Integration and Segmentation in International Markets for Rice and Wheat, 1877-1994*

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Abstract

Both correlation coefficients and coefficients of variation are commonly calculated using regional prices to see whether markets are integrated. Other things being equal, and as markets become more closely linked, correlation coefficients are likely to rise, and coefficients of variation to fall. Over an extended period, however, other things rarely remain the same in the real world, which often makes the two coefficients imperfect and misleading indices of market integration.

I first show that price correlations tended to be lower during the pre-1914 belle epoque than from 1914-38. Given the abundance of evidence indicating a disintegrating world economy in the latter period, the increase in the degree of price parallelism after 1913 is most likely to be a consequence of global shocks (e.g. simultaneous expansion of money supply to finance war efforts) or international transmission of aggregate demand shocks (e.g. deflationary policies to return to and stay on the gold standard) via trade and capital flows. These can cause most prices in different parts of the world to move in the same direction (generating high correlation coefficients) in the absence of market integration. I also show that coefficients of variation tended to be higher under a floating than under a fixed exchange rate regime. If a shift to a floating regime allows exchange rates to respond sensitively to shocks, with prices remaining sticky and adjusting sluggishly to remove the resulting international price gaps, a consequence of the regime shift will be a rise in coefficients of variation.

I set up and estimate structural vector autoregression models to filter the impact of global shocks, internationally transmitted aggregate demand shocks, and exchange rate shocks out of regional rice and wheat price fluctuations. Correlation coefficients are then calculated using thus "purified" price series to determine whether various pairs of major rice or wheat markets are integrated in three different periods, 1877-1913, 1914-36, and 1961-94. "Pure" correlation evidence demonstrates more than anything else that "raw" price correlations substantially exaggerate the actual extent of 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. If wheat markets seemed to become somewhat dislocated in 1914-36 in the wake of hostilities and the Great Depression, Asian rice market became better integrated during this period, probably because they were less closely linked with industrialized countries and therefore relatively insulated from the political and economic dislocations. Although peace returned and protectionism receded after 1945, rice markets grew more fragmented, and wheat markets failed to return to pre-1914 level of integration. I interpret this as a consequence of government interventions, as exemplified by policies pursuing rice self-sufficiency, industrialization through import substitution, and protection of domestic agriculture.

I. Introduction

Correlation coefficients are commonly calculated using regional prices to determine whether markets are integrated. For instance, McCloskey and Zecher(1976) used high correlation coefficients among wheat prices in Britain, Germany and the US as evidence for the presence of a unified world wheat market during the classical gold standard period.[1] High price correlation can obtain however in the absence of market integration: consider a sticky-price world economy, where aggregate demand shocks raise prices and income in one country and are then transmitted to another via the foreign trade multiplier to increase prices and income there too.

Coefficients of variation provide an alternative 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 witnessing shifts in international monetary regime, 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 first presents evidence in the following section (II) to suggest that a substantial part of high price correlation is attributable to global shocks and international transmission of aggregate shocks, and that higher coefficents of variation did prevail during floating rate periods, such as interwar and post-1971 years. Section III introduces and

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

estimates a structural vector autoregression model, which allows filtering the impact of macro and exchange rate shocks out of rice and wheat price movements. Correlation coefficients calculated among thus 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

Both rice and wheat have a long history of international trade. 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 steamships. 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.

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.

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 intriguing, because we are told 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 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)).

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.

While 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 one 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 overstate the degree of market integration in the presence of global shocks or international transmission of aggregate shocks, are coefficients of variation a better indicator of market integration? Indeed coefficient of variation calculated among Burmese, Chinese, Indian, and Thai rice prices does rise 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 increase however is not to be attributed entirely to trade distruptions after 1913, but also to the demise of the fixed exchange rate regime, the classical gold standard. For, with commodity prices less flexible than exchange rates, the greater the variability of exchange rate shocks, the larger will be international commodity price differentials. In fact, coefficients of variation rose substantially after the breakdown of the Bretton Woods system: from 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.

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 internatioanlly, correlation coefficients tend to overstate actual extent of market integration, while exchange rate shocks make coefficients of variation understate it.

III. Decomposition of Grain Prices

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 positively correlated, I claim that the two markets are integrated.

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, $\mathbf{e} = (e_w, e_x, e_s, e_d,)$, which are assumed to be linked to orthogonal structural shocks, $e = (\varepsilon_w, \varepsilon_x, \varepsilon_s, \varepsilon_d)$, in the following way:

$$e_w = \varepsilon_w \qquad (1)$$

$$e_x = a_1 e_s + \varepsilon_x \qquad (2)$$

$$e_s = a_2 e_w + a_3 e_x + \varepsilon_s \quad (3)$$

$$e_d = a_4 e_w + a_5 e_x + a_6 e_s + \varepsilon_d \quad (4).$$

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 supply center price, an assumption motivated by evidence showing stability of food demand.[2]

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

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(e) are then obtained by multiplying the inverse of estimated coefficient matrix with reduced form disturbances($\mathbf{e}$). 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.

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. 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 to be estimated) is applied to this era. Before the Second World War Anglo-American national income deflator[3] 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 are converted into the pound sterling, while they

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

3 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).

are denominated in terms of the US dollar in 1961-94. The pound sterling (US dollar) cannot be used as a numeraire in pre-WWII (post-WWII) pairs including the UK (US), in which cases all prices are 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 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.

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. negative) signs. In one half of the twelve pairs, filtering the impact of common shocks out of price movments reduces correlation 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.[4]

Table 4 Estimation Results, 1877-1913, Wheat

	a_2	a_4	a_6	raw correla-tion	pure correla-tion
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

[4] 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.

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.

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. negative) signs. When the influence of global shocks are filtered out correlation declines or remain the same in all but three cases; in these three exceptional pairs the improvement in price comovement is marginal. There are thirteen pairs showing significant raw price correlation, but correlation loses significance in Argentina-Sweden pair and Indian pairs with two industrialized countries (France and the UK) as a result of filtering. Such shifts make sense, given that both Argentina and India were two of the developing regions most closely linked with the industrialized parts of the world, Britain in particular, via capital and trade flows: 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. If we have seen in Table 3 that removal of the effects of global shocks does not affect correlation coefficients substantially in rice economies, this is probably because their linkage with the industrialized countries was not tight enough 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 European but also US-European wheat markets remained well integrated before 1914.

Table 5 Estimation Results, 1914-36, Rice

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

US-China	2.23 (12.55)		2.25 (16.87)		0.17 (5.86)	0.40	0.22
US-India	2.51 (17.91)		1.55 (11.42)		-0.06 (1.76)	0.18	0.20
US-Indonesia	2.57 (15.69)		0.14 (1.77)		-0.02 (1.04)	-0.23	0.30
US-Japan	2.63 (17.47)	0.49 (6.11)	0.47 (3.82)	-0.04 (0.67)	0.22 (7.37)	0.03	0.06

Notes: see Table 3.

In addition to the seven rice price series examined in Table 3, price data become available for two more rice exporters, Taiwan and the US, from 1914-36, and as a result there are 20 pairs (five exporters times four importers) to consider. Out of 66 estimated coefficients shown in Table 5, three have wrong signs. A key difference from pre-WWI era is that we have 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 probably demonstrates the impact of huge macro shocks, which include the First World War and Great Depression. Comparing Tables 3 and 5, one finds new connections between Burma-India, Taiwan-China, and Thai-China are established after 1914. And pre-1914 integration between Burma-Indonesia and Korea-Japan survive. Hence, a broad picture of three rice trading regions emerges: one is Japanese imperial connection between Japan with Korea, another linking Taiwan, China, and Thailand, and the third tying India, Burma, and Indonesia together. 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.

Table 6 Estimation Results, 1914-36, Wheat

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

Notes: see Table 3.

Number of available regional wheat price series unfortunately declines sharply with the outbreak of the First World War, leaving only 10 cases (five exporters times two importers) to examine. Three of the forty estimated coefficients shown in Table 6 have wrong signs. If in four of the ten pairs are raw price correlations significant and positive, two of the four 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 potent global shocks. If French connections with Australia and the US end with the

outbreak of the First World War, Britain forms 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 would appear to have become less integrated after 1914.

Table 7 Estimation Results, 1961-94, Rice

	a_2	a_3	a_4	a_5	a_6	raw correlation	pure correlation
China-Bangladesh	2.31 (10.04)		-0.57 (1.89)		0.01 (0.25)	0.16	0.05
China-Indonesia	2.21 (13.26)		-0.40 (3.11)		0.16 (5.83)	0.35	0.13
China-Saudi Arabia	1.49 (11.01)		0.61 (5.02)		0.52 (19.41)	0.59**	0.11
China-Senegal	1.20 (9.56)	0.44 (9.99)	2.09 (17.64)	-0.22 (5.34)	0.72 (24.71)	0.73**	-0.36*
China-UK	1.76 (14.56)		1.66 (15.34)		0.25 (9.79)	0.47**	-0.09
Italy-Bangladesh	2.26 (14.67)		0.14 (0.41)		-0.37 (4.36)	-0.05	-0.21
Italy-Indonesia	1.10 (7.10)		-0.04 (0.31)		0.05 (1.70)	0.13	-0.18
Italy-Saudi Arabia	1.28 (10.06)	0.17 (3.13)	0.26 (2.86)	-0.03 (0.78)	0.57 (26.25)	0.69**	0.54**
Italy-Senegal	1.25 (10.42)		1.94 (18.34)		0.61 (23.44)	0.69**	-0.03
Italy-UK	1.24 (10.08)	0.41 (4.57)	0.90 (11.53)	-0.15 (2.70)	0.54 (27.93)	0.73**	-0.12
Pakistan-Bangladesh	0.03 (0.10)		-0.56 (2.37)		0.46 (11.26)	0.48**	0.11
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	(3.94)		(8.68)		(1.96)		
Arabia							
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	(13.76)		(1.15)		(47.05)		
Arabia							
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	(15.91)		(1.16)		(30.85)		
Arabia							
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.

Table 7 shows estimation results for twenty-five pairs of countries, formed by five largest rice exporters and importers, from 1961-94. With eight out of eighty-five coefficients associated with wrong signs, the outcome is worse than 1914-1936, but comparable with the pre-1914 period. Among the fourteen pairs showing significant raw price correlation, only five turn out actually to be integrated, indicating the presence of a strong common inflationary trend

after the Second World War. Thus, if 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. In sum, the picture of world rice market in 1961-94 appears both less integrated and more polarized than in 1914-36, which is probably attributable to a large extent to distortions due to government interventions, as represented by policies pursuing self-sufficiency in rice and industrialization via import-substitution, and government-to-government contract handling around half only world rice trade, which accounts for only about 4 percent of world rice output (vs. 8-9% in 1936-8).[5]

Table 8 Estimation Results, 1961-94, Wheat

	a_1	a_2	a_3	a_4	a_5	a_6	raw correlation	pure correlation
Argentina-Brazil		3.15 (28.05)		0.65 (9.94)		0.83 (60.60)	0.92**	-0.19
Argentina-China		4.01 (34.01)		0.52 (5.49)		0.64 (37.05)	0.89**	0.52**
Argentina-Egypt		3.63 (32.57)		0.23 (1.97)		0.78 (34.11)	0.86**	0.58**
Argentina-Italy		3.06 (28.50)		0.15 (1.38)		0.22 (9.19)	0.55**	-0.21
Argentina-Japan		2.95 (29.26)		0.22 (2.40)		0.72 (34.19)	0.85**	-0.37
Australia-Brazil		1.33 (11.23)	0.06 (4.86)	2.31 (25.15)	-0.07 (8.70)	0.72 (30.76)	0.75**	-0.24
Australia-China		2.66 (23.30)		0.96 (13.11)		0.63 (38.71)	0.86**	-0.36

[5] 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."

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.

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 signifcance 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). If the world wheat market seemed to become better integrated after WWII, but failed to recover the pre-1914 level of integration, again policy distortions appear be responsible, which include 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.[6]

IV. 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 influence of these shocks was filtered out of regional prices using a structural vector autoregression model. 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 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 seemed to become somewhat dislocated in 1914-36 as a consequence of hostilities and the Depression, rice economies, being relatively insulated from these disruptions,

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

became more closely linked. Although peace returned and protectionism receded after 1945, rice markets grew more fragmented, while 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.

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