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Abstract

We construct new quarterly estimates of lending rates for 47 Japanese prefectures for the period 1886-1922, and test the extent to which regional capital markets integrated during this period. We analyze whether the capital market was efficient, estimate the speed of convergence among the rates, and assess the degree to which different regions were integrated with the main financial centers of Japan. Interest-rate differentials between the financial centers of Japan and other regions do not follow a random walk, and hence are suggestive of market efficiency – in the sense that arbitrage opportunities did not persist. Results from cointegration tests suggest that the integration in Japan is characterized by multiple stochastic elements. We find the existence of four long-run cointegrating relationships. We also find evidence that shocks occurring in a financial center, such as the Kanto region, were transmitted to outlying regions and had permanent, but small effects on their rates.

Keywords: Financial Market Development; Capital Market Integration; Economic Integration; Japanese Banks

JEL classification: F21, G21, N25, O16

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I. Introduction

There is considerable debate among economic historians as to how quickly financial markets in the United States integrated.[1] Apart from the large literature on the U.S. experience, comparatively little is known about the process of capital market integration in other countries.[2] On the one hand, the dearth in the literature is somewhat surprising given the interest of current policymakers in understanding the speed at which regional capital markets are integrating in Europe, whether interest rate shocks are synchronous, and the implications this has for the conduct of monetary policy within the EMU.[3] On the other, the scarcity of detailed historical data on regional interest rates or capital flows for regions within countries has proved a significant barrier to entry for conducting comparable long-run studies to those performed on the U.S.

This paper begins to fill this lacuna by examining the process of capital market integration in Japan. We assemble a new database of interest rates that prevailed in prefectures to test whether capital market integration took place within Japan during the late-nineteenth and early-twentieth centuries. A series of legal and institutional reforms that followed the Meiji Restoration of 1868 signaled a shift towards policies aimed at modernizing the Japanese economy. The reforms of the 1870s changed land ownership laws, permitted greater factor mobility, and shed many of the economic barriers of the feudal era that impeded the creation of national markets. In light of these changes, scholars have noted that this period marks the birth of a national Japanese economy.

[1] See Davis (1965), Sylla (1969), James (1976a, 1976b), Smiley (1975), Bodenhorn and Rockoff (1992), Bodenhorn (1992), Williamson (1974), Shuska and Barrett (1984), Rockoff (1977).
[2] For an analysis of capital market integration in Austria see Good (1977).
[3] For example, see Guiso, Jappelli, Padula, and Pagano (2004), Buch (2000), and Eichengreen & Bayoumi (1997).

However, detailed studies on the process of factor market integration (including financial market integration) within Japan are still in their infancy.[4]

Lack of data on regional financial markets has limited the number of studies that have analyzed Japanese capital-market integration. Those scholars that have examined the process have usually done so in a much broader context. As a consequence, the scope of the analysis has been quite limited – based on small sample periods, low frequency data, and a small number of cities or prefecture; moreover, most studies have primarily used simple descriptive statistics to summarize changes in rates over time.[5] A fresh empirical analysis employing a battery of statistical tests to examine the historical process of Japanese financial market integration will therefore further scholarly understanding of two important issues: (1) the extent to which the Japanese capital market can be described as integrated during the Meiji and Taisho periods and (2) the economic development of the modern Japanese economy. The evidence offered in this paper complements existing studies by historians (who have argued that the Meiji period stands out as the era when a national economy was forged) by testing whether there is evidence of a national capital market during this period and whether such a market was efficient. Moreover, because Japan experienced sustained economic development prior to World War II (Nakamura, 1981), our analysis of its financial markets in the late nineteenth and early twentieth

[4] For example, Ishii (1986) offers the 1880s and 1900s as candidates for when domestic markets for some commodities became integrated; his data are too limited to permit him to offer a more specific analysis. Nishikawa and Abe (1990) examine commodity markets in the 1890s and find some evidence of increased integration. Teranishi (2005) suggests that commodity market integration may have taken place prior to 1900 (at least as reflected in rice and silk prices), but inter-regional trade was limited until 1920s when railroads linked the whole nation. For studies of rice markets for earlier periods, see Iwahashi (1981) and Miyamoto (1988).

[5] See Yamamura (1970), Lewis and Yamamura (1971), Tsurumi (1981), Okada (1966), Sugiyama (1965), and Teranishi (2003).

centuries will provide a useful point of comparison for the U.S. experience and for countries at similar levels of economic development at that time.

In this paper, data from the Ministry of Finance are used to construct quarterly estimates of lending rates for 47 Japanese prefectures for the period 1886-1922. We employ a variety of time-series tests to examine the issue of capital market integration. We first present simple measures of integration based on the reduction in interest-rate differentials across the nine regions of Japan and the covariance in their movements. We next assess whether the capital market for loanable funds was efficient by examining whether interest-rate differentials between the major financial centers of Japan and outlying areas exhibit random walks. We find evidence that the capital market was efficient in the sense that arbitrage opportunities did not persist.

Then, using Engle-Granger and Johansen cointegration tests and Vector Error Correction Models (VECM), we search for evidence of common stochastic elements affecting interest rates in Japan. This is a natural approach to examining integration if we believe that the trends in interest rates may vary in magnitude across regions or that the process is not characterized by a single, overarching process of convergence in rates. We find evidence of four long-run cointegrating relationships during our sample period. Using impulse response functions, we show that a shock emanating from a financial center, such as Kanto, had a small, permanent effects on other regions' rates.

The paper is organized as follows. The next section reviews the economic and historical literature on capital market integration. Section III describes our data and presents some basic tests of capital market integration over our sample period. Section IV examines whether the market for loanable funds was efficient. Section V explores the adjustment of interest rates to shocks emanating from the financial centers of Tokyo and whether regional interest rate series exhibit long-run relationships or cointegration. Section V offers conclusions and avenues for future research.

II. Literature Review

The efficient mobilization of savings can direct resources to areas and investment projects that yield high rates of return. According to standard theories of economic growth, greater investment in physical capital and the development of new technologies increases labor productivity and spurs economic growth. The development of financial institutions may reduce frictions and improve the allocation of savings. Financial institutions that effectively mobilize financial capital and efficiently transfer it from savers to borrowers in turn may facilitate capital deepening, and therefore may be important for the transition to modern economic growth (Goldsmith, 1962; Gerschenkron, 1962; Davis, 1965). Recent empirical research has argued that the development of banking systems and financial markets are important factors in explaining the growth experience of a variety of now-developed countries.[6]

The extent to which countries are able to draw on existing savings in order to finance new projects and increase productivity may depend on how well funds are mobilized *across* regions. That is, since regionally integrated capital markets permit the flow of savings to be channeled towards the most productive uses in an economy, capital market integration can influence the economy's rate of economic growth. Persistent

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[6] See Levine (2005) for a review of the large literature on financial development and growth. For evidence on Japan, see Rousseau (1999).

differences in rates of return can signal that capital should move to where its marginal product is highest, in turn spurring economic growth. Financial market integration can improve the efficiency of the financial sector in several ways. First, integration increases the supply of finance by linking more efficient intermediaries to firms located in less-developed areas. Second, it enables firms located in these less-developed areas to obtain access to more distant financial markets (Guiso et. al., 2004). Hence, examining the process of capital market integration within countries provides additional insight into the nexus between finance and growth.

Capital market integration also has important implications for market efficiency and for the conduct of monetary policy. Since the cost of moving money is small and financial market participants are well versed in arbitrage, it might be expected that money markets are efficient; if that were the case, then long-run differences in interest rates (or their movements) may reflect market failure. Moreover, if changes in interest rates do not occur, nationally, or if they are not transmitted quickly from one region to another (or from the core to periphery areas), it may be prove extremely challenging for monetary authorities to choose an optimal interest rate within a monetary union. The extent of capital market integration thus has important implications for the conduct of macroeconomic policy within economic jurisdictions.

Analyses on the long-run process of capital market integration have largely focused on the United States.[7] In an influential early paper on this topic, Davis (1965) used the slow decline in regional interest-rate differential to suggest that a national capital market was slow to emerge in the nineteenth century. His research stimulated a rich vein

[7] Besides the studies on Japan described below, we are aware of only one other non-U.S. study examining long-run capital market integration within a country – Good's (1977) study of late nineteenth-century Austria.

of subsequent work since it challenged the conventional wisdom that financial markets quickly and completely eliminate price differentials among assets bearing the same risk. Subsequent studies have thus provided alternative data series for documenting the pace and degree of convergence in the U.S. and have offered a variety of explanations for the slow convergence of regional rates, including the development of the commercial paper and stock markets, differential risk, information and transportation costs, capital requirements and bank competition, and the probability of bank failure.[8]

The process of financial market integration in Japan has also received attention by scholars, although detailed studies published on this topic outside of Japan are almost non-existent. In comparison to studies on the U.S., those on Japan are comparatively underdeveloped in terms of the statistical assessment of when integration occurred, whether the capital market was efficient, and what caused capital market integration. Sugiyama (1965) and Okada (1966) pioneered research on Japanese financial market integration. The latter study primarily focuses on comparisons between Tokyo and Osaka's loan and deposit rates. Okada suggests that integration may have occurred during the first decade of the 1900s. In contrast, Tsurumi (1981, 1991) argues that Tokyo and Osaka had integrated by the early 1890s, and that other prefectures may have experienced a decline in interest rates during the period 1907-1912 (although he is less clear about when a national capital market emerged). Yamamura (1970) analyzed data on deposit rates and loan rates from 1889-1925 and concluded that the capital market had integrated by 1900.

[8] For the development of the commercial paper market see Davis (1965) and Smiley (1975); for the stock market's role see Sushka and Barrett (1984); for legal restrictions and banking market structure see Sylla (1967, 1969) and James (1976a, 1976b); for bank failures see Rockoff (1977); and for differential risk and transportation and information costs, see Stigler (1967). For a more extensive review of the literature on the U.S., see Bodenhorn and Rockoff (1992).

In one of the few English-language and econometrically-oriented studies on Japanese market integration, Lewis and Yamamura (1971) employ a reduced-form, structural model of commercial loan behavior to estimate separate supply and demand equations for short-term deposit and lending rates (and implicitly the supply and demand for loanable funds). Their estimated equation shows some evidence of greater interdependence between Tokyo and other prefectures after 1907. However, since their model imposes several strong assumptions, it is difficult to know how reliable the empirical estimates are.[9] Moreover, they do not account for correlation in the disturbances across the equations and solve their system of equations simultaneously; thus an identification problem in the estimation remains unresolved. Like most of the previous studies that examine Japanese capital markets, Lewis and Yamamura only compute a coefficient of variation across prefectures to examine the *dynamic* aspects of capital market integration. Based on this statistic, they argue that interest rates across prefectures fell more rapidly between 1899-1907 than thereafter, and suggest that the process of integration was not complete prior to World War I. In a similar vein, Teranishi (2003, 2005) examines the coefficient of variation for deposit rates across prefectures and suggests that the capital market integrated by 1900, but then diverged again until 1930.

As suggested by the existing literature, there is some disagreement as to when Japan's capital market integrated. The differences arise, in part, because previous research has not used consistent prefectures or cities and sample periods, and because

[9] These include assuming that the number of banks in a prefecture does not shift over time, that informational lags respond symmetrically across prefectures, and designating Tokyo as the "target" market for comparison even though they acknowledge that regional capital market centers may have existed (as in the case of Osaka). Moreover, for basis of comparison, the prefectural data are arbitrarily divided into four groups based on end-of-period shares of manufacturing population; this might be problematic if manufacturing shares are endogenous to financial development and capital market integration. Since we are interested in modeling the broader phenomenon of capital market integration rather than how banks set loan rates, it is not necessary for us to impose these restrictive assumptions on the data.

most studies relied on simple statistical tests which may have low explanatory power if low-frequency data are employed. This article attempts to shed further light on when capital market integration occurred in Japan by employing newly-assembled, quarterly interest rate data over a long sample period: 1886-1922. Our aim is to examine the time-series properties of these data to better understand the dynamics of capital market integration in Japan. Since there is no universally agreed upon statistical test for what constitutes capital market integration, we present a battery of tests that allows us to consider several different definitions of integration as well as test for the extent to which the capital market was efficient.

Our analysis focuses on Japan in the late-nineteenth and early-twentieth centuries for several reasons. First, the Meiji Restoration marks an important break from Japan's feudal legacy. It began an era of pronounced institutional change and economic modernization, which included the lifting of restrictions on communication and transportation as well as the removal of other barriers impeding the movement of goods, people, and capital.[10] With the removal of these restrictions, capital could be more easily allocated to where its marginal product was highest, and institutions evolved to facilitate its movement. Moreover, capital imports during the start of the period were low and bond markets for raising funds did not exist. So, it is likely that better allocating domestic savings was an important channel for facilitating the transition to Japan's era of modern growth. For example, commercial banking and stock exchanges grew in importance, and the government created a central bank and a postal savings system (which spurred competition with commercial banks, especially with savings banks, for deposits). Second,

[10] Although some social and economic restrictions remained, some of which may have impeded further market development, Nakamura (1981) suggests that a Western model of capitalism was introduced in early 1870s.

the development of transport and communication technologies around this time facilitated information transfer and may have encouraged cross-prefecture lending. Third, in contrast to the U.S. banking system of the late-nineteenth century, the Meiji-Taisho period is relatively unfettered in terms of entry regulations that might have affected bank lending rates. Indeed, Okazaki and Sawada (2006) conclude that entry regulations were fairly lax through the beginning of the twentieth century, and the period was one of relatively free banking.[11] Moreover, although a general usury law was introduced in 1877 for loans made by national banks, commercial banks, savings banks, and small money lenders, according to economic historians, the law was not enforced and had little practical effect on limiting the rate of interest money lending organizations charged.[12] Finally, since existing studies on capital market integration of Japan have largely focused on this period, we seek to understand whether our new empirical estimates confirm or contradict earlier studies.

III. Analyzing Regional Interest Rates

A. Interest Rate Data on Japanese Prefectures

There are a number of ways to measure the extent to which capital markets are integrated. These include assessing data on quantities (such as private capital flows), examining differences between savings and investment, and measuring consumption co-

[11] In related work, we discuss this issue in detail and suggest that entry restrictions had little influence on lending rates during this period (Mitchener and Ohnuki[2007]).

[12] Teranishi (2003) argues that lending rates of banks were set without restriction up until the 1920s. Asai (2000), who describes banks as operating in a laissez-faire environment, suggests that the turning point of the change of the environment was the mid-1920s, when new banking laws were promulgated.

movements. Each has its own empirical and theoretical advantages and shortcomings. Although not without its own limitations, this paper uses price-based measures to assess capital market integration by applying arbitrage conditions to interest-rate data for the prefectures of Japan. This widely-used method for assessing financial market integration rests on the basic assumption that the law of one price holds in capital markets. Arbitrage ensures that, in a perfectly integrated capital market with no market frictions, identical assets with the same risk and return trade for the same price.

We collected interest rate data for 47 prefectures of Japan beginning in the 1880s and continuing through the 1920s. These data come from the *Ginkokyoku Nenpo,* published by the Banking Bureau of the Ministry of Finance (MOF). Ministry of Finance Banking Bureau data on lending rates in prefectures are available on a monthly basis for commercial banks, and are based on government surveys. The commercial banks during our sample period consist of *kokuritsu ginko* ("national banks"),[13] *shiritsu ginko* ("private banks"), and *chochiku ginko* ("savings banks"). All three types of banks made loans to similar types of customers, with the only significant difference being that *kokuritsu ginko* had note issuing privileges although this privilege was banned in 1883.[14] [15] Beginning in the 1890's, *kokuritsu ginko* and *shiritsu ginko* converted to *futsu ginko* ("ordinary banks"). We constructed quarterly lending rates for commercial banks in each prefecture by averaging the high and low values of lending rates for each month, and then averaging data over three-month intervals to obtain a quarterly data series. The quarterly data allow

[13] The literal translation of *kokuritsu ginko* is government-established banks; in short, these were similar to U.S. national banks in that they were licensed by the government, but were private, commercial banks that were not government owned.

[14] Issuing of the banknote was banned in 1883 and the all national banknotes were invalid in 1899.

[15] Kozo Yamamura (1967) estimated that roughly one-third to one-half of the paid-in capital of the *kokuritsu ginko* in the 1880s came from the samurai commutation bonds.

us to examine capital market integration at a higher-frequency than previous studies, but are less noisy than using monthly data. The reporting of data by MOF begins in 1884, although our analysis begins in 1886 since earlier lending rates may not be entirely comparable with later data.[16] It ends in 1922, when monthly data are no longer available in *Ginkokyoku Nenpo*.[17] .

B. Preliminary Statistical Tests for Capital Market Integration

As Davis (1965) emphasized, in the early stages of development, rates of return may differ across regions if the movement of capital is impeded. Davis interpreted the law of one price to suggest that, unless impediments to integration remain, regional interest rates ought to be converging over time. Convergence in the price of money will drive the total volume of financial intermediation and link markets more closely together. As a starting point for understanding the trends in the data, Figure 1 plots quarterly averages of lending rates for the nine standard regions of Edo and Meiji Japan. Rates were initially highest in the regions farthest from the main metropolitan centers of Tokyo and Osaka[18]. The regions of Hokkaido/Tohoku, Kyushu, and Chugoku had rates that averaged more than 11% in the 1880s whereas Tokai's rates averaged 10%. (For individual quarters, some of the differences in rates between regions were nearly four percentage points). Figure 1 also suggests that there was an overall narrowing of interest-

[16] For some prefectures, more than one lending rate is reported in 1884 and 1885. It was not clear which figure was reported was consistent with the 1886 data, so these were omitted. Moreover, there were missing data for more than a dozen prefectures for this period.
[17] After 1922, data are reported on a biannually in June and December.
[18] Consistent with the secondary literature, we regard Kanto and Kinki as the financial centers of Japan during our sample period. These regions had the largest number of commercial banks and postal centers as well as the major stock exchanges in Japan.

rate differentials towards the end of the nineteenth century, but the two outermost regions of Kyushu and Hokkaido/Tohoku generally have rates entrenched above 12% in the decade of the 1890s. Rates further narrow towards the end of the first decade and into the second decade of the 1900s. Table 1 shows that the levels of the quarterly rates are highly correlated.

Examining the variation in the data across all 47 prefectures reveals similar patterns in the data. As Figure 2 shows, the coefficient of variation fell by roughly half, from 0.175 to 0.087, between 1886 and 1897. The ratio of the highest interest rate to the lowest rate (at the prefectural level) declined from 2.7 to 1.5 over this period. (In percentage points, the difference between the highest and lowest prefectures fell from 11 to 5 percentage points.)

The results from Figure 2 and Table 1 are broadly consistent with the hypothesis that the Japanese capital market was integrating during our sample period; however, equality or near equality of interest rates is neither a necessary nor sufficient condition for capital market integration. As Stigler (1967) pointed out, interest-rate differentials can persist even when capital markets are integrated because of regional differences in tastes, transaction costs, regional risk, or pure chance. Convergence in the price of loans or deposits are thus not unambiguous indicators of financial market integration, so we also consider whether interest rates tend to rise and fall together, another indicator that the markets may have been linked (Stigler and Sherwin, 1985). Figure 1 shows that, even though there were differences in rates across regions, the movements in rates are positively correlated. Table 2 shows short-run correlation coefficients for *first differences* of the quarterly interest rate series for the nine regions over the entire sample period, for the period up to 1900, and for the period after 1900. Changes in quarterly interest rates are positively correlated, consistent with the formation of a national capital market, although the correlations are considerably less than one. In terms of the sub-periods, they are closer to unity after 1900 than before, suggesting that movements in regional rates became more closely linked over time. Table 3 shows correlations in first differences using annual averages of interest rates. The correlations of annual movements in rates are considerably higher than the quarterly movements, suggesting that fluctuations in rates were closely tied over a slightly longer horizon. This is also true of the regions that were furthest from the commercial centers of Osaka and Tokyo. Simple descriptive statistics and graphical evidence are thus consistent with the view that a national capital market was forming during our sample period.

IV. Examining Regional Interest Rates in the Short Run: Market Efficiency Tests

The central issue in studies on market integration is how closely interest rates of a similar duration and risk are linked across space or geography. Such links can be defined by either short-run integration or long-run convergence. Markets are efficient (and integrated in the short run) when participants utilize all available information and this is reflected in the prices of the traded assets or goods. For example, if the regions of Kanto and Kinki are integrated in the short run, then no arbitrage opportunities exist: i.e., no relevant information can be used to predict changes in interest rates between these two markets. We showed some preliminary evidence of market efficiency in Table 3: first differences in rates between regions were correlated. We now provide additional analysis of market efficiency with a standard time-series test.

For the Japanese capital market to meet the above definition of efficiency, differences in interest rates between regions should be stationary: they should not follow a random walk. If differences in regional rates follow a random walk, then an arbitrageur, at that time, could have made profits simply by transferring funds between the two regions until a random shock eventually eliminated the difference.

We test for a random walk by estimating the following equation:

$$(1)\ \Delta d_{jkt} = B_0 + B_1 d_{jkt-1} + \Sigma_{i=1}^{N} \alpha_i \Delta d_{jkt-i} + \varepsilon_t,$$

where d_{jkt} is the interest rate differential between regions j and k in period t and where the Δd_{jkt-1} term captures the first differences of the interest rate differentials lagged i periods. If the coefficient on B_1 is negative and statistically significant, we can reject the null hypothesis of a random walk or a single unit root (i.e, they are integrated of order one, I(1)). We test this hypothesis by comparing the rates in the core regions of Kanto and Kinki, as well as comparing the rates in those two with those in outlying regions.

Table 4 presents the Augmented Dickey Fuller (ADF) and Phillips Peron (PP) tests for unit roots – the latter of which is an ADF test that has been made robust to serial correlation by using a Newey-West heteroskedasticity and autocorrelation consistent estimator. Regardless of which test we use, the results are quite consistent. We can reject the null hypothesis of a random walk at the one-percent or five-percent level in all pairs of regions. The results suggest that interest-rate differentials were eliminated quickly between regions (in three months or less) such that there were few profitable opportunities for market participants. This suggests that the capital market was both efficient and showed considerable integration in the short run.

V. Tests for Long-Run Convergence in Regional Rates

The unit root tests on interest-rate differentials suggest that the capital market was efficient and that regional series may not have drifted apart in the long run. It is therefore possible that interest-rate differentials fluctuated around some long-run level. However, examining the correlation of co-movements in rates or a simple coefficient of variation is an incomplete test of integration in the sense that neither can identify common trends or common shocks. Hence, we now more formally set out to test long-run convergence and examine the long-run dynamics, such as the speed of adjustment back to equilibrium using cointegration tests and vector error correction models. Long-run convergence can be defined as the case when long-run forecasts of two regions are equal, up to a fixed scalar. This definition has the implication that two markets' interest rates will depend on common permanent shocks in the long run, and equates long-run interest-rate convergence with the notion that the law of one price holds for pairs of regional interest rates. A test for this long-run null hypothesis is the same as a test for cointegration between the two regions' interest rates because a linear combination of these prices is stationary.

A. Unit Root and Stationarity Tests

Before we can proceed with a test of the long-run properties of data, we first test for non-stationarity of each regional time series; if the series appear to be I(1), we can proceed with cointegration tests[19]. As Figure 1 shows, the time series plots of the regions are all trending and are potential I(1) processes.

In developing a strategy for testing for unit roots, *a priori*, we are uncertain whether a deterministic time trend is present in the data. In general, one would not expect interest rates to have a time trend; however, since we are examining whether convergence in rates occurred as a result of financial market integration, it is possible that a negative trend existed during our sample period. However, it could alternatively be the case that the annual change in interest rates is equal to a constant. This is equivalent to a unit root with drift, which would also lead to decline in interest rates over the long run, and would imply that shocks to interest rates persist.

Because the data generating structure is unknown, we need a testing strategy to determine which of these alternatives is most plausible for our data. If we erroneously omit the time trend from the test when a trend is present, the unit root tests will indicate that convergence is due to the presence of unit roots. The tests will then be biased toward finding unit roots. On the other hand, if a trend term is included when there is no trend, this will impact the power of the unit root tests. Following the testing procedure recommended in Elder and Kennedy (2001), we first run an Augmented Dickey Fuller (ADF) test with a time trend included and check for the presence of a unit root using the appropriate critical values for the *t* statistic. (A constant term is also included to consider whether there is drift.) When the unit root test is rejected at standard confidence intervals,

[19] Stanton(1997) suggests that interest rates appear close to unit roots in finite samples, even though they are not pure unit roots (since they are bounded by zero and do not go to infinity).

it indicates that the series has no unit root over the long run and is stationary. If this were the outcome, we would then examine the *t* statistic on the time trend to see if the series is stationary with a deterministic trend. On the other hand, if we cannot reject the null hypothesis of a unit root, then we have ruled out the variable is stationary with a deterministic trend. As a second step for this outcome, we could then look for evidence of whether there is a unit root with drift by regressing the differenced series on a constant and examining the *t* statistic on the constant.

The ADF test statistics for each region are shown in the first column of Table 5. We use the AIC criterion to select the appropriate number of lags of the dependent variable to include in the regression and ensure that the error terms are white noise. As the test statistics in the tables indicate, we can reject the null hypothesis of a unit root in 4 of the 9 regions at the 5% level of significance.[20] The results did not change when we double tested the series by removing the trend term in order to improve the power of the test. Column 2 shows the results from the Phillips-Peron (PP) test for a unit root. In only 2 of 9 regions were able to reject the null of a unit at the 5% level of significance. The asymptotically-efficient DFGLS test is shown in column 3 since it has the best overall performance of the three unit root tests in terms of small sample size and power.[21] In only 1 region (Tokai) we can reject the null hypothesis of a unit root at the 5%-significance level. Column 4 shows the results from the Kwiatkowski, Phillips, Schmidt, Shin (1992) test, or KPSS test, where the null hypothesis is trend stationarity. We could reject the null

[20] In the secondary regression of the differenced series on a constant, we find no statistically significant evidence of a drift component.

[21] We follow Schwert's (1989) methodology for selecting the maximum number of lags of the first-differenced, detrended variable. We use the Ng-Perron sequential t (Ng and Perron, 1995), the Ng-Perron Modified Akaike Information Criteria (MAIC) (Ng and Perron, 2000) and the Schwartz Information Criteria (SIC) to select the appropriate number of lags in the DF-GLS tests.

hypothesis of stationarity in all nine regions. Finally, column 5 performs the ADF test on the first differences of each prefectural interest-rate series to assess whether the order of integration is I(1) or higher order. If the null of unit root is rejected on the differenced series, it is deemed I(1). The results clearly reject the null for the differenced series: we can reject the null for all regions at the 1% level. We interpret the results in table 5 as suggesting that the individual regional interest rate series display unit roots and are nonstationary.

B. Cointegration Tests

Since the regional interest-rate data are likely I(1), cointegration offers a viable estimation strategy for examining the long-run trends in the data, the relationship between regional interest rates, and the speed of convergence. If at least one cointegrating relationship exists (consisting of a linear combination of I(1) series), then the regional interest rates will not persistently deviate from one another in the long run and therefore will not violate the assumptions of capital market integration. Moreover, this long-run relationship will be stationary – the linear combination itself is an I(0) process. Using Engle-Granger tests, we first examine whether long-run relationships existed between pairs of regions. We then use Johansen's procedure to consider whether multiple cointegrating vectors existed across *all* regions and employ a VECM to examine the long-run relationships and the speed of convergence after an interest-rate shock.

We first search for cointegrating relationships between pairs of regions over our sample period: 1889-1922. Table 6 reports on Engle-Granger tests for all 36 possible pairs of regions. Almost all of the bivariate combinations have cointegrating relationships that are statistically significant at conventional levels. The table suggests that, across regions, interest rates were closely related in the sense that pairs of regions did not persistently deviate from one another in the long run. Tohokuho-Shikoku, Tozan-Kyushu, and Tohokuho-Tozan are the only combinations that are statistically insignificant at the 10% level. The lack of statistical significance for these three pairs of regions may not be that surprising since they are located far apart from one another and none of them was a financial center.

Although the Engle-Granger tests suggest that long-run relationships in interest rates existed across Japanese regions, we may also be interested in observing whether there groups, rather than pairs of regions, are related to each other. It might, for example, have been the case that financial centers, such as Kanto and Kinki, were particularly influential in driving rates in other regions. Although historical priors might suggest that we simply limit our search for relationships in this matter, the actual behavior of interest rates may be more complex in that multiple long-run relationships between regions existed. The Engle-Granger approach has no procedure for the separate estimation of multiple cointegrating vectors; rather than analyzing an entire system, it can only accommodate relationships that are bilateral.[22] Moreover, since the Engle-Granger procedure is done in two steps, any error introduced from generating the residuals in the first step will be carried over to the second step.

To account for these limitations in the Engle-Granger procedure and to develop a more complete understanding of long-run market integration that considers multilateral

[22] The results from the Engle-Granger tests often differ depending on which variable is put on the left-hand side of the equation, but here the difference is quite slight.

relationships, we employ Johansen's procedure for determining the number of cointegrating relationships among the nine regions of Meiji-Taisho Japan.[23] If we find that cointegrating vectors exist, then we estimate a vector error correction model (VECM) so that we can analyze the long-run relationships between the regions as well as the speed of adjustment back to the long-run equilibrium after an interest-rate shock. (On the other hand, the absence of cointegrating relationships would imply that there are no long-run relationships in interest rates across Japanese regions.) Following the work of Bernard and Durlauf (1995), we use the VECM to search for evidence of common stochastic elements affecting interest rates in Japan. This is a natural approach to examining integration if we believe that the trends in interest rates may vary in magnitude across regions. Our analysis will allow us to consider whether the data are characterized by multiple long-run relationships – something that the simple summary statistics presented earlier in the paper could not unveil.

We used four lags for the Johansen procedure, based on pre-testing for the VAR lag order with a likelihood ratio test. As Table 7 shows, we can reject the null hypothesis of no cointegration (max rank=0). Moreover, based on the trace statistic, Johansen's test reveals the existence of four cointegrating vectors (shown as the first value of the trace statistic for which we cannot reject the null of a cointegrating relationship at the 5%-level). Johansen's test suggests that several long-run relationships existed among regional interest rates and that these relationships are stationary. The existence of cointegrating relationships is consistent with capital market integration.

[23] Johansen's multivariate methods also permit some of the series to be I(0) while others to be I(1), so this provides some additional flexibility in dealing with cointegrating relationships.

Assuming q cointegrating equations, the VECM for a vector of interest rates, r, can be written as:

(2) $\Delta r_t = \alpha\beta r_{t-1} + \sum_{k=1}^{p-1} \Gamma_k \Delta r_{t-k} + \varepsilon_t$.

The vector β measures the long-run relationship, and represents the parameters of the cointegrating equations whereas Γ represents the matrix showing short-run impacts of shocks to the system (and includes p lags). Regions i and j have a common trend if their interest rate series, r_i and r_j, are cointegrated with a cointegrating vector of [1, -a]. The first vector, α, measures the speed of adjustment back to the long-run relationship after a deviation or an interest-rate "shock" has occurred. The second vector, β, defines the long-run relationships between interest rates in Japan. β is not uniquely determined in that different α will produce a different cointegrating matrix. Based on finding four cointegrating relationships identified by Johansen's maximum likelihood procedure, it is necessary to impose r^2 restrictions (16 restrictions) in order to exactly identify the system. Given the particular historical evolution of capital markets in Japan, we may be most interested in observing whether (1) whether long-run relationships existed between the core financial centers of Kanto and Kinki and (2) long-run, interest-rate relationships existed between the outer regions of Japan and the rest of Japan. Since we have to impose at least 16 restrictions to achieve identification, we chose our [1,0,0,0] normalization using the regions Kanto, Kyushu, Chugoku, Shikoku in order to strike a balance between the two characteristics of Japanese capital market integration we wish to observe. This normalization allows us to examine whether outer regions (such as Kyushu and Shikoku), a core financial center (like Kanto), and a region indicative of the rest of Japan

(Chugoku) have long-term relationships with other non-normalized regions. By selecting this particular normalization we can also explicitly examine the linkages between Kanto and Kinki as well as between Kanto and Tohoku and Hokkaido.[24] The estimated VECM model includes four lags to ensure that serial correlation in the errors is not present, and we specified the cointegrating equations as trend stationary based on a likelihood ratio test.[25]

Tables 8 and 9 present the results from the VECM, for the sample period 1889 (3rd quarter) to 1922 (4th quarter) with four cointegrating relationships.[26] Table 8 displays the vector β from equation (2). As explained above, β measures the long-run relationships between the normalized prefectures and the other (non-normalized) regions for the four cointegrating equations. β thus provides information on which regions' interest rates moved together in the long run. Cointegrating equation 1 shows how interest rates of other regions relate to Kanto. First, most of the regions have long-run relationships with Kanto. The coefficients on Kinki, Tohoku/Hokkaido, Hokuriku, and Tozan are statistically significant. It might be expected that the club of regions that share's a long-run relationship with Kanto is large, given Kanto's central role in the financial system of the Japanese economy. Second, consistent with Okada (1966), we also find that the regions that contain Osaka and Tokyo, i.e. Kinki and Kanto, exhibit a long-run relationship during our sample period. Third, an outer region, such as Tohoku/Hokkaido,

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[24] As noted in the preceding paragraph, the cointegration matrix, $\beta'\alpha$, is not uniquely determined in a VECM, and depends on the normalization chosen. Regardless of the normalization, however, the rank of the matrix is still related to the number of cointegrating vectors.

[25] We fail to reject the null hypothesis of no serial correlation in the errors for all four lags at the 5%-level using a Lagrange multiplier test for autocorrelation in the residuals. This suggests that our finite-sample parameter estimates will be unbiased.

[26] Since inference depends on the stationarity of the cointegrating equations, we checked our VECM model by graphing the predictions from the cointegrating equations. The predicted values hover around zero, consistent with the stationarity assumption.

appears to have a long-run relationship with Kanto. This suggests that some relationships were far reaching and included more distant regions as well as nearby ones.

The next three cointegrating equations show relationships with Kyushu, Chugoku, and Shikoku, respectively. Even a region that is further from Kanto and Kinki, such as Kyushu, exhibits a long-run relationship with several other regions: Kinki, Tozan, Tohoku/Hokkaido, and Hokuriku. Tokai, which did not matter in the first two equations, has a long-run relationship with Chukogu as well as with Shikoku. Looking across all four cointegrating equations, we find evidence that every non-normalized region (those that can be estimated in our system) shares long-run relationships with *at least* two other regions. If interest rates persistently deviated from one another in the long run, this would violate the assumptions of capital market integration. Hence, the findings of statistically significant β's provide further support that the Japanese capital market was integrated during our sample period.

Table 9 shows the estimated values of the α vector from equation (2), which as discussed above, measures the speed of adjustment back to the long-run relationship after a deviation has occurred. Not all of the speed of adjustment coefficients in the vector α are statistically significant; however, for each integrating equation, we have at least one region (and in three of the equations 2) adjustment coefficients which act to return the cointegrating relationship back towards the long-run equilibrium after a shock occurs. The larger the estimated speed of adjustment coefficient, the faster the adjustment value is: a value of -0.5 suggest that the half life of a shock coming from the normalized prefecture is one quarter or 3 months. Hence, for the statistically significant speed of adjustment coefficients, the half lives range from less than three months to one year.

We performed an additional check to ensure that we correctly specified the number of cointegrating equations in our model. The companion matrix of a VECM with 9 endogenous variables and 4 integrating equations has 5 unit eigenvalues. If the process is stable, the moduli of the remaining eigenvalues are strictly less than one. Hence, as a specification test, Figure 3 plots a graph of the eigenvalues and, other than the expected one root on the unit circle for the I(1) process, none of the other eigenvalues appear too close to the unit circle (none is greater than 0.85); we thus conclude that our model is not misspecified.

We now turn to estimating orthogonalized, impulse-response functions (IRF) to analyze how a shock in one of Japan's core regions affects other regions' rates in a transitory or permanent way. We chose Kanto to represent the origin of the interest-rate shock since it was a major financial and commercial center in the nineteenth century. In a VAR, each variable has a time-invariant mean and finite, time-invariant variance, so shocks die out over time; however, in a cointegrating VECM the I(1) variables are not mean reverting. Hence, IRFs can either display transitory shocks or permanent shocks (those that do not die out over time). The IRFs graphed in Figure 4 display how an interest-rate shock emanating in Kanto was transmitted to other regions over the subsequent eight years. The results indicate that changes in rates in the financial center had permanent effects on the periphery; the non-transitory impacts of shocks emanating from the financial center were generally between 5 to 15 basis points. This finding is consistent with the unit moduli shown in Figure 4. Moreover, as the graphs show, the relationship is positively correlated in nearly all the graphs, suggesting that as "negative shocks" hit Japan's financial centers, rates in the periphery moved in the same direction as the shock at the center of the system.[27]

In summary, although the decline in the coefficient of variation displayed in Figure 2 suggests that a process of interest-rate convergence in Japan occurred during our sample period, the results from the VECM suggest that might be too simple of a characterization of the actual process of integration. Rather, it appears that there were several long-run relationships characterized by regions that shared common stochastic elements, and the magnitude of the common trends differed.

V. Conclusions

The results from a variety of time-series tests presented in this paper are broadly suggestive of capital market integration during the Meiji-Taisho era. Evidence from cointegration tests as well as examination of correlations of rates across regions suggests that rates co-varied and had persistent long-run relationships, although precisely when integration took place during our sample period depends on the choice of statistical test and how convergence is defined. The Japanese capital market also appears to be efficient in that all available information was used by arbitrageurs to eliminate pure profit opportunities in the lending market. That is, at least relation to the financial centers based in Kanto and Kinki, interest-rate differentials with other regions did not exhibit random walks. Results from both Engle-Granger tests on pairs of regions and Johansen's

[27] In recent research, Landon-Lane and Rockoff (2007) suggest that financial markets in the U.S. were integrated in the sense that monetary shocks were transmitted from one region to another. Related to the analysis presented here, they find that interest-rate shocks were commonly transmitted from the core to the periphery, but also that some shocks also originated outside of the financial centers.

procedure suggest that interest rates did not deviate from each other in the long-run. Moreover, when a core financial center (such as the Kanto region of Japan) experienced an interest-rate "shock," it had permanent effects on outlying regions. In future research, we hope to complement the results presented here by examining the factors that impeded or accelerated the formation of a national capital market in Japan during this period.

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Figure 1. Co-movements in Quarterly Interest Rates in Nine Japanese Regions, 1886-1922

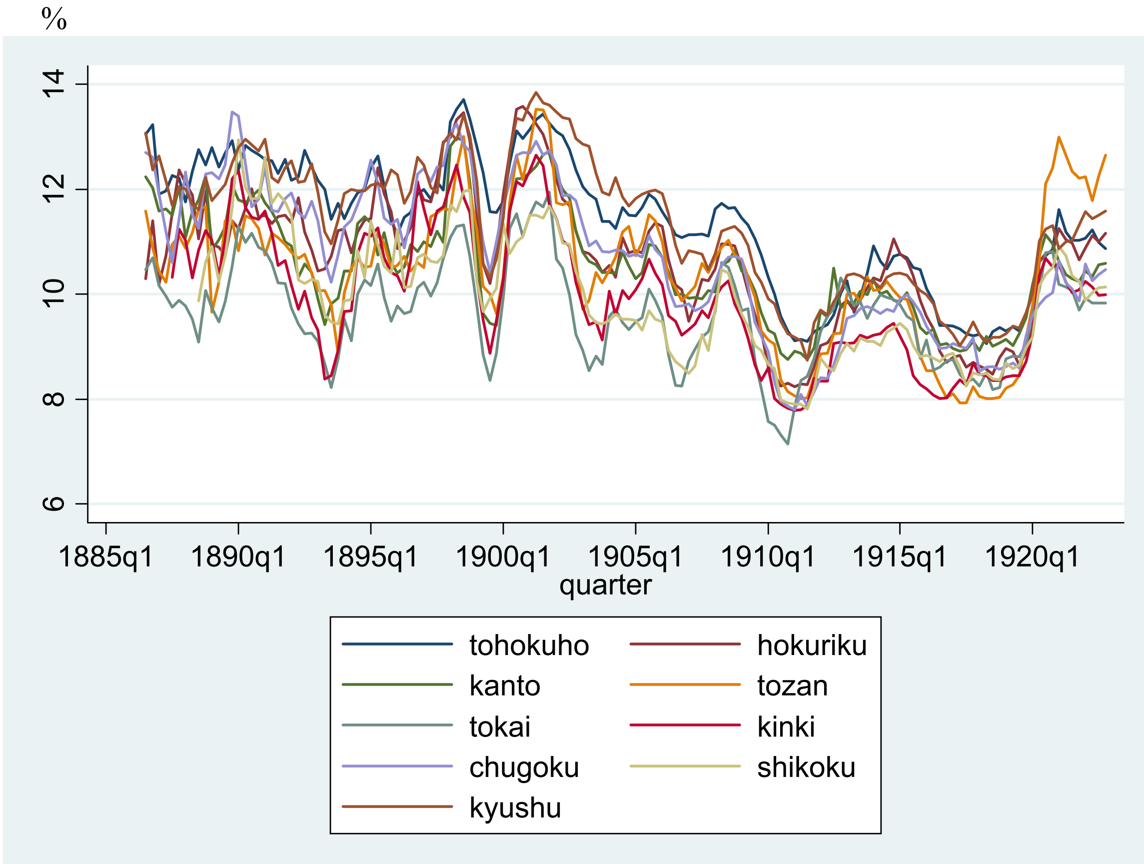


Figure 2. A Narrowing of Interest Rate Differentials across Japanese Prefectures

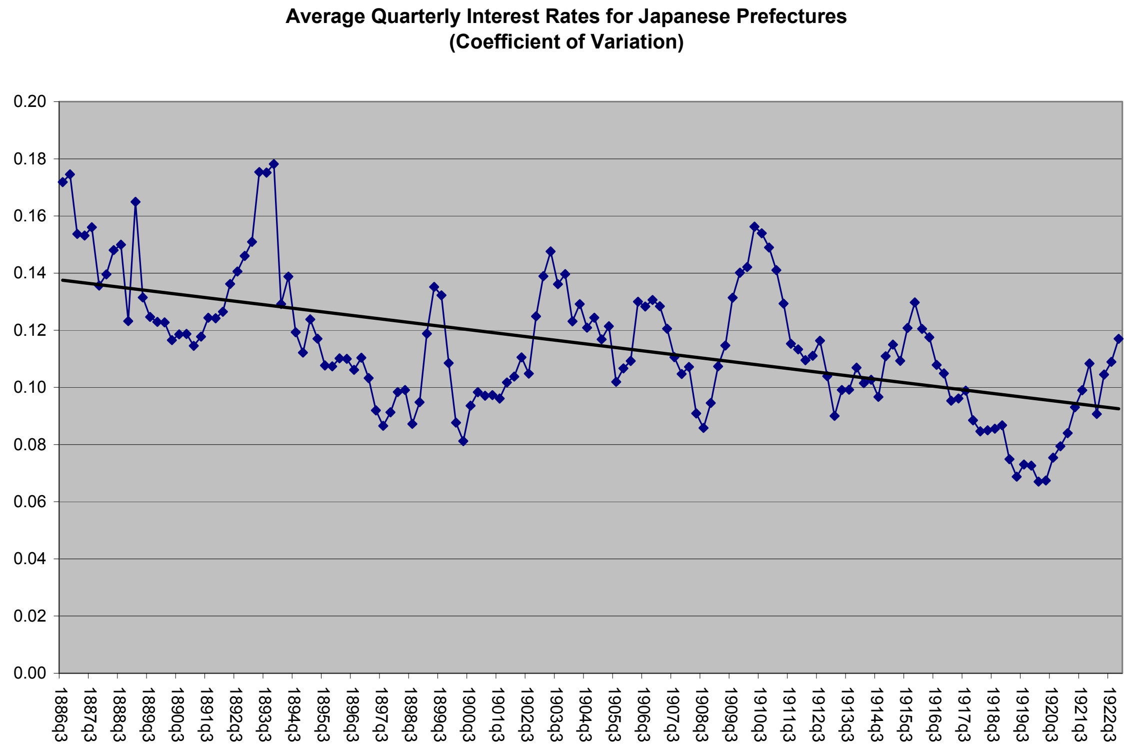


Figure 3. Testing for a specification error in the number of cointegrating vectors

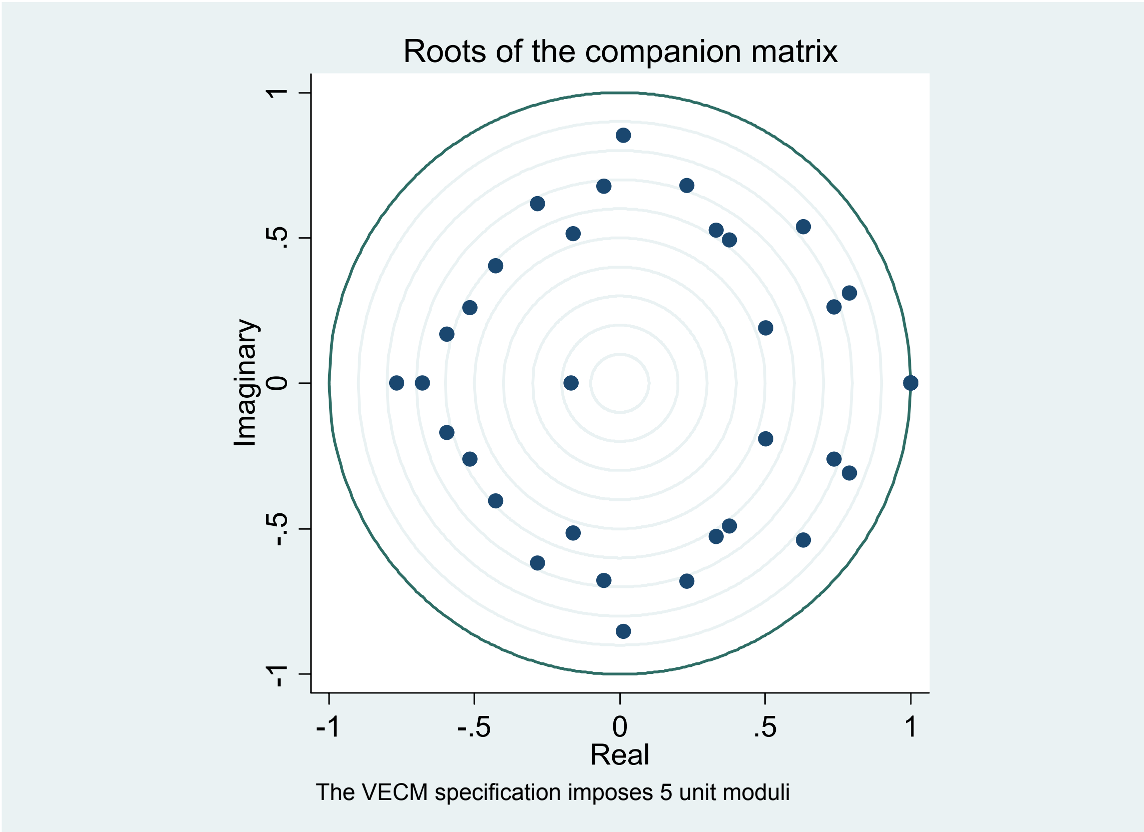
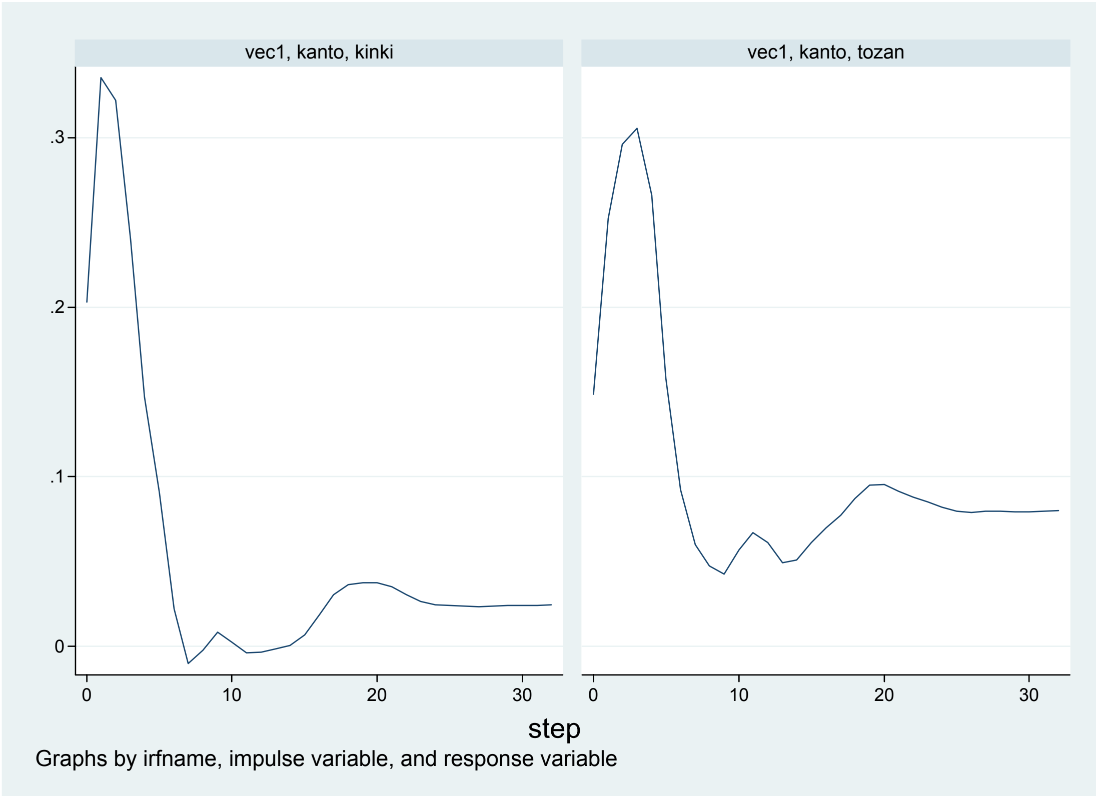


Figure 4. Effects of Orthogonalized Shocks to Kanto's Interest Rate



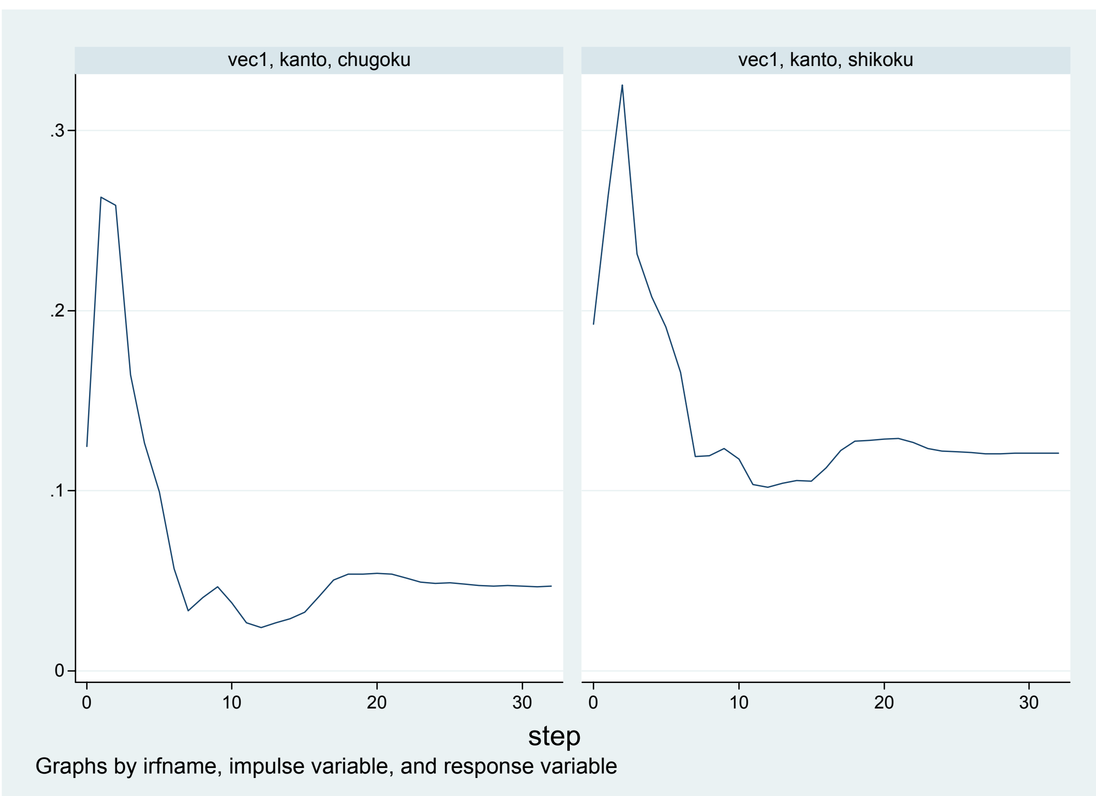
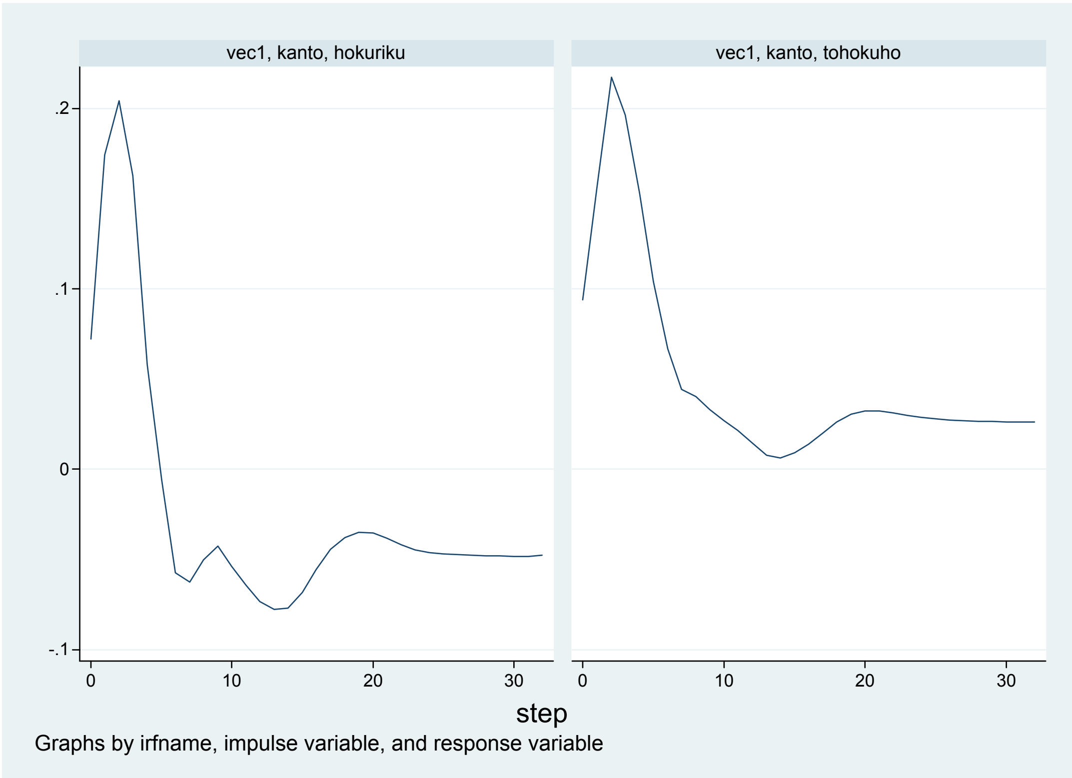


Figure 4 (continued). Effects of Orthogonalized Shocks to Kanto's Interest Rate



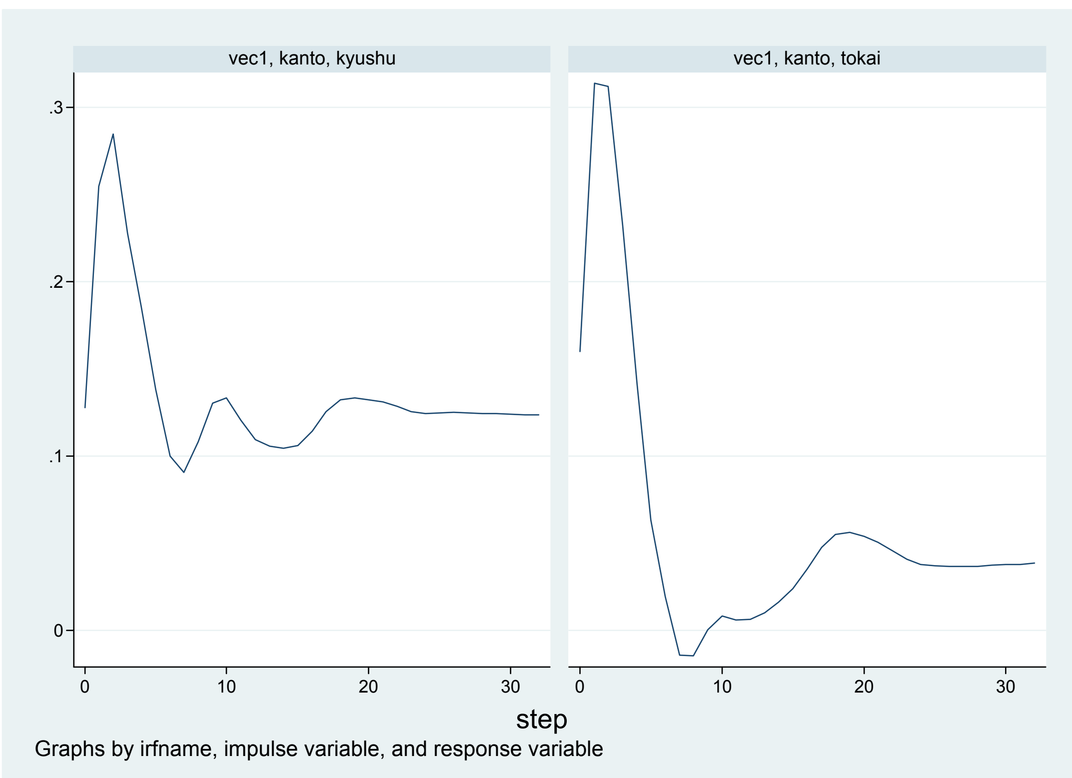


Table 1. Correlation of Interest Rates across Nine Japanese Regions, 1886 - 1922

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.90	1.00							
Kanto	0.88	0.89	1.00						
Tozan	0.79	0.86	0.84	1.00					
Tokai	0.67	0.82	0.84	0.80	1.00				
Kinki	0.86	0.91	0.93	0.84	0.86	1.00			
Chugoku	0.94	0.91	0.89	0.75	0.74	0.91	1.00		
Shikoku	0.85	0.85	0.87	0.76	0.81	0.89	0.90	1.00	
Kyushu	0.93	0.91	0.91	0.81	0.72	0.88	0.93	0.86	1.00

Table 2. Short-run Correlation of Interest Rate Movements across Nine Japanese Regions, 1886-1922

Panel A. Japanese Regions, 1886-1922 (first differences of quarterly averages)

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.49	1.00							
Kanto	0.47	0.49	1.00						
Tozan	0.43	0.46	0.56	1.00					
Tokai	0.37	0.58	0.55	0.47	1.00				
Kinki	0.47	0.60	0.57	0.42	0.65	1.00			
Chugoku	0.37	0.45	0.43	0.26	0.56	0.68	1.00		
Shikoku	0.28	0.38	0.42	0.22	0.54	0.54	0.64	1.00	
Kyushu	0.26	0.46	0.52	0.42	0.59	0.59	0.60	0.50	1.00

Panel B. Japanese Regions, 1886-1899 (first differences of quarterly averages)

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.36	1.00							
Kanto	0.45	0.40	1.00						
Tozan	0.26	0.32	0.47	1.00					
Tokai	0.33	0.63	0.50	0.26	1.00				
Kinki	0.39	0.52	0.51	0.19	0.73	1.00			
Chugoku	0.23	0.34	0.35	0.00	0.63	0.73	1.00		
Shikoku	0.18	0.20	0.43	0.01	0.61	0.59	0.68	1.00	
Kyushu	0.08	0.35	0.42	0.25	0.60	0.56	0.56	0.54	1.00

Panel C. Japanese Regions, 1900-1922 (first differences of quarterly averages)

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.66	1.00							
Kanto	0.51	0.63	1.00						
Tozan	0.62	0.62	0.68	1.00					
Tokai	0.43	0.57	0.62	0.62	1.00				
Kinki	0.58	0.70	0.65	0.68	0.61	1.00			
Chugoku	0.61	0.64	0.56	0.62	0.54	0.60	1.00		
Shikoku	0.42	0.63	0.41	0.48	0.51	0.47	0.55	1.00	
Kyushu	0.49	0.61	0.65	0.59	0.60	0.64	0.58	0.47	1.00

Table 3. Long-Run Correlation of Interest Rate Movements across Nine Japanese Regions, 1886-1922

Panel A. Japanese Regions, 1886-1922 (first differences of annual averages)

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.83	1.00							
Kanto	0.78	0.80	1.00						
Tozan	0.82	0.82	0.84	1.00					
Tokai	0.68	0.78	0.87	0.82	1.00				
Kinki	0.72	0.86	0.90	0.87	0.91	1.00			
Chugoku	0.88	0.85	0.82	0.81	0.78	0.86	1.00		
Shikoku	0.80	0.81	0.85	0.79	0.86	0.87	0.82	1.00	
Kyushu	0.81	0.84	0.91	0.82	0.81	0.87	0.87	0.86	1.00

Panel B. Japanese Regions, 1886-1899 (first differences of annual averages)

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.81	1.00							
Kanto	0.77	0.72	1.00						
Tozan	0.75	0.83	0.92	1.00					
Tokai	0.66	0.70	0.90	0.84	1.00				
Kinki	0.66	0.81	0.90	0.87	0.95	1.00			
Chugoku	0.90	0.76	0.76	0.76	0.73	0.88	1.00		
Shikoku	0.72	0.73	0.83	0.77	0.93	0.87	0.73	1.00	
Kyushu	0.79	0.81	0.91	0.86	0.98	0.97	0.77	0.96	1.00

Panel C. Japanese Regions, 1900-1922 (first differences of annual averages)

	Tohoku/Hokkaido	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohoku/Hokkaido	1.00								
Hokuriku	0.86	1.00							
Kanto	0.80	0.89	1.00						
Tozan	0.87	0.87	0.85	1.00					
Tokai	0.69	0.87	0.88	0.81	1.00				
Kinki	0.77	0.90	0.92	0.90	0.91	1.00			
Chugoku	0.88	0.92	0.85	0.85	0.82	0.84	1.00		
Shikoku	0.87	0.88	0.87	0.85	0.84	0.87	0.89	1.00	
Kyushu	0.83	0.87	0.92	0.82	0.75	0.83	0.90	0.83	1.00

Table 4. Unit Root Tests for Market Efficiency, 1887-1922
(Differences in Interest Rates Between Regions)

	ADF		PP	
Kanto-Kinki	-5.763	***	-5.892	***
Kanto-Tohokuho	-4.421	***	-4.189	***
Kanto-Hokuriku	-5.225	***	-5.185	***
Kanto-Tozan	-3.171	**	-3.000	**
Kanto-Tokai	-4.661	***	-4.574	***
Kanto-Chugoku	-4.048	***	-3.818	***
Kanto-Shikoku	-5.589	***	-5.664	***
Kanto-Kyushu	-3.644	***	-3.274	**
Kinki-Tohokuho	-3.822	***	-4.051	***
Kinki-Hokuriku	-4.552	***	-4.572	***
Kinki-Tozan	-3.960	***	-3.743	***
Kinki-Tokai	-3.518	***	-3.211	**
Kinki-Chugoku	-3.848	***	-3.762	***
Kinki-Shikoku	-4.896	***	-4.938	***
Kinki-Kyushu	-3.444	***	-3.301	**

Note: The dependent variable is the interest rate differential between the two regions.
*** denotes significance at the 1% level
** denotes signficance at the 5% level

Table 5. Unit Root and Stationarity Tests for 9 Japanese Regions

	Augmented Dickey Fuller Test		Phillips Perrron Test		DFGLS Test		KPSS Test		ADF First Differences	
Tohokuho	-3.254		-2.811		-2.117		2.520	***	-7.589	***
Hokuriku	-2.944		-3.138		-1.970		1.670	***	-6.695	***
Kanto	-4.069	***	-3.694	**	-1.674		1.800	***	-6.604	***
Tozan	-3.481	**	-2.516		-1.945		0.745	***	-5.314	***
Tokai	-4.859	***	-3.769	**	-4.572	***	0.646	**	-6.331	***
Kinki	-3.511	**	-3.223		-2.419		1.620	***	-7.335	***
Chugoku	-3.075		-2.835		-2.147		2.560	***	-9.235	***
Shikoku	-2.878		-3.242		-2.215		1.830	***	-8.326	***
Kyushu	-2.802		-2.548		-2.113		2.200	***	-8.174	***

*** denotes significance at the 1% level
** denotes signficance at the 5% level
Notes: KPSS test is defined with a null hypothesis of stationarity.
ADF, PP, and DFGLS tests are defined with null hypotheses of a unit root.

Table 6. The results of cointegration test between two regions

	Tohokuho	Hokuriku	Kanto	Tozan	Tokai	Kinki	Chugoku	Shikoku	Kyushu
Tohokuho		1%	1%	×	10%	5%	1%	×	1%
Hokuriku			1%	5%	5%	1%	1%	1%	1%
Kanto				1%	1%	1%	1%	1%	1%
Tozan					1%	5%	5%	1%	×
Tokai						1%	1%	1%	5%
Kinki							1%	1%	1%
Chugoku								1%	1%
Shikoku									1%
Kyushu									

Note: Percentage strands for the statistical significance of the existence of cointegrating relationship.
× stands for there are no cointegrating relationship.

Table 7. Cointegrating Relationships

Rank	Parameters	LL	Eigenvalue	Trace statistic	5% critical value
0	90	-213.6291	.	290.9007	192.89
1	107	-168.698	0.48354	201.0386	156
2	122	-141.136	0.33324	145.9146	124.24
3	135	-117.7516	0.29099	99.1457	94.15
4	146	-102.2624	0.2037	68.1675 *	68.52
5	155	-89.71027	0.16856	43.0631	47.21
6	162	-80.84895	0.12218	25.3405	29.68
7	167	-73.22481	0.10606	10.0922	15.41
8	170	-70.12501	0.04456	3.8926	3.76
9	171	-68.1787	0.02822		

Notes: Four lags and a constant trend were included. Sample period is 1889-1922.
* shows as the first value of the trace statistic for which we cannot reject the null of a cointegrating relationship at the 5% level.

Table 8. Estimates of Long-Run Interest Rate Relationships in Cointegrating Equations (β in Vector Error Correction Model)

	Coefficient	Standard Error	z statistic	P>|z|
Cointegrating Equation 1				
Kanto	1.000	.	.	.
Kyushu	0.000	.	.	.
Chugoku	0.000	.	.	.
Shikoku	0.000	.	.	.
Tohoku/Hokkaido	-1.848	0.375	-4.930	0.000
Hokuriku	0.988	0.284	3.480	0.001
Tokai	0.258	0.269	0.960	0.337
Tozan	0.533	0.230	2.310	0.021
Kinki	-1.025	0.260	-3.940	0.000
Trend	-0.019	0.006	-3.090	0.002
Constant	3.152	.	.	.
Cointegrating Equation 2				
Kanto	0.000	.	.	.
Kyushu	1.000	.	.	.
Chugoku	0.000	.	.	.
Shikoku	0.000	.	.	.
Tohoku/Hokkaido	-3.338	0.630	-5.300	0.000
Hokuriku	1.730	0.477	3.620	0.000
Tokai	0.136	0.452	0.300	0.763
Tozan	0.956	0.387	2.470	0.014
Kinki	-1.465	0.437	-3.350	0.001
Trend	-0.034	0.010	-3.380	0.001
Constant	13.381	.	.	.
Cointegrating Equation 3				
Kanto	0.000	.	.	.
Kyushu	0.000	.	.	.
Chugoku	1.000	.	.	.
Shikoku	0.000	.	.	.
Tohoku/Hokkaido	1.644	0.919	1.790	0.073
Hokuriku	-0.869	0.696	-1.250	0.211
Tokai	-2.768	0.659	-4.200	0.000
Tozan	-0.382	0.564	-0.680	0.498
Kinki	0.292	0.637	0.460	0.647
Trend	0.024	0.015	1.610	0.108
Constant	6.373	.	.	.
Cointegrating Equation 4				
Kanto	0.000	.	.	.
Kyushu	0.000	.	.	.
Chugoku	0.000	.	.	.
Shikoku	1.000	.	.	.
Tohoku/Hokkaido	5.976	2.082	2.870	0.004
Hokuriku	-1.787	1.576	-1.130	0.257
Tokai	-5.970	1.494	-4.000	0.000
Tozan	-2.178	1.278	-1.700	0.088
Kinki	1.811	1.445	1.250	0.210
Trend	0.076	0.033	2.260	0.024
Constant	-0.794	.	.	.

Table 9. Estimates of Speed of Adjustment Parameters
(α in Vector Error Correction Model)

	Coefficient	Standard Error	z statistic	P>|z|
Kanto				
Cointegrating Equation 1	-0.585	0.190	-3.080	0.002
Cointegrating Equation 2	0.247	0.091	2.720	0.006
Cointegrating Equation 3	0.098	0.132	0.740	0.457
Cointegrating Equation 4	-0.090	0.063	-1.430	0.154
Kinki				
Cointegrating Equation 1	0.223	0.223	1.000	0.317
Cointegrating Equation 2	-0.040	0.107	-0.380	0.707
Cointegrating Equation 3	0.365	0.155	2.350	0.019
Cointegrating Equation 4	-0.131	0.074	-1.770	0.077
Chugoku				
Cointegrating Equation 1	0.037	0.177	0.210	0.836
Cointegrating Equation 2	0.104	0.085	1.230	0.220
Cointegrating Equation 3	-0.165	0.123	-1.340	0.180
Cointegrating Equation 4	0.078	0.059	1.320	0.186
Shikoku				
Cointegrating Equation 1	-0.002	0.235	-0.010	0.993
Cointegrating Equation 2	-0.180	0.113	-1.600	0.109
Cointegrating Equation 3	0.354	0.163	2.170	0.030
Cointegrating Equation 4	-0.193	0.078	-2.460	0.014
Tozan				
Cointegrating Equation 1	-0.066	0.254	-0.260	0.794
Cointegrating Equation 2	0.098	0.121	0.810	0.418
Cointegrating Equation 3	-0.107	0.176	-0.600	0.545
Cointegrating Equation 4	0.071	0.084	0.840	0.401
Tokai				
Cointegrating Equation 1	-0.035	0.204	-0.170	0.862
Cointegrating Equation 2	0.173	0.129	1.340	0.179
Cointegrating Equation 3	-0.088	0.152	-0.580	0.561
Cointegrating Equation 4	0.017	0.062	0.270	0.785
Tohoku/Hokkaido				
Cointegrating Equation 1	0.078	0.159	0.490	0.625
Cointegrating Equation 2	-0.005	0.076	-0.060	0.952
Cointegrating Equation 3	0.159	0.111	1.440	0.150
Cointegrating Equation 4	-0.083	0.053	-1.570	0.117
Hokuriku				
Cointegrating Equation 1	-0.481	0.204	-2.360	0.018
Cointegrating Equation 2	0.146	0.097	1.500	0.133
Cointegrating Equation 3	0.081	0.141	0.570	0.565
Cointegrating Equation 4	-0.081	0.068	-1.200	0.229
Kyushu				
Cointegrating Equation 1	-0.088	0.169	-0.520	0.602
Cointegrating Equation 2	-0.032	0.081	-0.400	0.689
Cointegrating Equation 3	-0.021	0.117	-0.180	0.860
Cointegrating Equation 4	-0.013	0.056	-0.240	0.813