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Informational Efficiency under the Shogunate Governance:  
Concentration and Integration of the Rice Market in Tokugawa Japan

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# Informational Efficiency under the Shogunate Governance: Concentration and Integration of the Rice Market in Tokugawa Japan \*

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## Abstract

In the Tokugawa period, the market transaction explosively grew, and the local markets of all Japan were effectively integrated as a national market. This is the common view shared among the historians. Then, an important question is how these markets performed. To evaluate the performance, this paper focusses on the co-movement of rice prices between Osaka and Otsu. Applying the Granger causality test, it is shown that the Otsu market had reflected the rice prices in Osaka within two days in the early 19th century, and within a day in the mid-19th century. This change had stemmed from the development of the communication technology. The rice merchants' appetite for the information had made the co-movement of the rice prices so fast that the Otsu market did not need even one trading day to reflect the rice prices in Osaka.

**Key words:** Tokugawa period, the Dojima rice market, market integration

**JEL:** G20, N25, N75

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# I. Introduction

Under the governance mechanism established by the Tokugawa Shogunate in Edo,<sup>1</sup> the Shogunate and the feudal lords collected the rice in tax,<sup>2</sup> and shipped to the market for financing their budget. This system of taxation originally emerged based on the development of local markets, then lead to a sophisticated rice transaction mechanism in Osaka. The rice market in Osaka was called the Dojima rice market, and it was chartered by the Tokugawa Shogunate in 1730. The trades at the Osaka market was made through not the rice in kind, but the rice bills (“Kome kitte”),<sup>3</sup> and the claim over rice in kind represented by the rice bill was protected by the Shogunate.<sup>4</sup> The distribution network and the judicial system which provided by the Shogunate had made Osaka the center of the market with sophisticated trading mechanism.

The local markets, in turn, followed this trading system. One typical example of such a local market was the Otsu market. Otsu is located near Osaka, and it had second largest rice market after the Osaka market. The rice market in Otsu — “goyo komekaisyo (The rice market authorized by the Shogunate, henceforth referred to as the Otsu market)”, was chartered by the Shogunate in 1735. Both Otsu and Osaka were belonged to the Shogunate domain. While the Shogunate gave feudal lords the authority to rule their domains, it had its own domains (“Ten-ryo”) in various regions in Japan, which covered most important and developed city such as Osaka and Otsu. The trades in the Shogunate domain were under the jurisdiction of the Shogunate local court. In fact, as mentioned later, the Otsu market had basically similar trading system with the Osaka market, including judicial system.

These institutions made the market transaction in Tokugawa period explosively grew, and the local markets of all Japan were effectively integrated as a national market. Then, an important and exciting question is how these institutions performed.

According to the neoclassical economics, sufficient development of market transaction

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<sup>1</sup>Edo was the Shogunate capital, lately renamed as Tokyo in 1868.

<sup>2</sup>Tax here mentions the total amount of tax and rent, accrued to the Shogunate and the feudal lords.

<sup>3</sup>A rice bill was issued by the feudal lord’s warehouse, and it represented certain amount of rice. It was introduced as a means to reduce the transaction costs of trading large volume of rice.

<sup>4</sup>See Takatsuki (2008).

could lead to a Pareto-efficient allocation of resource. Unfortunately, it is not easy to directly evaluate the Pareto-efficiency of the real economy. But, market transaction, that could deliver efficient resource allocation, needs an important condition — informational efficiency. Using this basic but important idea, Fama (1970) establish the useful and practical measure to evaluate markets.

The informational efficiency is a proxy to measure how much, how fast, and how accurately available information is incorporated into the prices. Fama (1970) has classified this informational efficiency into three categories based on what is meant as “available information”; Namely, the weak, semistrong, and strong forms.

Among these criteria, the weak form efficiency is the most basic but important criterion, because if it does not hold, then neither the semi-strong form nor the strong form efficiency will be satisfied. The weak-form efficiency exists if the prices fully reflect all the information contained in the history of past prices and returns. In such a situation, the traders can not earn excess profits from using only the information of past prices and returns.

The author has already documented that the weak form efficiency was achieved at the Osaka market.<sup>5</sup> What we need to do as the next step is to inquire the co-movement of prices between Osaka and the local market. As in the case of trading system, it is quite natural to think that the prices in Osaka were also referred by the local market.

The literature have already inquired the Osaka market and the local markets co-moved, focussing on the price correlation. They found a high correlation among them, and thought that coefficient of correlation showed that Osaka worked as a center market. However, the coefficient of correlation, on which the literature relied, can tell us only the results of the co-movement among the valuables. To argue that Osaka was the center market, we need to observe not the results but the process of the transmission of the prices. As mentioned later, this paper relies on the bivariate Granger causality test.

Moreover, the price indices they used were not frequent at all — monthly or yearly. In the Tokugawa period, the letters from Edo to Osaka, distance between which was about 500 kilometers, were delivered within about 6 days, and the letters from Osaka to Otsu, distance

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<sup>5</sup>See Takatsuki (2007).

was about 50 kilometers, were delivered within a day. This implies that the prices at Osaka could be transmitted to very distant markets within a week, or to neighboring markets within a day. Under such a dense communication, the monthly or yearly price indices could mean nothing about the informational efficiency.

Therefore, we need to construct more reliable and highly frequent price index from an original historical document. Our new source is “Yorozu souba nikki (Daily memorandum of commodity price indices)”. From this memorandum, we can construct the daily price index both in Osaka and Otsu during the period from 1798 to 1856. Relying on this new index, this paper will evaluate the co-movement of prices between Osaka and Otsu.

The structure of this paper is as follows. Section II introduces the institutional aspects of the Dojima market and the Otsu market, and reviews the daily price index which was newly constructed. This section serves as background for subsequent discussions. Section III lays out the model for capturing the co-movement of prices, and presents results followed by the concluding remarks.

## II. Institutions and the price index

### Trades in the Osaka market

First, the trade activities in Osaka will be introduced.<sup>6</sup> The rices, collected and shipped by the feudal lords, were stored in the warehouses, and sold at the auction where officially chartered rice brokers bid. Rice brokers who made a successful bid received the rice bills which, per unit, was worth 1500kg real rice stored in the warehouses.<sup>7</sup> The rice brokers in principle could have submitted their rice bills to the warehouse and received real rice in exchange. However, in reality they mainly sold the bills in the secondary market; the Dojima rice market. Thus, the spot market in Osaka should be regarded as the exchange market of rice bills, not the rice in kind.

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<sup>6</sup>See Miyamoto (1988) and Schaede (1989) for further institutional descriptions of the Dojima rice market.

<sup>7</sup>In the late 17th century, each rice bill corresponded to a particular set of rice that the broker won at the auction. In late times, this correspondence gradually collapsed and rice bills came to take on the character of securities. See, Shimamoto (1960).

Issuing a rice bill without inventory was officially prohibited by the Shogunate in 1761. However, it did not mean that this restriction was literally complied by the warehouses, and it was known to the governor in Osaka.<sup>8</sup> That is, while the governor implicitly permitted issuing a rice bill without inventory, he did not allow the warehouses to dishonor a rice bill. This meant that claim over rice in kind represented by the rice bill was protected by the local court in Osaka.<sup>9</sup>

In the spot market, the rice bills were required to be delivered in exchange for cash within four days after the transaction. While the traders who could join in the market were limited to officially chartered rice brokers, anybody who paid some amount of fee to the chartered traders could join in the market.

There were about 30 kinds of rice bills issued by feudal lords' warehouses, and the traders' association choose one rice bill among those 30 rice bills as the standard rice. This standard rice was exactly the underlying asset for futures trade. Like the spot market, the traders in this market were formally limited to officially authorized members. However, any traders could actually join the market by paying a little amount of fee to the authorized traders. The fee associated with the futures trades was less than that of the spot trades. In addition, amount of cash needed in the futures market was relatively smaller than that in the spot market. These features of the futures market had attracted many traders, especially speculators.

In principle, the futures market traders had to close their positions by buying back or selling back before the maturity date; That is, "roll over" across the trading periods was strictly prohibited. For example, a trader who made a long position during the trading period must close his position until the maturity date by selling same amount of the contract. The settlement by delivery was permitted in the maturity date, while a constraint designated by Tokugawa Shogunate was imposed. That is, in the Osaka market, the allowed amount of the settlement by delivery was strictly limited to the fixed level; 1000 rice bills for the whole market. Under this constraint, the futures market participants the rice bills thorough the

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<sup>8</sup>The governor here, "Osaka-Machi-Bugyo", was in charge of judiciary, police, and other administrative services.

<sup>9</sup>For farther description, see Takatsuki (2008).

futures market. Usually, net settlements were the dominant method of the settlement.

Both the spot and the futures market have three separate trading seasons: January 4–April 27(28), May 7–October 8 (9), and October 17–December 23 (24)<sup>10</sup>. These seasons were called spring market, summer market, and winter market, respectively. The markets were closed for about 10 days between any of the two trading season. Every time the trading season started, futures market committee were supposed to re-select the standard rice, it was usually the case that the standard rice was selected from Big five lords' warehouses<sup>11</sup>.

Trading began at about 8 a.m. in the futures market, followed by the spot trading which began at about 10 a.m. Both trading began with opening price presented by the board members of the Dojima market. In the futures market, the opening price was determined by the closing price of the previous day. On the other hand, the opening price in the spot market was determined by two factors; the closing price in the previous day and the price movements of futures preceding the spot market.

In both markets, the price was fixed by an open-out-cry system. Traders in the circuit shout the price with gestures which stand for either “ask” or “bid”. The price was fixed only when the ask price and the bid price matched with each other. Every time a trading deal was established, the clerk beat out the wood stick and shouted the price. In the future market, the trading records were not written down until the completion of the trade in a day. After the trade was closed, the traders submitted the record to the clearing house. The clearing house checked each traders' transaction and canceled out his buying and selling. Finally, each traders' remaining position was kept in the record.

The spot market closed around the noon. On the other hand, the futures trade had a one-hour recess at noon and continued the trading until around 2 p.m. The closing price of the futures market was fixed by a special method. First, the clerk put fire on the fuse cord. The traders were allowed to trade until the fire extinguished. The closing price of the day was determined by the price at the moment the fire went out.

These features, introduced above, indicate that the trades at the Osaka market was

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<sup>10</sup>The dates in parentheses are those for spot market.

<sup>11</sup>That is, Kaga, Chikuzen, Chugoku, Higo, Hiroshima. Each was regarded as satisfying the condition, namely credibility and liquidity.

designed not only for the real demand, but also for the speculation. In other words, it was designed for accumulating traders' information. The concentration of rice and the information has made Osaka the center of the market at that time.

## Trades in the Otsu market

Some feudal lords, whose domain allocated along the coast of the Japan Sea, tended to ship their rices to Otsu. As in Osaka, the rices were stored in the warehouses, and sold at the auction. Then, the rice bills were issued and traded at the Otsu markets. The rice bills here were also, per unit, worth 1500kg rice in kind stored in the warehouses,<sup>12</sup> and claim over rice in kind represented by the rice bill was protected by the governor in Otsu.<sup>13</sup> Given that both markets were located in the Shogunate domain, it was rather natural that both systems were similar.

The rice bills traded at the spot market in Otsu were mainly issued by Wakasa warehouse, and Hikone warehouse. The former was called “Kumagawa-mai (The rice cropped in Kumagawa district, henceforth referred to as the Kumagawa rice)”, and the latter was called “Sawa-mai (The rice cropped in Sawayama district, henceforth referred to as the Sawa rice)”. Although a standard rice was not officially chosen, the Kumagawa rice was recognized as a kind of standard rice in Otsu.<sup>14</sup> Both Kumagawa rice and Sawa rice were designated as the underlying assets for the futures trades; That is, there existed mainly two futures markets — the Kumagawa futures market, and the Sawa futures market. While the “Yorozu souba nikki (Daily memorandum of commodity price indices)”, our new source for constructing a daily price index, recorded the prices of both markets, only the Kumagawa futures prices can be tracked continuously. We focus on the Kumagawa market.

While the trading activities in Otsu have not been clearly described, especially compared to Osaka, we can draw outlines.

Trading began at about 10 a.m. in the spot market and the kumagawa futures market. Both trading began with the opening price presented by the board members of the market.

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<sup>12</sup> *Otsu-Shi-Shi gekan* (The history of Otsu city — volume.3), pp.94-95.

<sup>13</sup> *Otsu-Shi-Shi gekan* (The history of Otsu city — volume.3), pp.80-81.

<sup>14</sup> *Otsu-Shi-Shi gekan* (The history of Otsu city — volume.3), pp.94-95.

As mentioned in the section III, the opening price here was determined referring the prices in Osaka on the previous day. The kumagawa futures market closed at about 2 p.m. as a general rule.

While traders both in the spot market and the futures market were formally limited to officially chartered members, they joined the market by a small transaction fee.<sup>15</sup> In the Kumagawa futures market, the traders closed their positions by buying back or selling back in principal. These procedures of the futures market were similar to those in Osaka.

On the other hand, there existed some differences. The settlement by delivery was permitted in the maturity date without any constraints, and the traders in Otsu could “roll over” the trades across the trading periods. While the Osaka markets was closed between each trading periods, the Otsu market had been open throughout the year.

## The new price index

As mentioned above, since non-frequent price indices can mean nothing about the informational efficiency, we need to construct highly frequent price index from an original historical document. Our new source, “Yorozu souba nikki (Daily memorandum of commodity price indices)”, is the memorandum described by the contemporary rice merchant who traded rice and fertilizer. Although he traded mainly in the Otsu market, he regularly recorded both prices in Osaka and Otsu. It mentions that his trades in Otsu were closely linked with the prices in Osaka.

From this memorandum, we can construct daily price index both in Osaka and Otsu, which covers the period from 1798 to 1856.<sup>16</sup> Among the prices, we will focus on i) the futures price in Osaka, and ii) the futures price of Kumagawa rice in Otsu. In Osaka, as mentioned above, the opening price in the spot market was determined by the price movements of futures market, and the spot market was closed about 3 hours before the closing time of the futures market. For this reason, all prices in Osaka can be seen as summarized in the futures price. On the other hand, since the price indices of Sawa rice and the spot prices

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<sup>15</sup> *Otsu-Shi-Shi gekan* (The history of Otsu city — volume.3), p.85.

<sup>16</sup> The prices in the period from 1819 to 1839 can not be observed because the documents' state of preservation is very poor.

of Kumagawa rice can not be tracked continuously, the futures prices of Kumagawa rice are used as representative prices of the Otsu market. Using these two price indices, we will inquire the co-movement of prices between Osaka and Otsu.

### III. The co-movement of rice prices between Osaka and Otsu

#### The communication between Osaka and Otsu

Following historical document was submitted by the rice merchants to the governor in Otsu. It reports the trading systems and practices in Otsu, focussing on the relationship between Osaka and Otsu.

Since the rice prices in Osaka are representative prices of all rice markets, any trader in Otsu can not trade without the information about the rice prices in Osaka. A market report from Osaka, which records the prices in the previous day, arrives at the Otsu market in every morning. In addition, some traders personally gather the information of the Osaka markets before the market report arrives at Otsu, because they are eager to catch the information as soon as possible.<sup>17</sup>

There are at least two points to be noted. First, the traders in Otsu market referred the prices in Osaka as representative ones. This supports the results of Takatsuki (2007); the Osaka market had achieved the informational efficiency at least in terms of weak form. In fact, a market report from Osaka can be found in many other markets. It is not only the Otsu market, but also many other local markets that tried to know the prices in Osaka as soon as they could. The rice price indices in Osaka were indeed referred as the informative prices by the local markets.

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<sup>17</sup>“Ho-reki 11 nen ku-gatsu, bugyo-no otazune-ni kootauru ko-jo-syo (The report submitted to the governor in September 1761)”, cited by *Otsu-shi-shi — tyu-kan* (The history and culture of Otsu city — volume.2), pp.856-859.

Second, the traders in Otsu were eager to know the prices at the Osaka market as soon as they could. This means that they could not earn the excess profits anymore, only from the market report arrived in the morning.

The rice merchants' appetite for the excess profits have led to the development of communication technique. According to the "Yorozu souba nikki", the prices in Osaka were transmitted to Otsu within a day from 1840. By this stage, the communication methods developed from the mailman to the flag signaling. In fact, while the "Yorozu souba nikki" recorded the closing prices of the Osaka rice market before 1818, it came to record not only the closing prices but also the intra-day prices after 1840. This clearly shows that dense trades both in Osaka and Otsu required update of communication technique.

How did these developments influence the co-movement of prices between Osaka and Otsu? This is the question to be answered in the following section.

## The test statistics

To inquire the points, this paper relies on the bivariate Granger causality test. Here we estimate the two-variable vector auto regressive (VAR) model to assess the co-movement of prices between Osaka and Otsu. The model includes the futures prices in Osaka and the futures prices of the Kumagawa rice in Otsu. The VAR model is given as follows;

$$\mathbf{y}_t = \psi_1 \mathbf{y}_{t-1} + \psi_2 \mathbf{y}_{t-2} + \cdots + \psi_p \mathbf{y}_{t-p} + \mathbf{u}_t,$$

where  $\mathbf{y}$  is the two-dimensional vector, consisted of the logarithmic returns of the futures market both in Osaka and Otsu,  $\mathbf{u}$  is the white noise vector, and  $t$  is timing.

Running the least square analysis, we can observe the cross-interaction between Osaka and Otsu. The optimal number of lags is determined by the S.B.I.C (Schwarz's Bayesian Information Criterion).

## The results

The results of the tests are shown in Table 1. In the period from 1798 to 1818, the futures prices in Otsu obviously followed the prices in Osaka. In addition, according to the S.B.I.C,

the futures prices in Osaka tended to precede those in Otsu by one trading day. This result implies that the Otsu market reflected the prices in Osaka within two days. Here we need to remember that, in this period, the information about the Osaka market was transmitted to Otsu by mailman. Hence, the delay of one trading day does not necessarily mean that the Otsu market took two trading days to reflect the prices in Osaka. Given the communication technique on those days, the Otsu market had reacted to the Osaka market, right after market participants received a market report.

On the other hand, in the period from 1840 to 1856, there did not exist clear lead-lag relationship between the two. There are two possible ways to understand. First, both prices moved independently. Second, both prices moved simultaneously. In both cases, the lead-lag relationship can never be detected by the VAR model.

To inquire which case had happened, the coefficient of correlation was calculated. Table 2 shows that both prices are highly correlated with each other, and the coefficient in the latter period is bigger than that in the earlier period. This implies that both prices moved simultaneously; That is, the Otsu market reflected the prices in Osaka within a day. It was the development of the communication technique that brought about this result. After this stage, the Otsu market did not need even one trading day to reflect the prices in Osaka.

## Concluding Remarks

The co-movement of prices in Tokugawa period had reached a level not previously experienced. The Otsu market did not need even one trading day to reflect the prices in Osaka in the early 19th century, and the traders at that time could not earn the excess profits without the latest information about the Osaka market.

Osaka indeed worked as a center market, and neighboring markets followed Osaka sufficiently fast. Distribution network had led to a sophisticated trading system in Osaka, and integration of the rice market had led to a dense communication network between the center market and the local markets.

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Table.1 The results of the Granger causality tests

Year	Direction	Optimal No. of lags	Degree of freedom	p-value at the optimal lags	Causality
1798	Otsu→Osaka Osaka→Otsu	1	117	0.663 0.000	Osaka → Otsu
1799	Otsu→Osaka Osaka→Otsu	1	132	0.130 0.000	Osaka → Otsu
1800	Otsu→Osaka Osaka→Otsu	1	144	0.239 0.000	Osaka → Otsu
1801	Otsu→Osaka Osaka→Otsu	1	174	0.740 0.000	Osaka → Otsu
1802	Otsu→Osaka Osaka→Otsu	1	169	0.863 0.000	Osaka → Otsu
1803	Otsu→Osaka Osaka→Otsu	1	167	0.822 0.000	Osaka → Otsu
1804	Otsu→Osaka Osaka→Otsu	1	161	0.279 0.000	Osaka → Otsu
1805	Otsu→Osaka Osaka→Otsu	1	184	0.945 0.129	None
1806	Otsu→Osaka Osaka→Otsu	1	143	0.145 0.000	Osaka → Otsu
1807	Otsu→Osaka Osaka→Otsu	1	189	0.048 0.752	None
1808	Otsu→Osaka Osaka→Otsu	1	138	0.069 0.000	Osaka → Otsu
1809	Otsu→Osaka Osaka→Otsu	1	163	0.717 0.000	Osaka → Otsu
1810	Otsu→Osaka Osaka→Otsu	1	131	0.288 0.000	Osaka → Otsu
1811	Otsu→Osaka Osaka→Otsu	1	166	0.809 0.000	Osaka → Otsu
1812	Otsu→Osaka Osaka→Otsu	1	150	0.053 0.006	Osaka → Otsu
1813	Otsu→Osaka Osaka→Otsu	1	235	0.045 0.399	None
1814	Otsu→Osaka Osaka→Otsu	1	201	0.415 0.032	None
1815	Otsu→Osaka Osaka→Otsu	1	81	0.682 0.000	Osaka → Otsu

Table.1 continued

Year	Direction	Optimal No. of lags	Degree of freedom	p-value at the optimal lags	Causality
1816	Otsu→Osaka Osaka→Otsu	1	187	0.355 0.000	Osaka → Otsu
1817	Otsu→Osaka Osaka→Otsu	2	193	0.149 0.000	Osaka → Otsu
1818	Otsu→Osaka Osaka→Otsu	1	180	0.745 0.003	Osaka → Otsu
1840	Otsu→Osaka Osaka→Otsu	1	141	0.147 0.790	None
1841	Otsu→Osaka Osaka→Otsu	1	202	0.813 0.141	None
1842	Otsu→Osaka Osaka→Otsu	1	172	0.323 0.462	None
1843	Otsu→Osaka Osaka→Otsu	1	233	0.041 0.483	None
1846	Otsu→Osaka Osaka→Otsu	1	209	0.350 0.000	Osaka → Otsu
1851	Otsu→Osaka Osaka→Otsu	1	203	0.351 0.594	None
1854	Otsu→Osaka Osaka→Otsu	1	207	0.695 0.913	None
1855	Otsu→Osaka Osaka→Otsu	1	207	0.067 0.156	None
1856	Otsu→Osaka Osaka→Otsu	1	203	0.709 0.756	None

Note)

- The optimal number of lags is determined by the S.B.I.C.
- The significance level is 1%.

Table.2 Correlation between Osaka and Otsu

<u>Year</u>	<u>The coefficient</u>	<u>Year</u>	<u>The coefficient</u>	<u>Period</u>	<u>Average</u>
1798	0.401	1813	0.707	all	0.588
1799	0.574	1814	0.846	1798-1818	0.554
1800	0.793	1815	0.562	<u>1834-1856</u>	<u>0.667</u>
1801	0.635	1816	0.889		
1802	0.453	1817	0.929		
1803	0.559	1818	0.390		
1804	0.878	1840	0.898		
1805	-0.203	1841	0.679		
1806	0.698	1842	0.726		
1807	0.709	1843	0.656		
1808	0.511	1846	0.519		
1809	0.821	1851	0.844		
1810	0.243	1854	0.663		
1811	-0.250	1855	0.827		
1812	0.414	1856	0.172		