. Two theories exist pertinent to the question: one, advanced by Working (1948) and others, attaches importance to the physical factors of the commodity concerned; while the other, advanced by Keynes (1930) and others, attaches importance to the risk premium involved. The following equation, which incorporates the two theories, describes the theoretically desirable relationship between spot and futures prices:

\[
\text{Futures premium} = \frac{(\text{Futures prices} - \text{Spot prices})}{\text{Spot prices}} \\
= \text{Interest rate} - \text{Marginal convenience yield} \\
- \text{Cost of storing and transporting stocked rice} \\
+ \text{Risk premium}. \tag{1}
\]

If the Dojima rice market had been a pure financial securities exchange incapable of readjusting the demand for and the supply of rice, both the convenience yield and the stock-carrying cost would have been irrelevant such that the risk premium would have had a positive effect on the futures premium. The implications of each of the terms in (1) are discussed below:

1. The “interest rate” has a positive effect on the futures premium. In any market it must usually and theoretically be positive, reflecting the opportunity cost when money can be invested in other interest-bearing assets.

2. The “convenience yield” represents the extent by which the utility derived from the purchase of actual rice at present exceeds the utility derived from rice futures. In the autumn and spring markets, which opened soon after harvest time, due to a sufficient rice stock the current convenience yield must have had a very small effect on the futures premium. On the other hand, in
the summer market operating during the off-crop season, this value should have had a large negative effect on the futures premium.

3. While the “cost of storing stocked rice” would be fairly large in modern times, rice storage during the Tokugawa era was practically free since it was stored in warehouses operated by the ruling samurai class. Accordingly, this makes it difficult to surmise that the opportunity cost of storage found its way explicitly into the rice futures price.

4. In contrast, “the cost of transporting stocked rice” which would be small today was quite sizable at the time. It should be remembered, however, that (i) this cost would have affected the price evenly across all seasons, and (ii) even more importantly, the maritime transportation of rice to Osaka from various localities entailed great risks, e.g., a shipwreck or long delays due to bad weather; risks that naturally led to substantial risk premiums making maritime shipping an important factor affecting the rice trading in Dojima. Miyamoto (1988) showed that the rice stock in Osaka typically reached its peak in November, then declined subsequently. In other words, it is reasonable to surmise that this transportation-related risk presented itself in the autumn market producing a positive effect on the futures premium. It was also present in the spring market, since shipments from the colder Hokuriku districts typically arrived in April.

5. The production-related risk premium is the most important factor; especially so in the summer market when the market-supplying clan governments needed to hedge against such risk. The risk premium at this time directly reflected the uncertainty of the coming harvest, and produced a negative effect on the futures premium.

6. In the autumn and spring markets, where the harvest yield was known and trading was to be cleared before the next harvest, no risk peculiar to rice production could have been present. Thus, the risk premium, if present at all in the autumn and spring markets, could only represent the default risk of borrowers, producing a corresponding positive effect on the futures premium seen in an ordinary financial market.

In summary, as a commodity futures market, the Dojima rice market would have behaved as follows. In the summer market, which opened while rice was growing, either the convenience yield or the risk premium (reflecting clan governments’ willingness to hedge against the uncertainty of the coming harvest) caused the futures premium to be lower; whereas in the autumn and spring markets, which opened during the transportation seasons and were affected by both the uncertainty in the amount of rice to be shipped to Osaka and the risk of transportation, the futures premium would be relatively lower.

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3 A well-known story is told of Kinokuniya Bunzaemon, who made fortunes by shipping Kishu (presently Wakayama) oranges to the consumer market of Edo (presently Tokyo) by risking the loss of ships on the way.
4. Data

The stage is now set for an empirical analysis. As mentioned, monthly data are necessary for looking into the seasonal pattern of rice prices, with the respective data source being the “Otsu Kokurui Sonota Soba-hyo” (Table of Prices of Grains and Other Commodities in Otsu) provided by Tsuruoka (1972). The prices used are those covering the period prior to the Tenpo era (1830–1843), i.e., the years from 1760 to 1827 when rice prices remained relatively stable (Miyamoto, 1988). Although times exist when trading was suspended by the Shogunate or data are otherwise unavailable, and the data do not include prices at maturity dates, this particular time series is nevertheless quite useful due to covering such an exceptionally long period.

Fig. 1 plots the spot and futures prices over the entire period, where it is immediately evident that the shomai and choaimai prices are closely linked; a feature indicating that the effects of over-issuing rice tickets, which would cause a difference between the two prices, were rather insignificant, at least over the period concerned. The effect of having no information on the prices at maturity dates prevents conclusively determining whether or not there was arbitrage between actual rice and futures rice (see Ito, 1993). Nonetheless, it seems plausible to assume that there was arbitrage at the time, as supported by Yamagata Banto (1748–1821), a merchant-intellectual of Osaka, in his work Yume no Shiro (1802): “Rice sold on a rice ticket and choaimai are like day and night... Although the prices of the two are usually at variance with each other, the prices of shomai and choaimai become identical at the end of April, October, and December, and thus they are of the same blood”.

Fig. 2 shows monthly average prices, where quite amazingly, the relationship between the two prices changes from one season to the next in the exact, distinct pattern suggested by conventional theory of a commodity futures market.

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4 For currently available data on the trading in Dojima, see Miyamoto (1988, p. 364). The data compiled in the “Yagi Sobacho Tsuiko”, as reproduced in Shimamoto (1970), are best suited for an empirical analysis, and are in fact used by several authors including Ito (1993). However, they are too small in size to be used in identifying a seasonal pattern.

5 Since the time span for hedging against risks is not infinite in the time series data used here, there is no need for the prices series to be of a random walk nature. In order to determine whether the data have a unit root, a simple DF-test was conducted on all the samples i.e., all monthly data, not monthly averages data, as well as month-on-month annual data, e.g., annual data of January prices etc., but a unit root could not be detected (a coefficient ranging from 0.6 or 0.3). The frequent occurrence of missing data, which causes frequent jumps in the samples, tends to make it more likely for a unit root to be detected as is evident from Fig. 1, where the movement of prices is very stationary before the Tenpo era.

6 The quotation is from Nihon Shiso Taikei, 43: Tominaga Nakamoto, Yamagata Banto (Collected Anthologies of Important Philosophical Works in Japan, 43: Tominaga Nakamoto and Yamagata Banto), Iwanami Shoten, p. 398.
Because the price should reflect all available information on the prices of the commodity at the time of maturity, the movement of the price of a commodity futures must be stable over the transaction period such that futures prices become a means of hedging against the expected risk over the transaction period.

The above understanding also asserts that futures and spot prices must move in close linkage with each other during the transaction period, unless of course some factors which do not widen the spread between the two fluctuate violently. This cuts a stark contrast to the commodity futures market of today, where (i) financial commodities can be traded in numerous combinations such that a risk involved in the trading of a certain commodity can be hedged against over a virtually infinite time horizon, and (ii) the transaction period for one commodity can never be identified clearly and independently of the transaction periods of other commodities. The transaction period in the Dojima rice market was rigidly defined in a manner that the risk involved in a futures transaction could be hedged against only over the duration of the seasonal market concerned, this being the reason why the relationship between the spot and futures prices followed a fixed seasonal pattern.

Moreover, according to conventional theory of commodity futures market operation, in the summer market where transactions could be made in futures for the new crop of rice to be harvested in the months of September and October, the spot price must have decreased in line with the futures price. Indeed, the trajectory of the spot price (Fig. 2) is clearly in agreement with this theory,
since it stays at low levels in the summer market, where futures for the forthcoming crops of rice could be transacted, and at high levels in the autumn and spring markets, where such futures could not be transacted. Moreover, the time series plotting of the spot prices in both markets (Fig. 3) suggests that this tendency is robust. However, a question naturally arises as to why arbitrage fails. In this context, it should be remembered that the suppliers in the Tokugawa period, i.e., ruling samurai class, were becoming poor and faced severe liquidity constraints. Thus, it is possible that they needed to sell rice futures immediately after the market opened.

The effect of a futures market on the movement of spot price has never in my knowledge been demonstrated in a more straightforward manner than can be seen by this simple procedure of plotting monthly changes in the average price.

Fig. 2. Seasonal fluctuation of spot and futures prices.
Such a clear-cut seasonal pattern in the price movement seems to reflect the fact that rice production in the Tokugawa era was fairly stationary, being quite similar to the assumptions postulated under any standard theoretical model.

Finally, Fig. 4 shows us the futures premium for the entire sample, where even though it is difficult to tell which price remained higher over the entire period, during the great famine of Tenmei the shomai price shoots up to very high levels while the choaimai price remains somewhat lower. In any case, however, if my hypothesis is valid, then it should be possible to establish that the spread between the spot and futures prices presented a clear-cut seasonal pattern in each month of the year and in each seasonal market. To confirm this, the futures premium was regressed on both a seasonal dummy and that for the great Tenmei famine. Fig. 5 shows the coefficient for the seasonal dummy and its standard deviation.

Note that the seasonal pattern of the futures premium is stable, with the futures price exceeding the spot price in the spring market. Also, the greatest margin occurs in May, the first month of the summer market, becoming narrower as the settlement time approached.

5. Unbiasedness

What underlies the stable futures premium in each month of the year? To answer this question, we must first examine whether futures prices were determined by a rational prediction of the closing prices in each market. If so, it becomes possible to analyze the effects on the futures premium. For this purpose, an unbiasedness test is used like Ito (1993), i.e., where the hypothesis of rational expectations is rejected and the same test is carried out again with the exception that monthly data are used. The regression equation is

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![Fig. 3. Average prices in the spring and summer markets.](image-url)
Fig. 4. Futures premium (%) from 1759 to 1859.
where $\epsilon_t$ is the error term. Because the closing shomai price is not known, the shomai prices in April, September, and December are used as the closing price of the spring, summer, and autumn markets, respectively. Our objective here is to determine whether the $F$-test supports the restriction that $\alpha = 0$ and $\beta = 1$, i.e., whether the futures price was equal to the spot price on average. 7

Tests of non-stationary time series are considered as well. First, DF and ADF unit root tests are conducted for spot and futures prices from 1760 to 1827 (Table 1), with Table 2 presenting the results. Next, co-integration tests are considered. Brenner and Kroner (1995) propose the following co-integration test using standard hypothesis testing

$$\Delta \log S_t = \alpha + \beta \Delta \log f_{t-1} + \delta(\log f_{t-1} - \log S_{t-1}) + \epsilon_t,$$

where $\Delta$ is the difference operator, $S_t$ the shomai price at $t$, and $f_{t-1}$ the choaimai price at $t - 1$ expiring at time $t$. The unbiasedness hypothesis in this

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7 As is evident from the calendar schedule, the transaction period for rice futures, for instance, was not fixed, and the estimation errors in each seasonal market were necessarily correlated with each other. Moreover, the pattern of such correlation was not stable. Because of these factors, it is difficult to take into account a possible error structure in the estimation.
### Table 1

**Test of rational expectation: Unbiasedness**

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<td>(0.063)</td>
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<tr>
<td>$\beta$</td>
<td>1.180</td>
<td>1.163</td>
<td>1.213</td>
<td>1.149</td>
<td>1.155</td>
<td>1.269</td>
<td>1.344</td>
<td>1.230</td>
<td>1.233</td>
<td>1.124</td>
<td>1.107</td>
<td>1.112</td>
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<tr>
<td></td>
<td>(0.054)</td>
<td>(0.043)</td>
<td>(0.029)</td>
<td>(0.025)</td>
<td>(0.079)</td>
<td>(0.079)</td>
<td>(0.075)</td>
<td>(0.051)</td>
<td>(0.026)</td>
<td>(0.047)</td>
<td>(0.027)</td>
<td>(0.015)</td>
</tr>
<tr>
<td>$\mathbb{R}^2$</td>
<td>0.867</td>
<td>0.899</td>
<td>0.955</td>
<td>0.962</td>
<td>0.724</td>
<td>0.748</td>
<td>0.792</td>
<td>0.876</td>
<td>0.963</td>
<td>0.883</td>
<td>0.950</td>
<td>0.985</td>
</tr>
<tr>
<td>$F(0,1)$</td>
<td>6.143***</td>
<td>7.926***</td>
<td>28.881***</td>
<td>22.149***</td>
<td>5.325**</td>
<td>9.858**</td>
<td>16.373***</td>
<td>17.378***</td>
<td>55.423***</td>
<td>7.527***</td>
<td>7.745***</td>
<td>28.258***</td>
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*** Significant at 1% level.
** Significant at 5% level.
* Significant at 10% level.
regression is satisfied if \((x, \beta, \gamma) = (0, 1, 1)\). Table 3 gives the results, where the data do not exhibit non-stationarity and are similar to test results using regression (2). Furthermore, a simple test using (2) can utilize the data in the presence of missing data, and therefore I will discuss the result derived from this test using (2).

As in Ito (1993), the test generally entails a joint hypothesis, risk-neutrality, and rational expectations. Although it should also take into account the interest rate and cost of stock maintenance, lack of such data prevents using these variables; and hence, the test should be regarded as dealing with a special case in which both variables are set to 0. For these reasons, a rejection of the unbiasedness hypothesis does not necessarily mean that the rational expectations hypothesis is rejected. As shown in Table 1 during the period from 1760 to 1827, the unbiasedness hypothesis cannot be rejected for six months of the year, i.e., January, February, April, July, August, and October.

It is, however, rejected in September and December, although the fact that the constant term assumes significantly large values and the value of \(\beta\) is close to 0 suggests that the excluded effect of the interest rate can be significant in
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</tr>
</thead>
<tbody>
<tr>
<td>( \overline{R}^2 )</td>
<td>0.965</td>
<td>0.944</td>
<td>0.965</td>
<td>0.958</td>
<td>0.951</td>
<td>0.944</td>
<td>0.818</td>
<td>0.823</td>
<td>0.953</td>
<td>0.879</td>
<td>0.951</td>
<td>0.985</td>
</tr>
<tr>
<td>D. W.</td>
<td>1.473</td>
<td>1.596</td>
<td>1.807</td>
<td>1.518</td>
<td>2.435</td>
<td>1.998</td>
<td>2.152</td>
<td>2.094</td>
<td>1.770</td>
<td>1.917</td>
<td>2.002</td>
<td>1.831</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>-0.008 (0.005)</td>
<td>-0.009 (0.006)</td>
<td>-0.006 (0.005)</td>
<td>0.000 (0.005)</td>
<td>0.010 (0.007)</td>
<td>0.008 (0.005)</td>
<td>0.014 (0.012)</td>
<td>0.013 (0.004)</td>
<td>0.000 (0.008)</td>
<td>0.005 (0.007)</td>
<td>-0.26 (0.007)</td>
<td>-0.12 (0.004)</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.981 (0.035)</td>
<td>0.976 (0.039)</td>
<td>1.042 (0.028)</td>
<td>1.022 (0.032)</td>
<td>1.148 (0.041)</td>
<td>1.029 (0.033)</td>
<td>1.128 (0.087)</td>
<td>1.038 (0.075)</td>
<td>0.998 (0.035)</td>
<td>0.911 (0.055)</td>
<td>0.981 (0.029)</td>
<td>0.988 (0.019)</td>
</tr>
<tr>
<td>( \delta )</td>
<td>0.843 (0.091)</td>
<td>0.715 (0.175)</td>
<td>0.710 (0.136)</td>
<td>1.328 (0.127)</td>
<td>0.446 (0.127)</td>
<td>0.585 (0.107)</td>
<td>0.638 (0.133)</td>
<td>0.796 (0.127)</td>
<td>0.750 (0.141)</td>
<td>0.852 (0.189)</td>
<td>0.734 (0.127)</td>
<td>0.624 (0.117)</td>
</tr>
<tr>
<td>( F(0, 1, 1) )</td>
<td>2.713</td>
<td>2.936*</td>
<td>3.242*</td>
<td>2.296</td>
<td>12.171**</td>
<td>7.893**</td>
<td>3.797*</td>
<td>1.503</td>
<td>1.169</td>
<td>1.165</td>
<td>20.410**</td>
<td>22.164**</td>
</tr>
</tbody>
</table>

* Period = 1760–1827.
* Significant at 10% level.
** Significant at 5% level.
these months. In other words, given the fact that the unbiasedness hypothesis is found to have held for six months of the year, and given also the incompleteness of the data for some of the remaining months in which the hypothesis is found to be statistically rejected, the evidence derived by the test is not strong enough to deny unbiasedness. Ito’s rejection of the unbiasedness hypothesis is probably due to pooling of data over all the seasonal markets, and my analysis seems to suggest that his conclusion was based on large prediction errors for May and June.

Despite inadequacy in the data used, because the unbiasedness hypothesis could not be rejected for six months of the year, and because $\beta$ assumed a value quite close to unity even in the remaining months (except for May and June), such features could very well justify that rational expectations were at work in the Dojima rice market.

The spring and autumn markets assuredly appear to represent pure “securities exchange markets”. For one thing, they were open in the months when transactions could be carried out without giving much consideration to the forthcoming production. And, more importantly, the closing date for each market was specified so that transactions in futures for delivery after the harvest were not possible. In other words, the spring and autumn markets lacked the important functions of a commodity futures market. One factor that may still characterize these markets as commodity futures markets is the risk involved in the transaction of rice, as previously pointed out. In theory, this factor should have the effect of widening the futures premium in a commodity futures markets; whereas in reality, the effect of this factor adds up to a positive value (Fig. 5) indicating that these markets were not equipped with important attributes of commodity markets.

Regarding the rejection of the unbiasedness hypothesis for May and June, this might be attributed to a possibility that the futures market in these months was strongly affected by the suppliers’ willingness to hedge against the uncertainty in the coming harvest and by the convenience yield of rice, which will be examined in the next section.

6. The summer market

It seems worthwhile to look more closely into the factors responsible for the larger futures premium as well as the rejection of the unbiasedness hypothesis in May and June. It does not stand to reason that the market participants became irrational only during May and June, being more plausible to assume that the futures premium widened in May and June on a regular basis due to the systematic effect of a particular factor.

This brings us back to the four factors in Eq. (1). Given the fact that the futures premium widened only during the summer market, where the spot price
remained higher than the futures price, two of the four factors, i.e., the interest rate and the costs of storing and transporting the stock of rice, may safely be removed from consideration. The two remaining factors are the producers’ willingness to hedge against risks, as emphasized by Keynes (1930), and the convenience yield of actual rice, as emphasized by Working (1948).

The futures premium itself can be explained by either theory, but it is important to note that the absolute levels of both the spot and futures prices remained low in the summer market (Fig. 2). Put briefly, Keynes’s theory tries to explain a growing premium primarily by the emergence of an excess supply caused by the selling of futures by suppliers; whereas in contrast, Working’s theory is characterized by its emphasis on the emergence of an excess demand caused by an increase in the “convenience yield” as the primary factor responsible for the wide premium. Given the fact that both the spot and futures prices remained low in the summer market, it is possible to assume that the premium widened not because of an increase in the “convenience yield” as suggested by Ito (1993) within the framework of Fama and French (1988), but rather because of “excess supply” emphasized by Keynes. 8

In fact, it seems reasonable to regard the Dojima rice market as an institution that catered primarily to enhancing the “convenience yield” for the sake of city dwellers, rather than one designed to facilitate smooth cashing of the rice collected by the ruling samurai class as land tax. Admittedly, as shown in Figs. 1 and 3, during extraordinary times such as the period of the Great Tenmei Famine, the spot price soared more rapidly than the future price such that a large premium occurred. On the whole, however, it seems appropriate to regard the summer market as a commodity futures market where producers could hedge against risk.

7. Conclusions

It has been shown that the Dojima rice market was an economically rational institution where the movement of rice price followed a clear-cut seasonal pattern. Major findings are summarized as follows:

1. During the period under study, the movement of the price of choaimai (i.e., the price of rice futures) and that of the price of a rice ticket (i.e., a certificate for actual rice) or the price of shomai were interlocked with each other.

8 Ito (1993) refutes Keynes’s explanation as irrelevant by referring to the fact that the futures premium was positive on average, and by interpreting this as pointing to the tendency for the futures price to bring down the spot price. There is nothing strange about this conclusion, because Ito’s test is based on the data pooled across all seasonal markets, two-thirds of which pertained to the spring and autumn markets, where the producers’ willingness to hedge against risks was totally irrelevant.
2. In the summer market, where transactions in futures for the forthcoming crop of rice were possible, both prices remained low. On the other hand, in the spring and autumn markets, where such transactions were impossible, both prices stayed high.

3. The spring and autumn markets were characterized by unbiasedness in the sense of rational expectations, suggesting that the factors peculiar to a commodity futures market did not significantly affect the futures premium.

4. The futures premium in the summer market increased on a regular basis; a phenomenon that is not ascribed to an increase in the convenience yield of actual rice, but rather to the producers' risk-hedging behavior.

Basically, the summer market was strongly characterized as a commodity futures market, while the spring and autumn markets were not. The institutional setup of the market was such that transactions in spot rice took the form of transactions in “rice tickets” as in transactions in securities. Given the fact that these securities transactions were linked with futures transactions during the spring and autumn markets, it is reasonable to consider these markets as securities futures markets; in fact, this institutional feature allows us to aptly call the Dojima rice market the world’s oldest securities futures market.

Some words must be said about an important question stemming from the above assertion; i.e., should these securities be characterized as certificates for a real commodity, or rather as financial securities? In other words, should the Dojima rice markets be characterized as a commodity futures market or as a financial futures market? This question has been discussed repeatedly for years. My own position is to consider it for the most part (summer market and classification into three seasonal markets) as a commodity futures market heavily influenced by the pattern of rice production. However, if one focuses on the individual spring or autumn market alone, both markets are characterized as financial markets. Taken together then, the Dojima rice market functioned both as a single goods commodity futures market and financial futures market.

It should be remembered, though, that the economic system of that era pivoted around what might be called the “rice standard”, and as such, might therefore be described far more accurately than any present-day economy by simply using an abstract, one-sector optimal growth model. If the 18th century Japanese economy is reappraised from the standpoint of such a model, it is possible to regard the stock of rice and the production pattern as the major determinants of the real interest rate. Accordingly, it may not be far-fetched to say the koku (5.119 US bushels), the unit by which the stipend of a samurai was calculated, was actually the unit for expressing nominal wages.

The procedure used for analyzing the Dojima rice markets is qualitatively different from that justifiable for analyzing a futures market of today, which is not only small compared with the size of the economy as a whole, but is also complemented by a multitude of well-developed financial markets. Today, analyzing the futures market with a partial equilibrium methodology, which
uses as given the interest rate determined in the extensive financial markets, may well be justified. In contrast, it seems quite difficult to determine in a straightforward manner whether the Dojima rice market was a financial securities exchange or a commodity futures market. As a matter of fact, the Shogunate’s policies for rice price regulation, such as its “Order on Purchased Rice”, often had the effect of causing much strain not simply on the rice market but also on the money market in general. For example, a sudden increase in the futures premium caused by the 1761 order (Fig. 6). An inquiry into this last aspect, which will require a more sophisticated analysis, is left as a challenging task for future research.

Acknowledgements

The author would like to thank Masahiro Kawai, Naoto Kunitomo, Satoshi Nakanishi, Jun Suzuki, seminar participants at the Japan statistical Institute, and two anonymous referees for their helpful comments and suggestions.

References