# Online Appendix
# Market Integration in Japanese Rice Markets, 1880–1932

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**Abstract:** This note provides a historical review and interim results of the time-varying VEC model, which both appear in Ito et al. (2016).

**Keywords:** Market Integration; Rice Futures Market; GLS-based Time-Varying Model Approach; Telecommunication.

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# A.1 Historical Review of Rice Markets and Telecommunications in Japan

In Japan, rice was circulated as pseudo-money from the 16th century, before the Tokugawa Shogunate was established in 1603. During the period when the Shogunate ruled throughout Japan until 1867, the authority and clan governments (feudal lords) ordered most people to pay their taxes in rice. However, in the early 17th century, the authority began mintage of coins. In the 1660s, currency was circulated all over Japan; that is, Japan's monetary economy was advancing. At the same time, because the authorities were urged to pay merchants for necessities in their castles using specie money, the authority and clan governments needed to turn their collected rice into money. Accordingly, they sold their rice to brokers in Osaka, which was the major trading center in Japan. However, because the rice crop strongly depended on the climate condition each year, the rice price fluctuated wildly according to its seasonal harvest. Both authorities and brokers faced volatile price risks whenever they traded rice.

In the early 18th century, brokers began to trade in futures in Osaka to hedge price risks (see Schaede (1989)). Then, the Shogunate certified the *Dojima Kome Kaisho* (the Osaka-Dojima Rice Exchange) in 1730. Designated rice-price messengers transferred the price at the Osaka-Dojima rice exchange to various local cities in Japan. In addition, rice traders desiring the latest price information used pigeon post and flag signaling. Although these means of communication were prohibited by the Shogunate, they provided the fastest manner of communication at that time (see Takatsuki (2012, pp.335–340)). As a result, the Osaka-Dojima Rice Exchange provided a standard price for at least western Japan (see Miyamoto (1988, pp.402–403)).

In 1868, the Meiji government declared a new regime. Thereafter, the rice futures market changed. In the 1870s, new rice exchanges were established in Tokyo. In 1871, Hachirouemon Mitsui, the representative Japanese merchant in Tokyo, established a company named *Bouekishousha* to deal in rice futures. In 1874, another company, *Chugai Shougyo Kaisha*, established by wealthy merchants in Kagoshima, began to deal in rice futures. In 1883, these two rice exchanges were unified and renamed *Tokyo Kome-Shoukaisho* (Tokyo Rice Exchange) (see Tokyo Grain Exchange (2003, pp.27–36)). Therefore, after the 1870s, rice brokers could trade rice futures in Tokyo and Osaka, the two major cities in Japan, and thus, the rice-trading environment changed.

After the 1870s, rice traders could use the telegraph network to obtain the latest information regarding rice trading. The government began to build and operate this network using a British company's technique in the early 1870s. In fact, the government laid the first telegraphic line between Tokyo and Nagasaki via Osaka in 1873; users could send and receive telegrams between Tokyo and Osaka. In the next decade, rice traders were able to obtain the latest price information more rapidly.

In 1889, the Ministry of Communications began to operate a limited telephone service between Tokyo and Atami on a trial basis. In the following year, the government launched a local and long-distance telephone service in Tokyo and Yokohama on a commercial basis. Moreover, in 1893, the Ministry of Communications opened another local telephone service in Osaka, and a new long-distance telephone service between Tokyo and Osaka became

available in 1899 (see Ministry of Communications (1940, pp.453–454)). The series of improvements of the telephone network enabled high-speed communication between Tokyo and Osaka.

In particular, rice traders used the telegraph and telephone frequently. Previous literature on the history of information and communications in Japan mentions that stock dealers in Tokyo and Osaka exchanged information about stock prices with each other using the telegraph and telephone from the Meiji period (see Ishii (1994, p.192)). Rice traders also began to use communication facilities and exchange price information between Tokyo and Osaka in the Meiji period, since they often arbitraged between Tokyo and Osaka (see Shimizu (1913, pp.290–291)). In fact, *Chugai Shogyo Shimpo* (Chugai Commercial Newspaper) reported that a major rice trader in Kyoto made deals in both Tokyo and Osaka in October 1893.[1] In this situation, rice traders obtained the latest trade information for rice, and the rice prices in certain markets responded sensitively to price fluctuations in the other markets.

In particular, rice traders in Tokyo and Osaka mainly used the telegram for long distance communications, owing to two factors. First, the telegram fee between Tokyo and Osaka was lower than the corresponding telephone fee, as described in Section 4. Second, using the long-distance telephone service did not always accelerate communication speed. Users of the long-distance telephone service had to wait a long time for telephone switching because the capacity of the telephone lines was insufficient. In fact, the average waiting time for a telephone call from Tokyo to Osaka was 203 minutes in 1937 (see Nippon Telegraph and Telephone Public Corporation (1960, p.482)). Consequently, rice traders used telegrams frequently, and attempted to reduce the number of characters, since the fee was based on number of characters. Accordingly, rice traders sent telegrams in code, which also helped protect the secrecy of communications. Figure A.1 shows a telegram code that Masuzo Hirai, a representative rice trader in Tokyo, used in 1899.

(Figure A.1 around here)

To transmit rice-trading information, many rice traders used their own telegram codes, similar to that in Figure A.1, which reduced their telegram fee. In addition, on September 25, 1893, according to *Yomiuri Shimbun* (Yomiuri Newspaper), the rice price in Tokyo increased as soon as rice traders there obtained information about large transactions by major rice traders in Osaka.[2] Furthermore, the telegram transmitted not only trade information but also disaster information. For example, in October 1893, when a typhoon passed through western Japan, the telegraph transmitted information on the flood damage in western Japan to Tokyo and Osaka, and the rice price increased in both cities.[3]

At the same time, rice traders could use another instrument to obtain information. In the 1870s, many publishers of newspapers and business magazines were established; they introduced steam-driven printing machines enabling printing of large quantities (see Minami (1976, pp.31–32)). The publishers sold their newspapers and magazines with various price information acquired using the telegram for lead articles. The publishers' wide reach extensively diffused price information among market participants.

[1] See Chugai Shogyo Shimpo (1893b) for more details.

[2] See Yomiuri Shimbun (1893) for details.

[3] See Chugai Shogyo Shimpo (1893a) for details.

During the same period, transportation infrastructure was developed. The Japanese government began to build a railroad network in 1870 (see Muramatsu and Amazawa (1965, p.42)). However, the network did not connect cities and farming villages, since it was built between major cities until the end of the 19th century. Consequently, until the 1890s, rice was transported mainly by sailing ships, which had the advantage of lower transportations costs. However, in 1902, the tonnage of a steam ship exceeded that of a sailing ship in Japan (see Miwa (1975, p.346)).

The widespread use of steam ships improved transportation conditions. First, transportation costs were reduced by the intensifying competition among steam ships. In fact, the cost for coal transportation from the port of Wakamatsu to the port of Yokohama, the major index of ship-freight cost in prewar Japan, decreased by 32% in just a few years from 1899 to 1903 (see Toyo Keizai Shimpo Sha (1927, p.624)).[4] Second, numerous steamer coastal lines were introduced, reducing transportation costs. For example, rice traders in Kagoshima, which is almost 1,000 kilometers (600 miles) from Tokyo, paid 80 yen for the transportation of 100 koku of rice to Tokyo in 1897. [5] This cost included the transshipment charge at the port of Kobe, since a direct ship route between Kagoshima and Tokyo had not yet been introduced. However, after its introduction, rice traders in Kagoshima paid only 40 yen for the rice freight cost to Tokyo in 1902 (see Sasaki (1937, pp.456–457)). In the same year, the annual average rice price per 100 koku in Tokyo was 1,267 yen (see Nakazawa (1933, p.390)). Overall, the transportation cost between both cities was only 3% of the rice price. Even rice traders who were located in remote places, away from the major markets of Tokyo and Osaka, could use this low-cost transportation in the 1900s.

In the next decade, World War I began, and the ship freight cost dramatically increased, causing the cost gap between ship freight and rail transportation to shrink. For example, the cost to transport 100 koku of rice from Oita to Osaka, which are almost 400 kilometers (250 miles) apart, changed from 90 yen by rail and 50 yen by ship in 1914 to 76 yen by rail and 70 yen by ship in 1919; however, these costs remained below 2% of the rice price (see Transportation Bureau, Ministry of Railways (1925, p.550); Nakazawa (1933, p.458)). From 1890 to 1910, the total length of the railroad network in Japan increased from 2,816 kilometers (1,750 miles) to 9,021 kilometers (5,606 miles), and it connected cities and farming villages (see Toyo Keizai Shimpo Sha (1927, p.619)). Furthermore, the Japanese government nationalized private mainlines in 1906 and integrated the system of rail transportation. Consequently, rice traders mainly used railroad to transport rice after the war. In fact, 98% of the rice that arrived in Tokyo in 1921 was transported by rail (see Sasaki (1937, p.273)).

From the late 19th to early 20th century, when communication infrastructure was developed, transportation infrastructure was also rapidly developing, which significantly reduced the transportation cost. However, the rice transportation cost remained a small percentage of the rice price from the turn of the 20th century. The government-operated telegraph and railroad networks not only increased the amount of information, communication, and transportation, but also accelerated their speed. Whereas private firms mainly

[4]The port of Wakamatsu was the major coal port, since Wakamatsu City was near Chikuho coalfield, one of the largest coalfields in Japan.

[5]*Koku* is a unit of rice trading volume in Japan. One *koku* equals 180.39 liters.

built telegraph and railroad networks in Europe, the government in Japan imported Western techniques in order to introduce both networks rapidly itself. Consequently, the Japanese government operated transportation and telecommunication infrastructure on its own initiative and tremendously increased the speed of transportation and information communication between Tokyo and Osaka.

Figure A.1: Telegram Code: A Case of Masuzo Hirai

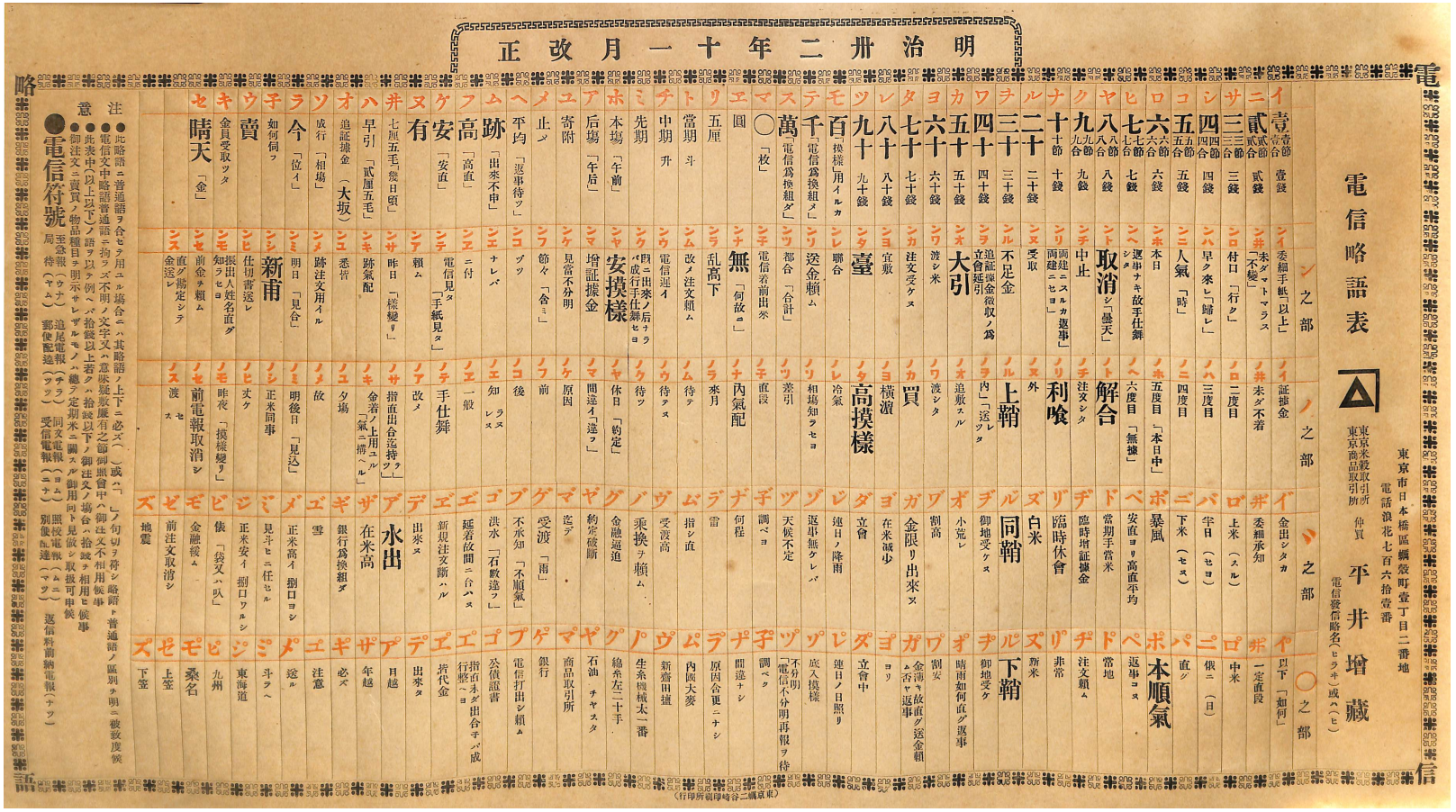
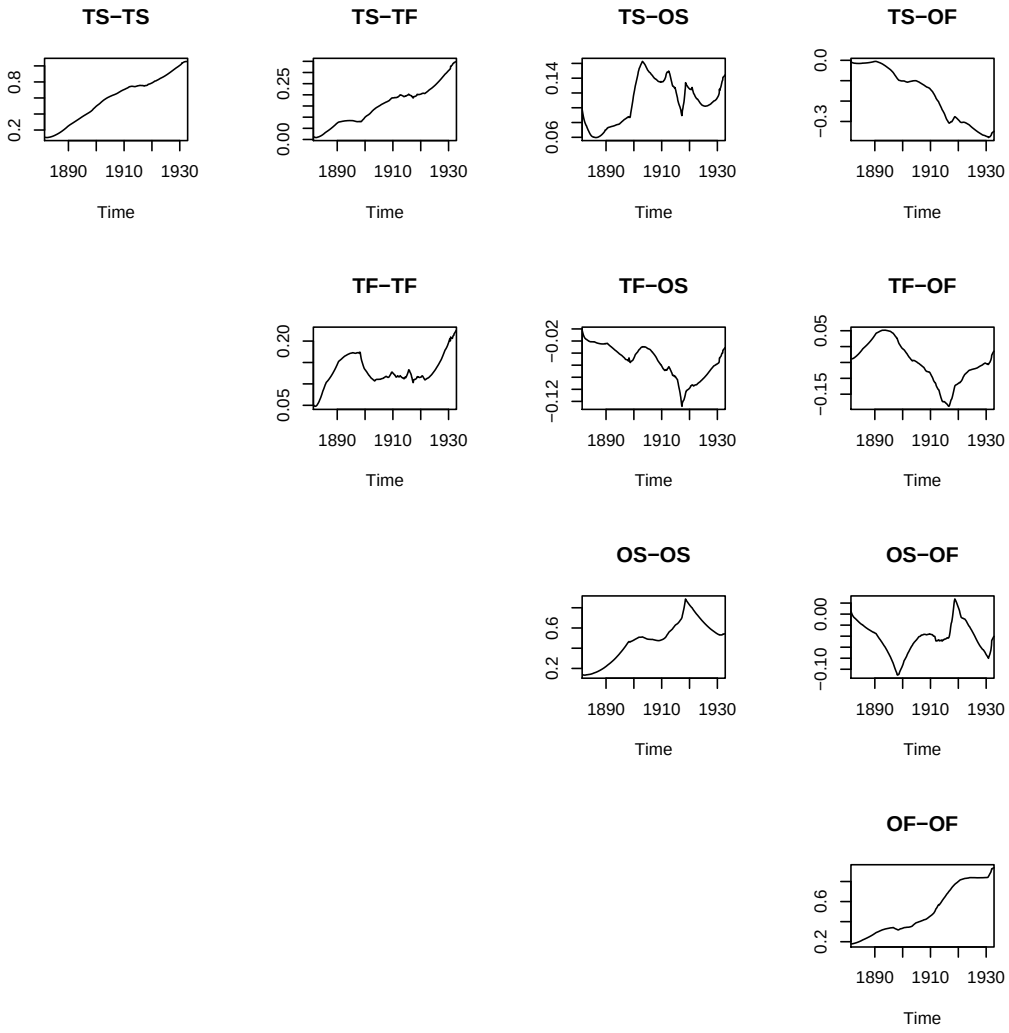


Figure A.2: The Time-Varying Behavior of $\boldsymbol{\alpha}_t \boldsymbol{\alpha}_t'$ in Equation (6)




Notes:

(1) "TS," and "TF" denote the prices of spot market and futures market in Tokyo Rice Exchange, respectively.

(2) "OS," and "OF" denote the prices of spot market and futures market in Osaka Rice Exchange, respectively.

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