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INTEGRATION AND SEGMENTATION IN INTERNATIONAL MARKETS FOR RICE AND WHEAT, 1877-1994

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Did international grain markets become ever better integrated during the past century? This question cannot be addressed by looking at either price correlation or coefficient of variation, which are sensitive to aggregate shocks. This paper calculates correlation coefficients after removing the impact of macro shocks, which indicate pre-1914 wheat markets were better developed than rice markets. In 1914-36, both WWI and protectionism dislocated wheat markets, but could not prevent rice markets from becoming better integrated. Although peace and free trade returned after 1945, rice markets disintegrated, and wheat markets failed to recover the pre-1914 level of integration, due to growing state interventionism.

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I. INTRODUCTION

Correlation coefficients are commonly calculated using prices observed in different regional markets to determine whether they are integrated. For instance, McCloskey and Zecher(1976) used high correlation coefficients among wheat prices in Britain, Germany and the US as evidence showing the presence of a unified world wheat market during the classical gold standard period.[1] High price correlation may arise however in the absence of market integration: consider a sticky-price world economy, where aggregate demand shocks raise prices and

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[1] Other examples include Latham and Neal(1983) and Brandt(1993).

income in one country and are then transmitted to another via the foreign trade multiplier to increase prices and income there as well.

Coefficients of variation is another common measure of market integration. Both Hurd(1975) and Williamson(1996) presented declining coefficients of varations to argue that regional goods and factor markets were becoming more closely linked in the late nineteenth and early twentieth centuries. However, over a longer period of time, during which shifts in international monetary regime occur, coefficients of variation may change although markets remain integrated to the same extent. When prices are imperfectly flexible and therefore international arbitrage is less than instantaneous, coefficients of variation will tend to be lower under a fixed than under a floating exchange rate regime, where exchange rates responds sensitively to shocks, with prices adjusting sluggishly to remove the resulting international price gaps.

This paper begins by presenting evidence in the following section (II) to show 1) that a substantial part of high price correlation is attributable to global shocks and international transmission of aggregate shocks, and 2) that price coefficents of variation tended to be higher under a floating than a fixed exchange rate regime. Section III introduces and estimates a structural vector autoregression model to purge the impact of macro and exchange rate shocks out of rice and wheat price movements. Correlation coefficients calculated using the filtered price series show not only that high (raw) price correlations are often spurious, but also that the past one hundred and twenty years witnessed a unitary evolution towards greater integration neither in rice nor in wheat markets. Section IV summarizes and concludes.

Ⅱ. WHY CORRELATION COEFFICIENT AND COEFFICIENT OF VARIATION MAY MISLEAD

While both rice and wheat have a long history of international trade, the trade in the two major food grains however began to expand rapidly in the late nineteenth century with a sharp decline in transportation costs due to railway building and introduction of steamship. A consequence of the expansion of international grain trade is that wheat and rice price data become available in many different parts of the world after around 1870. Table 1 compares different values of correlation coefficients calculated using such price data in pre-WWI period and interwar period.

In a majority of the cases shown in the table price correlation is higher in the war and interwar period than in the pre-1914 belle epoque. This is puzzling, given that before the First World War international trade, capital flows and migration flourished under international peace and relatively low levels of tariffs, while international movement of goods and factors suffered a setback during hostilities and the Great Depression giving rise to protectionism. A familiar piece of evidence indicating disintegration of the world economy is falling share of

[Table 1] Price Correlation

	1878-1913	1914-1936
Burma-Japan (rice)	0.11	0.58**
Korea-China (rice)	0.18	0.78**
Burma-China (rice)	0.27	0.75**
Australia-UK (wheat)	0.27	0.57*
India-UK (wheat)	0.40*	0.51*
US-UK (wheat)	0.78**	0.58**

Notes: calculated with log-differences; * and ** indicate that a positive coefficient, significantly different from zero at 5% and 1% level respecively, obtains in an OLS regression between a pair of price series.
Source: see Appendix.

[Table 2] Correlation Coefficients in Pre-1914 Period

UK-Russian wheat price, 1878-1906	0.37
Japanese-Thai rice price, 1878-1913	0.46
UK - US construction costs, 1872-1913	0.37
Korean rice - US brick prices, 1878-1913	0.38
Korean rice price - UK unemployment rate, 1878-1913	-0.41

Note: Calculated with first differences.
Source: see Appendix.

trade in national product after 1913 (Krugman(1989, p.7)).

How is the higher price correlation after 1914 to be reconciled with an apparently disintegrating international economy? Plotting available regional rice and wheat prices together, one sees that the rise in correlation is chiefly due to a simultaneous sharp surge in prices during the war years, steep fall in postwar slump and the Great Depression. Not only rice and wheat prices observed in different places but also prices of widely different commodities, including raw cotton and rubber, displayed swings of similar pattern and amplitude (Kindleberger(1973)). This striking parallelism in commodity prices during this turbulent period was probably attributable to global shocks, such as simultaneous expansion of money supply to finance the war (Hardach(1977)), and international transmission of aggregate shocks, such as deflationary policies to restore and stay on the gold standard, leading eventually to the Great Depression (Eichengreen(1992)).

Although the pre-1914 world economy was not exposed to shocks of a scale comparable to WWI or the Great Depression, there are reasons to believe that a substantial part of pre-1914 price correlation is also due to macroeconomic shocks. Table 2 shows that price correlation does not differ significantly between

tradables (such as rice and wheat) and between construction materials consisting to a substantial extent of non-tradable items. One also finds a similar level of correlation between annual change in Korean rice price on the one hand and US brick prices and UK unemployment rate on the other in the absence of direct economic link between Korea and the other two countries.

If correlation coefficients are less than a satisfactory indicator of market integration because they overstate the degree of market integration in the presence of global shocks or international transmission of aggregate shocks, do coefficients of variation provide a better alternative? While it is not immediately clear whether aggregate demand shocks will raise or lower price coefficient of variation, it certainly depends upon the incidence of exchange rate shocks. Price differentials tend to be wider under the floating than under the fixed exchange rate regime, because exchange rate shocks generated under a floating regime widen price differential, which are not readily closed instantaneously by super-efficient international arbitrage. This is why despite the progress in globalization price coefficients of variation rose substantially after the breakdown of the Bretton Woods system.[2] Also price coefficient of variation between Burmese, Chinese, Indian, and Thai rice prices rose from 0.40 (from 1878-1913) to 0.48 (from 1914-1936), and that between US and Australian wheat prices from 0.13 to 0.27. This may reflect the political and economic turmoil and resulting trade disruption, but the demise of the fixed exchange rate regime (the classical gold standard) and the shift to the floating rate regime may also have played an important role.

In sum, the evidence examined above suggests that grain prices were less than perfectly flexible, and that under such circumstances neither correlation coefficient nor coefficient of variation is a satisfactory measure of market integration. When global shocks are generated or aggregate demand shocks are spread internationally, correlation coefficients tend to overstate the actual extent of market integration, while exchange rate shocks make coefficients of variation understate it.

Ⅲ. DECOMPOSITION OF GRAIN PRICES USING A STRUCTURAL VAR MODEL

This section introduces and estimates structural vector autoregression (SVAR) models to filter the impact of global aggregate demand and exchange rate shocks out of national rice and wheat price fluctuations. I consider the residual grain price variations as due to local rice (or wheat) supply and demand shocks, such as harvests, agricultural innovation, and changes in taste. If this residual price variations in any two markets are found to be positively correlated, I will claim that the two markets are integrated.

[2] Price coefficient of variation from rom 0.12 in 1961-71 to 0.19 in 1972-94 among ten major wheat trading countries and from 0.19 to 0.42 among ten major rice trading countries.

Consider a vector autoregressive (VAR) system defined in terms of 1) the world price level, 2) exchange rate between a grain importing and exporting country, 3) grain price in the grain exporting country (supply center), 4) grain price in the importing country (demand center). The world price level and grain prices in both supply and demand center are denominated in the world currency unit, i.e. a currency unit other than those used in the two grain trading countries. Estimating the VAR system yields reduced form disturbances, $e=(e_w, e_x, e_s, e_d)$, which are assumed to be linked to orthogonal structural shocks, $\varepsilon=(\varepsilon_w, \varepsilon_x, \varepsilon_s, \varepsilon_d)$, in the following way:

$$e_w = \varepsilon_w \tag{1}$$

$$e_x = a_1 e_s + \varepsilon_x \tag{2}$$

$$e_s = a_2 e_w + a_3 e_x + \varepsilon_s \tag{3}$$

$$e_d = a_4 e_w + a_5 e_x + a_6 e_s + \varepsilon_d \tag{4}$$

The identifying restrictions embodied in these four equations express the following asumptions. First, global and internationally transmitted aggregate demand shocks (ε_w) affect the world price level, which in turn influences grain prices in the supply and demand centers (equations (1), (3), and (4)): a_2 and a_4 are therefore expected to be positive. Second, exchange rate shocks (ε_x) affect not only exchange rate, but also the two grain prices, if price adjustment is sluggish (equations (2), (3), and (4)): with exchange rate defined as number of units of demand center currency per supply center currency, expected signs of a_3 and a_4 are positive and negative, respectiveley. Third, shocks arising from supply center (local supply shocks, ε_s) have impacts upon supply center price, demand center price, and exchange rate (equations (3), (4), and (2)): while international arbitrage implies a positive a_6, a_1 may be either postive or negative, depending upon the price elasticity of demand for grains. Finally, shocks arising from demand center (local demand shocks, ε_d) are assumed to be sufficiently weak to have influence only upon demand center but not upon either supply center price or exchange rate, an assumption motivated by evidence showing stability of food demand.[3]

The variance-covariance matrix of residuals from the four variable VAR system contains ten distinct moments, allowing estimation of up to ten parameters, which is equal to the number of parameters the above system contains (six coefficients and variances of the four structural shocks). I begin by estimating the SVAR model using an algorithm developed by Giannini (1992). Where convergence in maximum likelihood estimation procedure is found difficult to

[3] For evidence of low income and cross elasticity of demand for food, see Goldberger and Gamaletsos(1970), Parks & Barten(1973), and Blunden(1988).

achieve, I try a slightly simplified specification with $a_1 e_s$ term in equation (2) left out. Finally, when a_3 and/or a_5 turn out to be either insignificantly different from zero or associated with wrong signs, the model is further simplified by eliminating equation (2) and exchange rate terms in equations (3) and (4).

Once coefficients are estimated, structural shocks(ε) are then obtained by multiplying the inverse of estimated coefficient matrix with reduced form disturbances(e). Inverting the initial VAR to derive vector moving average(VMA) representation and replacing reduced form disturbance with structural shocks yields expressions relating each of the four variables to present and past structural shocks. Now, the impact of, say, global inflationary trend can be filtered out from regional grain price fluctuations by setting the present and past values of ε_w equal to zero in VMA expressions for regional price changes.

Ⅳ. RESULTS

I estimate the SVAR system and filter prices for various country pairs formed by major rice and wheat trading countries in the three periods, i.e. 1877-1913, 1914-1936, and 1961-1994. The period from 1937-60 is excluded, because grain price data are not available for a sufficiently large number of countries. Since during the pre-WWI period exchange rates were either fixed (as among gold standard countries) or remained stable relatively to the subsequent two periods, the most parsimonious specification (having only a_2, a_4, and a_6 as coefficients to be estimated) was applied to this era. Before the Second World War Anglo-American national income deflator[4] was used to represent the world price level, while for 1961-1994 world wholesale price index is available from *International Financial Statistics*, published by the International Monetary Fund. Before the Second World War all price series were converted into the pound sterling and into the US dollar in 1961-94. Since the pound sterling (US dollar) could not be used as a numeraire in pre-WWII (post-WWII) pairs including the UK (US), in such cases all prices were converted into the US dollar (SDR). Unit root test results indicates that all price and post-1913 exchange rate series are integrated series of order one except the post-WWII world wholesale price index, which is found to be an integrated series of order two. Therefore, VAR's are specified in terms of log second difference of the post-WWII world price level and log-differences of all other series.

Table 3 shows estimation results for twelve pairs of rice economies (three exporters times four importers). Among 36 estimated coefficients five have wrong (i.e. significantly negative) signs. In one half of the twelve pairs, filtering the impact of common shocks out of price movments reduces correlation

[4] This was obtained by dividing the sum of current price UK GDP and US GNP (both converted into the pound sterling) with the sum of constant price UK GDP and US GNP. These series are taken from Mitchell(1988) and Gordon(1986).

[Table 3] Estimation Results, 1877-1913, Rice

	a_2	a_4	a_6	Raw Correlation	Pure Correlation
Burma-China	0.01(0.06)	0.92(5.15)	0.45(12.59)	0.27	0.34
Burma-India	-0.50(3.39)	-0.68(4.13)	0.47(14.72)	0.32	0.24
Burma-Indonesia	-0.10(0.69)	0.57(5.79)	0.43(21.84)	0.57**	0.47**
Burma-Japan	-0.22(1.50)	0.30(1.61)	0.07(2.03)	0.11	0.08
Korea-China	1.81(1.00)	0.48(2.55)	-0.03(1.21)	0.18	0.02
Korea-India	2.27(12.68)	-0.67(3.56)	0.03(1.11)	0.14	0.22
Korea-Indonesia	1.64(9.50)	0.15(1.29)	0.14(7.20)	0.26	0.31
Korea-Japan	1.92(10.66)	-1.20(9.43)	0.84(43.31)	0.74**	0.51**
Thai-China	1.49(11.79)	0.10(0.55)	0.55(14.25)	0.29	0.31
Thai-India	1.40(10.84)	-0.60(3.56)	-0.06(1.61)	-0.20	0.09
Thai-Indonesia	1.53(12.10)	0.26(2.47)	0.22(9.71)	0.17	0.23
Thai-Japan	1.29(10.07)	0.22(1.14)	0.28(6.64)	0.38	0.14

Notes: country pairs show a supply center, followed by a demand center;. t-ratios shown in parentheses; * and ** denote significance at 5% and 1% level, respectively.

coefficients, while in the other half the opposite happens. In no case, however, does the filtering worsen (improve) correlation enough to turn a signifcant (insignificant) correlation into an insignificant(significant) one. There are only two integrated pairs: Burma-Indonesia and Korea-Japan. Burma and Korea represented the two largest rice exporters in Southeast and East Asia, respectively (Owen (1971), Wickizer and Bennett(1941)). And Indonesian rice trade with Burma expanded more rapidly than rice trade with other regions in pre-1914 decades (Mansvelt(1978, pp. 67-69)), while virtually all of Korean rice trade was already with Japan even before annexation in 1910. Except for these two pairs, east and southeast Asian rice markets overall did not seem well integrated before the First World War.[5]

Estimation results for twenty four pairs of wheat economies (six exporters times four importers) are much better (Table 4): among 72 estimated coefficients only three are associated with wrong (i.e. significantly negative) signs. Removing the influence of global shocks tends to reduce correlation coefficients. Out of thirteen pairs showing significant raw price correlation, Argentina-Sweden, India-France, and India-UK pairs lose significance as a result of filtering. This makes sense, given that both Argentina and India were two of those developing regions most closely linked with the industrialized parts of the world (Britain in

[5] This claim contradicts both Latham & Neal(1983) and Coclanis(1993), who argued for a well-integrated world market for rice. As supporting evidence they presented raw correlation coefficients substantially larger than those shown in Table 3. Their coefficients are larger because price *levels*, rather than *annual differences* were used.

[Table 4] Estimation Results, 1877-1913, Wheat

	a_2	a_4	a_6	Raw Correlation	Pure Correlation
Argentina-France	0.73(1.41)	0.26(1.66)	0.08(7.49)	0.14	-0.21
Argentina-Germany	0.73(1.45)	0.62(4.02)	0.16(15.07)	0.35	-0.29
Argentina-Sweden	0.39(0.78)	0.57(3.59)	0.18(16.15)	0.43*	-0.19
Argentina-UK	1.15(2.20)	0.90(5.54)	0.14(13.18)	0.35	-0.16
Australia-France	0.11(0.33)	1.14(13.42)	0.13(16.70)	0.37*	0.42*
Australia-Germany	-0.68(1.59)	0.90(6.45)	0.05(5.23)	0.14	-0.18
Australia-Sweden	-1.41(4.41)	0.86(7.67)	0.09(8.57)	0.18	-0.01
Australia-UK	-0.20(0.63)	1.07(11.62)	0.11(13.66)	0.27	-0.05
Canada--France	0.88(3.21)	1.21(11.96)	0.02(2.24)	0.05	0.04
Canada-Germany	-1.95(5.40)	0.62(4.53)	0.06(4.84)	0.00	-0.09
Canada-Sweden	0.56(1.91)	0.74(6.83)	0.12(11.68)	0.23	0.10
Canada-UK	0.71(2.61)	1.08(11.30)	0.02(2.02)	-0.07	-0.19
India-France	0.06(0.36)	1.10(12.42)	0.27(17.35)	0.42*	0.30
India-Germany	0.58(2.86)	0.65(4.61)	0.09(3.94)	0.15	0.09
India-Sweden	-0.32(1.88)	0.79(7.35)	0.24(13.41)	0.41*	0.39*
India-UK	-0.03(0.20)	1.00(10.86)	0.24(14.33)	0.40*	0.29
Russia-France	0.01(0.38)	1.05(20.77)	0.26(10.75)	0.48*	0.43*
Russia-Germany	1.76(9.33)	-0.62(3.66)	0.59(17.12)	0.68**	0.67**
Russia-Sweden	-0.09(0.60)	0.90(8.03)	0.70(27.44)	0.59**	0.64**
Russia-UK	-0.01(0.15)	0.94(23.66)	0.25(13.14)	0.68**	0.69**
US-France	0.47(3.52)	0.77(8.78)	0.34(17.92)	0.58**	0.41*
US-Germany	1.53(8.90)	-0.04(0.43)	0.61(33.92)	0.76**	0.76**
US-Sweden	0.27(1.97)	0.58(6.10)	0.50(25.02)	0.60**	0.60**
US-UK	0.48(3.61)	0.76(11.43)	0.61(42.34)	0.78**	0.77**

Notes: see Table 3.

particular) via capital and trade flows, and that the closer a developing region is tied with a developed country, the greater is likely to be the portion in price parallelism between the two due to transmission of macro shocks from the developed country. In contrast, we have seen in Table 3 that removal of the effects of global shocks did not affect correlation coefficients between rice economies very much, which were not linked yet with industrialized countries as tightly before the First World War. Finally, Table 4 shows that pre-1914 wheat markets were better linked with each other than rice markets: not only different regions in Europe but also US-European wheat markets remained well integrated before 1914.

In addition to the seven rice price series examined in Table 3, rice price data for two exporters (Taiwan and the US) are available from 1914-36, which means there are 20 pairs (five exporters times four importers) to consider. Out

[Table 5] Estimation Results, 1914-36, Rice

	a_2	a_3	a_4	a_5	a_6	Raw Correlation	Pure Correlation
Burma	0.91		1.82		0.47	0.75**	0.05
China	(8.00)		(20.12)		(13.81)		
Burma-	1.02		0.99		0.64	0.79**	0.65**
India	(10.06)		(17.53)		(27.60)		
Burma-	-0.54	1.25	0.86	-0.67	0.36	0.64**	0.57*
Indonesia	(5.52)	(19.31)	(19.00)	(17.47)	(17.92)		
Burma-	0.90		1.45		0.01		
Japan	(12.16)		(16.07)		(0.16)	0.58**	-0.18
Korea-	2.17		0.32		0.95	0.78**	0.39
China	(33.09)		(2.58)		(19.93)		
Korea-	1.61		0.66		0.55	0.74**	0.24
India	(22.48)		(6.46)		(12.22)		
Korea-	1.42		0.50		-0.08	0.50*	0.07
Indonesia	(16.21)		(6.59)		(2.41)		
Korea-	1.79		-0.17		0.95	0.85**	0.63**
Japan	(24.65)		(1.96)		(25.60)		
Taiwan-	2.32		0.77		0.72	0.78**	0.49*
China	(30.91)		(5.52)		(14.59)		
Taiwan-	1.76		0.77		0.45	0.79**	0.22
India	(21.88)		(7.81)		(11.29)		
Taiwan-	1.59		0.35		0.02	0.53*	0.06
Indonesia	(17.27)		(4.56)		(0.73)		
Taiwan-	1.83		0.12		0.77	0.77**	0.40
Japan	(24.43)		(1.17)		(18.41)		
Thailand-	1.38		1.33		0.31	0.41	0.51*
China	(6.36)		(12.85)		(14.87)		
Thailand-	0.34		0.48		0.36	0.33	0.09
India	(1.75)		(6.75)		(21.53)		
Thailand-	0.75	0.45	0.45	-0.21	0.03	-0.24	-0.02
Indonesia	(9.93)	(9.87)	(10.35)	(7.85)	(3.38)		
Thailand-	1.74		1.04		0.23	0.44	-0.03
Japan	(8.72)		(8.24)		(8.75)		
US-	2.23		2.25		0.17	0.40	0.22
China	(12.55)		(16.87)		(5.86)		
US-	2.51		1.55		-0.06	0.18	0.20
India	(17.91)		(11.42)		(1.76)		
US-	2.57		0.14		-0.02	-0.23	0.30
Indonesia	(15.69)		(1.77)		(1.04)		
US-	2.63	0.49	0.47	-0.04	0.22	0.03	0.06
Japan	(17.47)	(6.11)	(3.82)	(0.67)	(7.37)		

Notes: see Table 3.

[Table 6] Estimation Results, 1914-36, Wheat

	a_2	a_3	a_4	a_5	a_6	Raw Correlation	Pure Correlation
Argentina-	0.04		0.70		-0.06	-0.09	-0.20
France	(0.14)		(4.36)		(2.11)		
Argentina-	-0.04		0.55		0.25	0.60*	0.27
UK	(0.14)		(7.10)		(16.90)		
Australia-	0.38	0.84	1.50	-0.61	-0.05	0.00	0.08
France	(1.78)	(9.33)	(14.16)	(12.62)	(2.37)		
Australia-	1.40	5.59	0.60	-0.82	0.34	0.66**	0.42
UK	(23.80)	(22.11)	(14.28)	(4.74)	(15.68)		
Canada-	0.55		1.19		0.33	-0.18	-0.02
France	(3.89)		(9.18)		(8.05)		
Canada-	0.47		0.55		0.11	0.41	-0.32
UK	(3.12)		(5.25)		(3.62)		
India-	0.65	0.15	1.56	-0.45	0.31	-0.14	0.33
France	(5.70)	(4.00)	(12.73)	(11.39)	(6.65)		
India-	0.76	0.79	0.79	-0.17	0.23	0.87**	0.55*
UK	(35.75)	(18.28)	(44.16)	(5.18)	(18.21)		
US-	2.63	0.02	1.42		-0.08	0.05	-0.38
France	(28.75)	(0.74)	(7.26)	-0.59	(1.38)		
US-	2.59		-1.31	(14.05)	0.82	0.58**	0.68**
UK	(31.42)		(12.35)		(24.50)		

Notes: see Table 3.

of 66 estimated coefficients shown in Table 5, three have wrong signs. A key difference from pre-WWI era is a proportionately larger number (twelve out of twenty vs. two out of twelve) of significant raw correlation, two thirds of which turn insignificant after filtering. This demonstrates the impact of massive macro shocks, which included the First World War and Great Depression. Comparing Tables 3 and 5, one finds three new connections between Burma-India, Taiwan-China, and Thai-China were formed after 1914, in addition to the pre-1914 linkage between Burma-Indonesia and Korea-Japan. This suggests a broad picture of the world rice market consisting of three major rice trading blocs: one is Japanese imperial connection between Japan and Korea, another linking Taiwan, China, and Thailand, and the third tying India, Burma, and Indonesia together. Interwar Asian rice economies thus appeared better interrelated than in the pre-1914 period. Table 5 also shows that the US, a new supplier to the world rice market, was not fully integrated with the Asian rice economies before the Second World War.

Number of available regional wheat price series unfortunately declines after 1914, which leaves only 10 pairs (five exporters times two importers) to

examine. Three out of the forty estimated coefficients shown in Table 6 have wrong signs. While in four of the ten pairs are raw price correlations significant and positive, two of the four significant correlations become insignificant when the influence of common shocks are eliminated. Compared to the pre-WWI period, when three of thirteen significant raw correlations turned insignificant after filtering, this is a proportionately larger number, again displaying the influence of strong global shocks. French connections with Australia and the US end with the outbreak of the First World War, but Britain establishes a new tie with an imperial wheat supplier, India. These are shifts entirely consistent with rising protectionism in the wake of the Great Depression, as represented by the British General Tariff, and Hawley-Smoot Act. All in all, while the pre-1914 US-UK connection survives and Table 6 does not contain evidence on intra-European wheat trade, international wheat markets appears to have become less integrated after 1914.

Table 7 shows estimation results for twenty-five pairs of countries, formed by five largest rice exporters and importers, from 1961-94. Eight out of eighty-five estimated coefficients are of wrong signs, an outcome is worse than that from 1914-1936, but comparable with that for the pre-1914 period. Out of the twenty

[Table 7] Estimation Results, 1961-94, Ricec

	a_2	a_3	a_4	a_5	a_6	Raw Correlation	Pure Correlation
China-	2.31		-0.57		0.01	0.16	0.05
Bangladesh	(10.04)		(1.89)		(0.25)		
China-	2.21		-0.40		0.16	0.35	0.13
Indonesia	(13.26)		(3.11)		(5.83)		
China-	1.49		0.61		0.52	0.59**	0.11
Saudi	(11.01)		(5.02)		(19.41)		
Arabia							
China-	1.20	0.44	2.09	-0.22	0.72	0.73**	-0.36*
Senegal	(9.56)	(9.99)	(17.64)	(5.34)	(24.71)		
China-	1.76		1.66		0.25	0.47**	-0.09
UK	(14.56)		(15.34)		(9.79)		
Italy-	2.26		0.14		-0.37	-0.05	-0.21
Bangladesh	(14.67)		(0.41)		(4.36)		
Italy-	1.10		-0.04		0.05	0.13	-0.18
Indonesia	(7.10)		(0.31)		(1.70)		
Italy-	1.28	0.17	0.26	-0.03	0.57	0.69**	0.54**
Saudi Arabia	(10.06)	(3.13)	(2.86)	(0.78)	(26.25)		
Italy-	1.25		1.94		0.61	0.69**	-0.03
Senegal	(10.42)		(18.34)		(23.44)		
Italy-	1.24	0.41	0.90	-0.15	0.54	0.73**	-0.12
UK	(10.08)	(4.57)	(11.53)	(2.70)	(27.93)		

Pakistan-	0.03		-0.56		0.46	0.48**	0.11
Bangladesh	(0.10)		(2.37)		(11.26)		
Pakistan-	-0.07		0.08		0.49	0.66**	0.19
Indonesia	(0.46)		(0.81)		(21.27)		
Pakistan-	-0.63		1.21		-0.05	0.11	-0.33
Saudi Arabia	(3.94)		(8.68)		(1.96)		
Pakistan-	-0.89		2.76		-0.12	0.19	-0.33
Senegal	(6.58)		(18.32)		(3.44)		
Pakistan-	-0.39		1.84		-0.20	0.04	-0.56**
UK	(2.86)		(17.75)		(8.43)		
Thailand-	2.41		-0.93		0.11	0.36	-0.18
Bangladesh	(9.28)		(2.94)		(2.12)		
Thailand-	2.74		-0.08		0.04	0.31	-0.08
Indonesia	(14.72)		(0.64)		(1.69)		
Thailand-	2.29		-0.10		0.70	0.83**	-0.01
Saudi Arabia	(13.76)		(1.15)		(47.05)		
Thailand-	2.35	0.16	1.38	-0.24	0.81	0.89**	0.45**
Senegal	(14.47)	(3.47)	(17.79)	(11.74)	(58.39)		
Thailand-	2.76		0.74		0.52	0.77**	0.31
UK	(18.30)		(9.47)		(36.90)		
US-	1.09		0.14		0.67	0.17	0.32
Banlgadesh	(12.22)		(2.58)		(28.22)		
US-	0.97		0.65		0.05	0.31	-0.10
Indonesia	(12.46)		(8.96)		(1.60)		
US-	1.02		-0.06		0.75	0.69**	0.70**
Saudi Arabia	(15.91)		(1.16)		(30.85)		
US-	0.77	0.21	0.91	-0.46	1.04	0.83**	0.47**
Senegal	(9.65)	(6.20)	(13.80)	(16.68)	(40.67)		
US-	1.00		0.36		0.58	0.67**	0.41*
UK	(16.12)		(7.14)		(25.02)		

Notes: see Table 3.

five pairs, fourteen show significant raw price correlation, nine of which turn out to be spurious, generated by a strong inflationary trend after the Second World War. Thus, while the proportion of integrated pairs rose from 20%(2 out of 10) in pre-1914 years to 25% (5 out of 20) during 1914-36, it fell back to 20% (5 out of 25) after WWII. The five linkages revolve largely around two largest post-1945 rice producers, Thailand and the US. Hence, the picture of world rice market in 1961-94 appears both less integrated and more polarized than in 1914-36. This is probably due to a large extent to distortions arising from government interventions, such as policies pursuing self-sufficiency in rice and industrialization via import-substitution, and government-to-government contract handling around half only world rice trade, which accounted for only about

[Table 8] Estimation Results, 1961-94, Wheat

	a_1	a_2	a_3	a_4	a_5	a_6	Raw Correlation	Pure Correlation
Argentina-		3.15		0.65		0.83	0.92**	-0.19
Brazil		(28.05)		(9.94)		(60.60)		
Argentina-		4.01		0.52		0.64	0.89**	0.52**
China		(34.01)		(5.49)		(37.05)		
Argentina-		3.63		0.23		0.78	0.86**	0.58**
Egypt		(32.57)		(1.97)		(34.11)		
Argentina-		3.06		0.15		0.22	0.55**	-0.21
Italy		(28.50)		(1.38)		(9.19)		
Argentina-		2.95		0.22		0.72	0.85**	-0.37
Japan		(29.26)		(2.40)		(34.19)		
Australia-		1.33	0.06	2.31	-0.07	0.72	0.75**	-0.24
Brazil		(11.23)	(4.86)	(25.15)	(8.70)	(30.76)		
Australia-		2.66		0.96		0.63	0.86**	-0.36
China		(23.30)		(13.11)		(38.71)		
Australia-		2.35		0.78		0.77	0.82**	-0.25
Egypt		(21.48)		(7.13)		(29.75)		
Australia-		1.94		0.21		0.13	0.50**	-0.40*
Italy		(16.33)		(2.13)		(5.41)		
Australia-		1.28		0.94		0.81	0.70**	-0.46*
Japan		(15.64)		(9.50)		(23.93)		
Canada-		2.87		1.85		0.51	0.78**	0.56**
Brazil		(23.84)		(19.34)		(25.46)		
Canada-		2.69		1.41		0.45	0.78**	-0.10
China		(20.45)		(15.94)		(25.42)		
Canada-		3.02	0.06	0.79	-0.33	0.74	0.85**	-0.11
Egypt		(22.24)	(1.79)	(9.00)	(19.86)	(43.82)		
Canada-		2.65	0.16	0.11	-0.74	0.38	0.59**	-0.12
Italy		(24.90)	(3.71)	(1.43)	(30.58)	(21.23)		
Canada-		2.31	0.36	0.57	-0.37	0.72	0.89**	0.77**
Japan		(16.10)	(6.54)	(8.16)	(15.24)	(51.79)		
France-		1.00		2.73		0.45	0.44*	0.27
Brazil		(12.80)		(26.33)		(11.76)		
France-		1.07		2.17		0.50	0.47*	0.17
China		(12.39)		(22.28)		(15.19)		
France-		0.93	0.03	2.05	-0.38	0.62	0.42*	0.30
Egypt		(11.29)	(1.99)	(19.46)	(18.70)	(16.07)		
France-	-0.09	1.09	0.86	0.10	-0.45	0.79	0.64**	0.62**
Italy	(2.51)	(13.22)	(4.08)	(1.54)	(7.11)	(31.51)		
France-	0.21	1.10	0.02	2.05	-0.24	0.59	0.49**	0.42*
Japan	(3.59)	(12.76)	(0.21)	(19.70)	(5.07)	(15.25)		

US-	1.54		0.34		0.97	0.93**	0.53**
Brazil	(27.69)		(9.69)		(64.44)		
US-	1.71		-0.08		0.81	0.86**	0.25
China	(27.42)		(2.06)		(56.35)		
US-	1.55		0.67		0.83	0.85**	0.40*
Egypt	(27.41)		(12.17)		(35.17)		
US-	1.46		-0.34		0.46	0.61**	0.11
Italy	(25.45)		(7.31)		(22.48)		
US-	1.47	0.01	0.35	-0.23	0.91	0.95**	-0.14
Japan	(22.04)	(0.16)	(11.32)	(11.51)	(75.44)		

Notes: see Table 3.

4 percent of post-1945 world rice output (vs. 8-9% in 1936-8).[6]

Post-WWII estimation results for 25 wheat pairs (Table 8) are substantially better than those for rice economies: only two of ninety-three estimated coefficients have wrong signs. Raw correlations are all positive and significant, but only about one-third (eight pairs) maintains significance after filtering. Eight out of total 25 observations is a proportion higher than that in 1914-36 (two out of ten), but lower than that in pre-1914 years (ten out of twenty-four). While the world wheat market became better integrated after WWII, but failed to recover the pre-1914 level of integration. Again policy interventions may be held responsible, which included price support to protect domestic agricuture in developed countries and price distortions in developing countries to extract resources from the agricultural sector to finance industrialization.[7]

V. SUMMARY AND CONCLUSIONS

Evidence exists to show that regional rice and wheat prices fluctuate in response not only to local supply and demand shocks, but also to global shocks, aggregate demand shocks transmitted internationally, and exchange rate shocks. The presence of these shocks render the two common measures of market integration -- price correlation coefficient and coefficient of variation -- both inadequate and misleading. Removing the influence of such shocks upon regional prices by structural vector autoregression technique, I calculated correlation coefficients among thus "purified" price series to determine whether a pair of markets are integrated. "Pure" correlation evidence demonstrates more than anything else that "raw" correlation substantially exaggerates the actual extent of

[6] See Atkin(1992), Barker, Herdt, and Rose (1985, p.190), Falcon and Monke(1979/80), Hayami and Ruttan(1985, chapter 12), Roche(1992, p.100), Wickizer and Bennett(1941, p.28, footnote 33). It is relevant to note here that Petzel and Monke(1979/80) present *raw* correlation evidence to concluce that during 1961-77 "firm linkages existed" among ten rice economies except for "the relatively unimportant japonica import markets."

[7] Hayami and Ruttan (1985. Chapter 12).

market integration, particularly after the First World War, when massive aggregate demand shocks were generated and spread around the globe. Pre-1914 rice markets were not so well integrated internationally either as raw price correlations suggest or as pre-1914 wheat markets. In contrast to wheat markets, which became dislocated in 1914-36 as a consequence of hostilities and the Depression, rice economies, being relatively insulated from these disruptions, underwent further integration. Although peace returned and protectionism receded after 1945, rice markets became more fragmented, and wheat markets failed to return to pre-1914 level of integration, probably because economies became politicized as exemplified by policies pursuing rice self-sufficiency, industrialization through import substitution, and protection of domestic agriculture.

Appendix: Data Sources

Pre-WWII Rice Price Data
Burma: Statistical Abstract for British India.
China: Hsiao (1974).
India: Statistical Abstract for British India.
Indonesia: Mansvelt(1978).
Japan: Nagaoka (1989).
Korea: Oh(1991) and Yoshino(1975), Chosen Sotokufu Tokei Nempo.
Taiwan: *Taiwan Beikoku Yoran*, 1942.
Thai: Ingram (1964)
US: *Historical Statistics of the US.*

Pre-WWII Wheat Price Data
Argentina: Mitchell(1982)
Australia: Vamplew(1987).
Canada: Mitchell(1982).
France and Germany: Fourastié(1958)
Russia: Harley(1980)
Sweden: Jorberg(1972).
US: *Historical Statistics of the* US.

Rice and Wheat Price Data, 1961-1994
Food and Agriculture Organization Web site: www.fao.org

Exchange Rates
Japanese yen/U.S. dollar: *Nihon Chogi Tokei Yoran.*
U.S. dollar/British pound: Friedman and Schwartz (1982).
Chinese haikwan tael/British pound : Hsiao (1974).
Thai baht/British pound: Ingram (1971)
Indian rupee/British pound: *Statistical Abstract for British India.*
U.S. dollar/Argentine pesos: Federal Reserve Board(1942).
U.S. dollar/Canadian dollar: Federal Reserve Board(1942).

REFERENCES

Atkin, M. (1992) *The International Grain Trade* (Cambridge: Woodhead Publishing).

Barker, R., I. Herdt, and B. Rose (1985) *The Rice Economy of Asia* (Washington D.C.: Resources for the Future).

Blundell, R. (1988) "Consumer Behaviour: Theory and Empirical Evidence - A Survey," *Economic Journal* 98, pp. 16-65.

Brandt, L. (1993) "Interwar Japanese Agriculture: Revisionist Views on the Impact of the Colonial Rice Policy and the Labor-Surplus Hypothesis," *Explorations in Economic History* 30, pp. 259-293.

Coclanis, P. A. (1993) "Distant Thunder: The Creation of a World Market in Rice and the Transformation It Wrought," *American Historical Review* 98.

Eichengreen, B. (1992) *Golden Fetters* (Oxford: Oxford University Press).

Falcon, W. and E. Monke (1979/80) "International Trade in Rice," *Food Research Institute Studies* 17, pp. 279-306.

Federal Reserve Board (1942) *Banking and Monetary Statistics.*

Fourastie, J. (1958) *Documents pour l'Histoire et la Théorie des Prix* (Paris: Armand Colin).

Friedman, M. and A. J. Schwartz (1982) *Monetary Trends in the United States and the United Kingdom* (Chicago: Chicago University Press).

Giannini, C. (1992) *Topics in Structural VAR Econometrics* (Berlin: Springer Verlag).

Goldberger, A. S. and T. Gamaletsos (1970) "A Cross-country Comparison of Consumer Expenditure Patterns," *European Economic Review* 1, pp. 357-400.

Gordon, R. J. (1986) *The American Business Cycle* (Chicago: Chicago University Press).

Hardach, G. (1977) *The First World War, 1914-1918* (Allen Lane: Penguin).

Harley, K. (1980), "Transportation, the World Wheat Trade and the Kuznets Cycle 1850-1913," *Explorations in Economic History* 17, pp. 218-250.

Hayami, Y. and Vernon Ruttan (1985) *Agricultural Development: An International Perspective*, revised ed. (Baltimore: Johns Hopkins University Press).

Hsiao, L. (1974) *China's Foreign Trade Statistics, 1864-1949* (Cambridge, Mass.: Harvard University Press).

Hurd, John (1975) "Railways and Expansion of Markets in India, 1861-1921," *Explorations in Economic History* 12, pp. 263-88.

Ingram, J. C. (1964) "Thailand's Rice Trade and Allocation of Resources," in C. D. Cowan, ed., *The Economic Development of South-East Asia* (London: George Allen & Unwin).

Ingram, J. C. (1971) *Economic Change in Thailand 1850-1970* (Stanford: Stanford University Press).

Joerberg, L. (1972) *A History of Prices in Sweden, 1732-1914* (Lund: CWK Gleerup).

Kindleberger, C. P. (1973) *The World in Depression* (Allen Lane: Penguin).
Krugman, P. (1989) *Exchange-Rate Instability* (Cambridge, Mass.: MIT Press).
Latham, A. J. H. & Larry Neal (1983) "The International Market in Rice and Wheat, 1868-1914", *Economic History Review* 36, pp. 260-280.
Mansvelt, W. (1978) *Changing Economy in Indonesia*, vol. 4 (Hague: Martinus Nijhoff).
McCloskey, D. N. and J. R. Zecher (1976) "How the Gold Standard Worked, 1880-1913," in Johnson H. and J. Frenkel, eds., *The Monetary Approach to the Balance of Payments* (Toronto: University of Toronto Press), pp. 357-385.
Mitchell, B. R. (1988) *British Historical Statistics* (Cambridge: Cambridge University Press).
Mitchell, B. R. (1982) *International Historical Statistics: Americas and Australasia* (London: Macmillan).
Mitchell, B. R. (1981) *International Historical Statistics: Asia and Africa* (London: Macmillan).
Nagaoka, S. (1989) *Kindai Nihon no Keizai* (Tokyo: Minerva).
Oh, Doohwan (1991) *Hanguk Kundae Hwapyesa* (Seoul: Hanguk Yonguwon).
Owen, N. G. (1971) The Rice Industry of Mainland Southeast Asia 1850-1914, *Journal of the Siam Society* 59, pp.78-142.
Parks, R. W. and A. P. Barten (1973) "A Cross-country Comparison of the Effects of Prices, Income and Population Composition on Consumption Patterns," *Economic Journal* 83, pp. 834-852.
Petzel, T. and E. Monke (1979/80) "The Integration of the International Rice Market," *Food Research Institute Studies* 17, pp.307-26.
Vamplew, W. (1987) Australians: Historical Statistics (Sydney: Fairfax, Syme & Weldon Associates).
Wickizer, V. D. and M. K. Bennett (1941) *The Rice Economy of Monsoon Asia* (Stanford: Stanford University Press).
Williamson, J. G. (1996) "Globalization, Convergence, and History," *Journal of Economic History* 56, pp. 277-306.
Yoshino, H. (1975) Yichokaikokuko no Kokumotsu Boeki ni tsuite, *Chosenshi Kenkyukai Ronbunshu* 12.
Historical Statistics of the US.
Nihon Chogi Tokei Yoran.
Statistical Abstract for British India.
Taiwan Beikoku Yoran.