Deriving the factor endowment-commodity output relationship for Thailand (1920-1929) using a three-factor two-good model

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Section 1.Introduction

Feeny (1982, p26-28) applied a three-factor two-good general equilibrium trade model (hereinafter 3 x 2 model) to data from Thailand before 1940 to analyze the terms of trade and trends in relative factor prices. His model is with 2 goods (rice and textiles), and 3 factors (land, labor and capital), where land is specific to agriculture. We call this type of model as an unsymmetrical specific factors model.

But, in a review of Feeny's work, I find that he made an error in his statement. In his Appendix 3, Feeny referred to the equations derived by Hueckel (see Feeny (1982, p169-170, Table A2-3), see also (Hueckel 1985, p72)). It seems that these equations include a serious mistake. It seems that Hueckel employed elasticity of substitution defined for 2 factors in both sectors. But he should use Allen-partial elasticity of substitution in sector 1, because sector 1 employed 3 factors.

Therefore, the question arises: Is Feeny's statement plausible? Notably, Feeny (1982, p28) stated, based on Table 3-16 (p27), 'The growth in the terms of trade and the growth in the labor and land stocks would be responsible for the large growth of rice output relative to textile output which occurred.'.

In other words, for example, Feeny concluded: Labor stocks affected rice output relative to textile output positively. However, this explanation are not self-evident. No one has analyzed about a sufficient condition for the labor stocks to affect the growth of rice output relative to textile output positively (or negatively), to the author's knowledge.

To the best of my knowledge, after Feeny and Hueckel, only Bliss (2003) alone referred to the unsymmetrical specific factors model. After Feeny, Williamson applied 3 X 2 model of the simplest type, what you call, specific-factors model to Thailand (1870-1939) (see Williamson (2002; p67-70)). The questions arise as follows:

(i) Especially about the factor endowment-commodity output relationship, what results can we derive if we analyze the 3 x 2 model properly?
(ii) What may we conclude if we apply these results derived to Thailand for the period 1920-1929?

Hardly any study has systematically analyzed question (i), at least about the sufficient condition for 'a strong Rybczynski result' to hold (or not to hold) in the 3 x 2 model of Batra and Casas (1976) (hereinafter BC)'s original type where all 3 factors are mobile (see Nakada (2015a, p2)). Nakada (2015a) tackled this question in a systematic manner, and derived some results. He concluded that if land and capital are economy-wide complements, ‘a strong Rybczynski result’ holds. Thereafter, Nakada (2015b) derived the sufficient condition for land and capital to be economy-wide complements.

According to Suzuki (1983, p141), BC contended in Theorem 6 (p34) that ‘if commodity 1 is relatively capital intensive and commodity 2 is relatively labor intensive, an increase in the supply of labor increases the output of commodity 2 and reduces the output of commodity 1.’ This is what ‘a strong Rybczynski result’ implies.

Further, no one has attempted answering question (ii). Purpose of this paper is to apply the results of Nakada (2015a, 2015b) to data from Thailand, and to derive the factor endowment-commodity output relationship in Thailand during the period 1920-1929. I restrict the analysis to this period, on account of data availability.

I show that land and capital are economy-wide complements. I start by deriving the trends of some variables for the period under study (on this, see Nakada (2015b, p26)).

In the model, I consider rice as exportable, and cotton textiles as importable. We consider land, capital, and labor as the 3 factors. It seems plausible that cotton products and cotton textiles made in Thailand compete with imported cotton textiles.

Section 2. Assumptions of the model and some results

Like BC (pp22-23), I make the following assumptions. Products and factors markets are perfectly competitive. Supply of all factors is perfectly inelastic. Production functions are homogeneous of degree one and strictly quasi-concave. All factors are not specific and perfectly mobile between sectors, and factor prices are perfectly flexible. These two ensure the full employment of all resources. The country is small and faces exogenously given world prices, or the movement in the relative price of a commodity is exogenously determined. The movements in factor endowments are also exogenously determined.

For additional definitions of the symbols used and derivations of the basic equations, see Nakada (2015a, 2015b).

Assumption (i) We assume about 'the factor intensity ranking' (see Jones; Easton (p69) (hereinafter JE), see also BC (pp26-27), Suzuki (1983, p142),). That is, we assume that sector 1 is relatively land intensive, and sector 2 is relatively capital intensive, and that labor is the middle factor, and land and capital are extreme factors (see also Ruffin (1981, p180)).

Assumption (ii) We assume about 'the factor intensity ranking for middle factor (on this, see JE (1983, p70))'. It implies, 'the middle factor is used relatively intensively in the first industry.'

Rybczynski matrix (to use Thompson's terminology (1985, p619)) in elasticity terms is (see Nakada (2015a)):

$$[X_j*/V_i*]=\begin{bmatrix} X_1*/V_T* & X_1*/V_K* & X_1*/V_L* \\ X_2*/V_T* & X_2*/V_K* & X_2*/V_L* \end{bmatrix}. \quad (1)$$

where X_j denotes the amount produced of good j (j=l, 2); V_i is the supply of factor i, where, $i=T,K,L, j=1, 2.$ T is the land, K capital, and L labor. The asterisk denotes the rate of change (e.g., $X_j*=dX_j/X_j$).

The following result has been established already (Nakada 2015a, section 10). I have rearranged it below.

Theorem 1. If extreme factors are economy-wide complements, ‘a strong Rybczynski result’ holds necessarily. In this case, Rybczynski sign patterns (to use Thompson’s terminology (1985, p619)) for subregion P1-P3 are:

$$\begin{array}{cccc} & P1 & P2 & P3 \\ \text{sign}[X_j*/V_i*]= & \begin{bmatrix} + & - & - \\ - & + & + \end{bmatrix} & \begin{bmatrix} + & - & + \\ - & + & + \end{bmatrix} & \begin{bmatrix} + & - & + \\ - & + & - \end{bmatrix}. \quad (2) \end{array}$$

Each sign pattern shows the factor endowment-commodity output relationship. Especially, the sign of Column 3 shows the labor endowment-commodity output relationship.

(2) implies as follows. An increase in the supply of land increases the output of commodity 1 and reduces the output of commodity 2. And, an increase in the supply of capital increases the output of commodity 2 and reduces the output of commodity 1.

But, it is indeterminate how an increase in the supply of labor affects the output of commodity 1 and 2. There are 3 patterns possible.

The following result has been established already (see Nakada (2015b)). I have rearranged a little.

Theorem 2. If we assume

P>0, (3)

$$(X > Z > Y \leftrightarrow \mathrm{w_T}{*} - \mathrm{p_1}{*} > \mathrm{w_L}{*} - \mathrm{p_1}{*} > \mathrm{w_K}{*} - \mathrm{p_1}{*}), \quad (4)$$

$$(a_{T0}', a_{K0}', a_{L0}') = (+,+,-), \quad (5)$$

we derive

$$\frac{-W_{TL}}{W_{KL}} < S' < \alpha_0 \theta_{KT}, \frac{\theta_L}{\theta_K} \frac{-W_{LT}}{W_{KT}} > \mathrm{U}' > \beta_0, \quad (6)$$

$$(S', U') = (+,-) \leftrightarrow \quad (S, \mathrm{T}, U) = (g_{LK}, g_{LT}, g_{KT}) = (+,+,-). \quad (7)$$

This implies that extreme factors are economy-wide complements.

The symbols are defined as follows:

$$P = (p_1 / p_2)* = p_1 * - p_2 *, \quad (8)$$

$$(X, Y, Z) = (w_{T1}*, w_{K1}*, w_{L1}*) = (w_T * - \mathrm{p_1}*, w_K * - \mathrm{p_1}*, w_L * - \mathrm{p_1}*), \quad (9)$$

$$a_{i0}' = \sum_j \lambda_{ij} a_{ij}*, \mathrm{i} = T, K, L, \quad (10)$$

where $w_{ij} = w_i / p_j$, $w_{ij}* = (w_i / p_j)* = w_i * - p_j *$. P is the rate of change in the relative price of a commodity; w_i is the reward of factor i; p_j is the price of good j; w_{ij} is the real factor price measured by good j; a_{ij} is the requirement of input i per unit of output of good j (or the input-output coefficient); λ_{ij} is the proportion of the total supply of factor i in sector j (that is, $\lambda_{ij}=a_{ij} X_j / V_i$). Note that $\Sigma_j \lambda_{ij}=1$; a_{i0}'is the aggregate of rate of change of the input-output-coefficient. In addition, definition of symbols are:

$$(S', U')=(S/T, U/T), (S, T, U)=(g_{LK}, g_{LT}, g_{KT}), \quad (11)$$

We call (S', U') the 'economy-wide substitution' (EWS)-ratio vector. g_{ih} is the EWS between factors i and h, as defined by JE (p75).

We may also define (i≠h) (see Nakada (2015a)),

Factors i and h are economy-wide substitutes, if $g_{ih} >0$; and

Factors i and h are economy-wide complements, if $g_{ih} <0$. (12)

For additional details of the other symbols, see Nakada (2015a, 2015b).

Section 3. Estimating the sign of some variables and factor-price-change-ranking

We can derive 'the factor intensity ranking' as shown in Assumption (i). About 'the factor intensity ranking of middle factor', we assume as shown in Assumption (ii).

We will prove whether (3)-(5) hold or not, for the period 1920-1929. That is,

P>0, (13)

$(X > Z > Y \leftrightarrow w_T^* - p_I^* > w_L^* - p_I^* > w_K^* - p_I^*)$, (14)

$(a_{T0}', a_{K0}', a_{L0}') = (+,+,-)$, (15)

(13) implies that relative price of a commodity price increased. We call (14) 'factor-price-change-ranking'. (14) implies that the rate of change in real reward for labor is intermediate (or middle), and the rate of change in real reward for land and capital are

extreme (see Nakada (2015b, p7-8, eq. (31)). (15) implies as follows. The aggregate of rate of change in input-output-coefficient of land and capital increased. But, the aggregate of rate of change in input-output-coefficient of labor decreased.

We can easily show that (13) holds. We prove whether (14) holds or not.

We analyze the real wage in the period of 1864-1938. Some authors have mentioned about wage in Thailand before World War II. For example, see Skinner (1957: p172-174), Ingram (1964: p113-117), Feeny (1982: 34), Sompop (1989: Table 6.4, p164-166; Table 6.7, p168).

Ingram stated, “The trend of this rice wage-rate...was downward from the 1820's to about 1910, after which it recovered slightly in the 1920's and rose sharply with the onset of the depression in

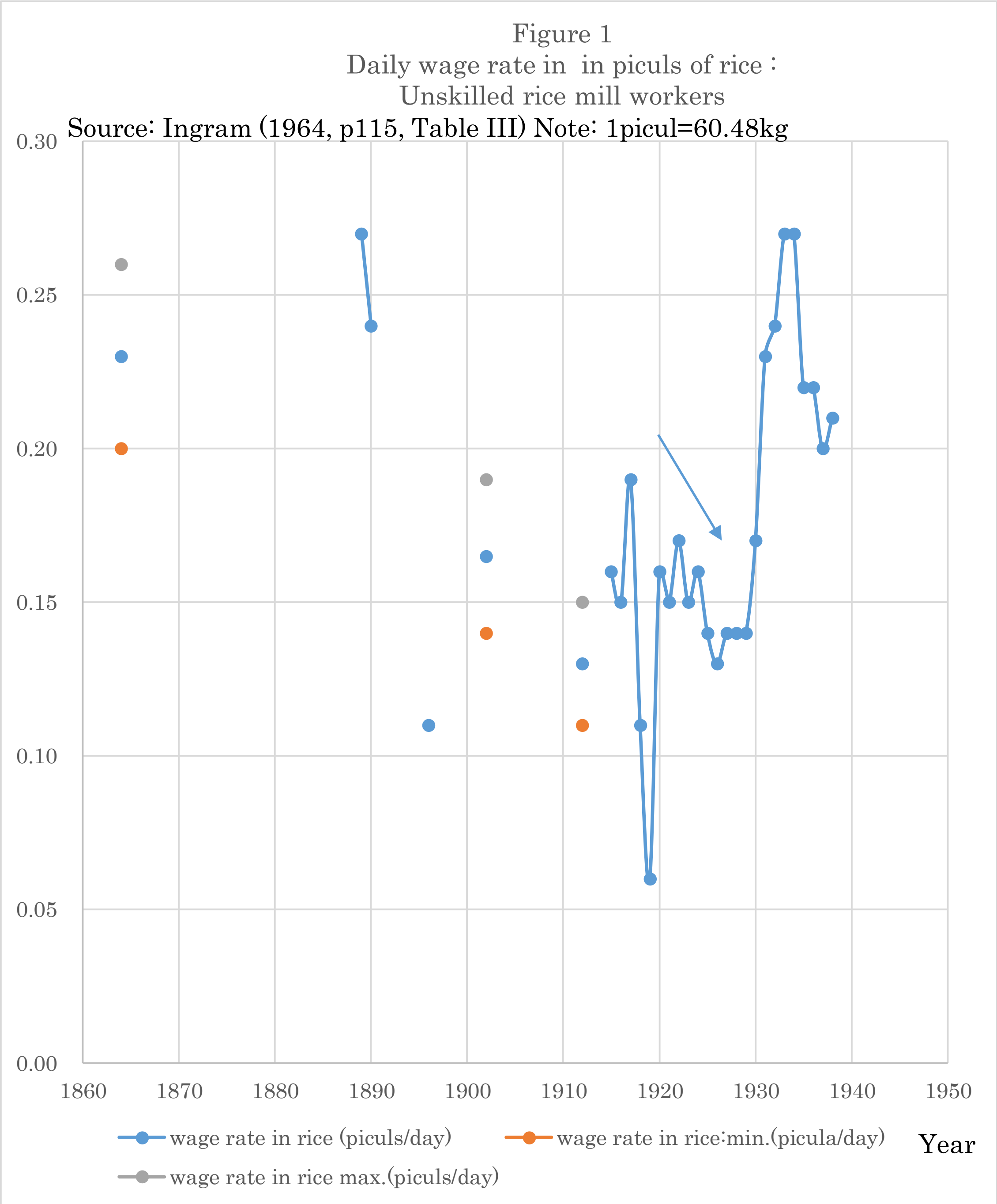


Figure 1
Daily wage rate in in piculs of rice :
Unskilled rice mill workers
Source: Ingram (1964, p115, Table III) Note: 1picul=60.48kg
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
Year
wage rate in rice (piculs/day)
wage rate in rice:min.(picula/day)
wage rate in rice max.(piculs/day)

1930…."(see Ingram 1964: 112). However, his statement does not provide exact value.

Figure 1 plots the daily wages of unskilled ('coolie') laborers. The wage data are not available so much. Ingram (1964, p112) noted, 'The sharp drop [of rice wage-rate] in 1919 was the result of a severe crop failure in which rice prices rose drastically and an embargo was put on rice.' Using this information, we can trace the trends in the rice wage-rate as follows.

During 1920-1929, it decreased a little.

Next, we analyze the rent in the period of 1880-1941. But, data on rent are not available so much. Therefore, I attempt to use the land price instead. The lack of land prices in the same area leads me to use the data provided in Johnston (1975) and Feeny

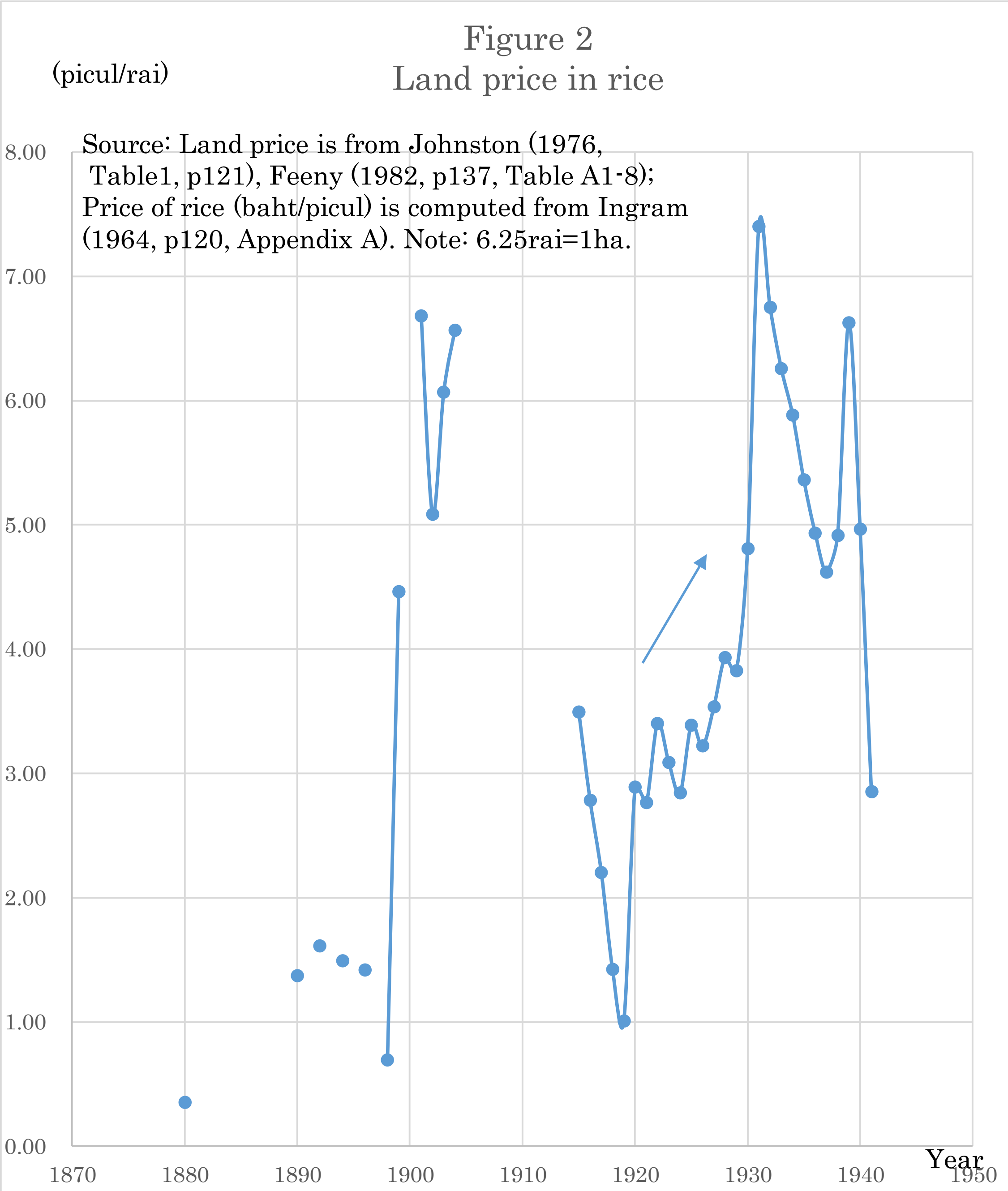


Figure 2
Land price in rice
(picul/rai)
Source: Land price is from Johnston (1976, Table1, p121), Feeny (1982, p137, Table A1-8); Price of rice (baht/picul) is computed from Ingram (1964, p120, Appendix A). Note: 6.25rai=1ha.
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1870
1880
1890
1900
1910
1920
1930
1940
1950
Year

(1982).

Using the data of Johnston (1975, p121) and Feeny (1982), **Figure** 2 presents the land price in terms of rice in the period of 1880-1904, and 1915-1941. Unfortunately, land price data for the period 1904-1915 are not available to the extent needed.

The following trend may be observed with respect to the real land price measured by rice.

During 1919-1931, it increased.

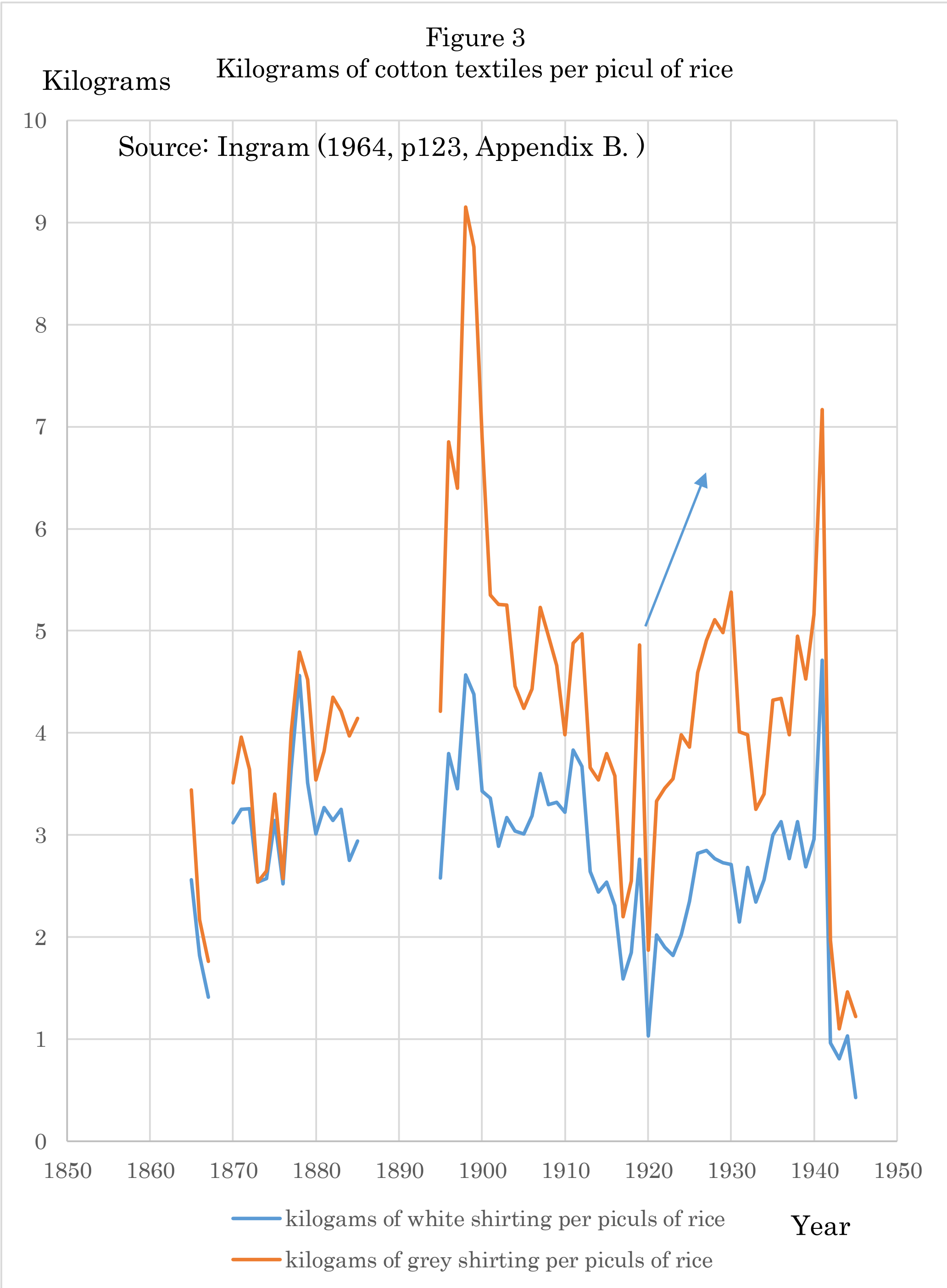


Figure 3
Kilograms of cotton textiles per picul of rice
Kilograms
Source: Ingram (1964, p123, Appendix B.)
10
9
8
7
6
5
4
3
2
1
0
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
Year
kilogams of white shirting per piculs of rice
kilogams of grey shirting per piculs of rice

We analyze the terms of trade, that is, kilograms of grey (and white) shirting per picul of rice. **Figure** 3 presents the terms of trade for the period 1864-1945.

The following trend for terms of trade is evident.

During 1920-1929, terms of trade increased.

Figure 4 summarizes the trend of 3 variables mentioned above. In the period of around 1920-1929, the terms of trade increased. The real wage measured by rice decreased. The land price in rice increased.

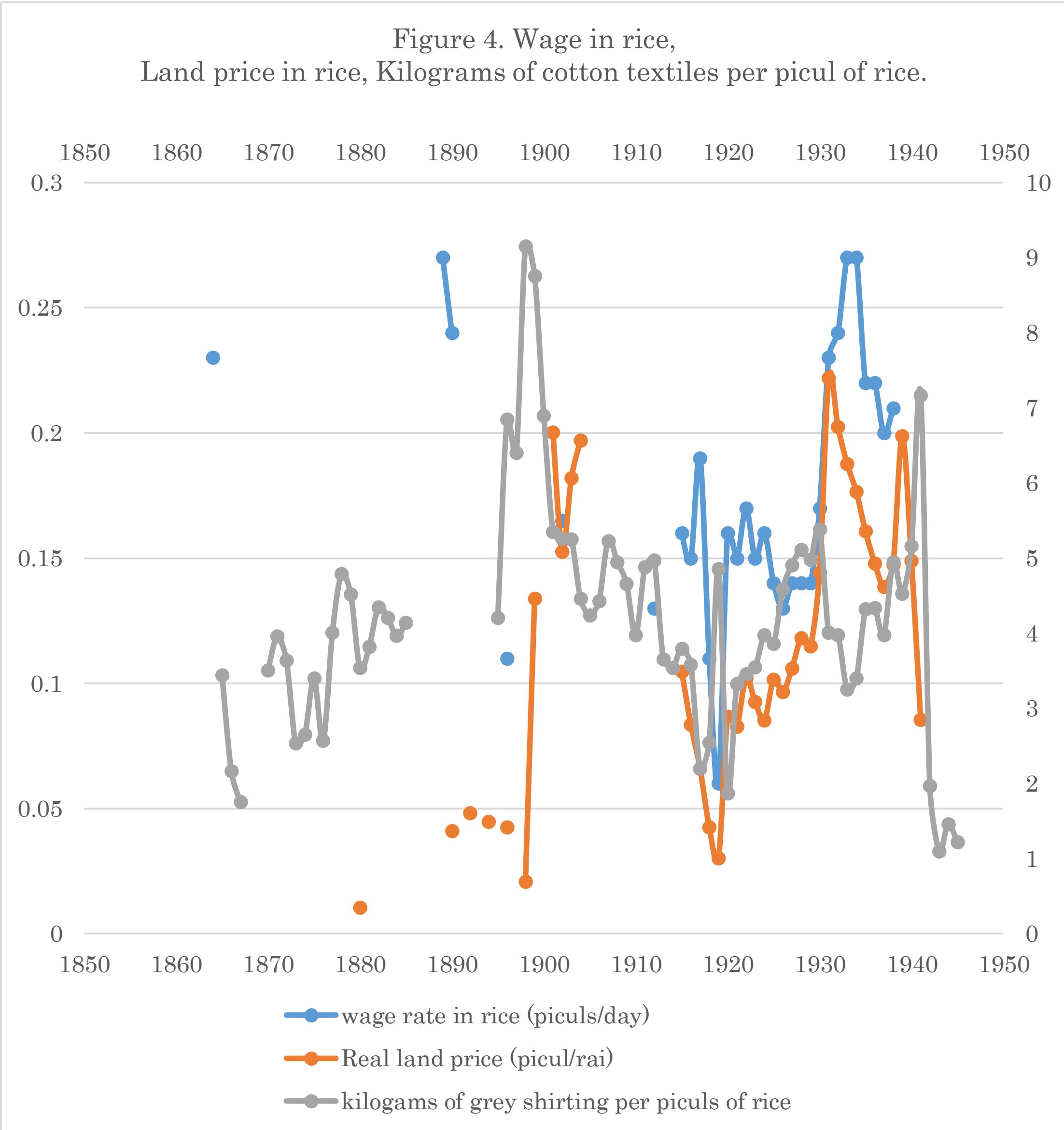


Figure 4. Wage in rice,
Land price in rice, Kilograms of cotton textiles per picul of rice.
1850 1860 1870 1880 1890 1900 1910 1920 1930 1940 1950
0.3 0.25 0.2 0.15 0.1 0.05 0
10 9 8 7 6 5 4 3 2 1 0
wage rate in rice (piculs/day)
Real land price (picul/rai)
kilogams of grey shirting per piculs of rice

Under the assumption of P>0, only 4 rankings are possible, that is (see Nakada (2015b, (30), p8)),

X>Y>Z, X>Z>Y, Z>X>Y, Z>Y>X. (16)

Either of the 4 patterns is possible.

From the data, I derive a rate of change for some variables per year, for the period 1920-1929 as follows:

$$P = (p_1{*} - p_2{*}) = +10.88\%, X(= \mathrm{w_T}{*} - \mathrm{p_1}{*}) = +3.13\%, Z(= \mathrm{w_L}{*} - \mathrm{p_1}{*}) = -1.48\%$$

(17)

Hence, I show that

$$P > 0,\ X > Z > -P(> \frac{-\theta_{T1}}{A} P), \quad (18)$$

where A= $\theta_{T1} - \theta_{T2}$. $(-\theta_{T1}/A)P$ is the S' value of intersection point of Line-Y and Line-Z. We can draw these lines by using eq. (27) in Nakada (2015b, p7). If (18) holds, I derive,

$P > 0,\ X > Z(> -P) > Y$. (19)

Hence, we have shown that (13) and (14) hold.

However, (15) is not self-evident. If (13) and (14) hold, we can show that the sign A, B, C, and D are possible in sector j. That is,

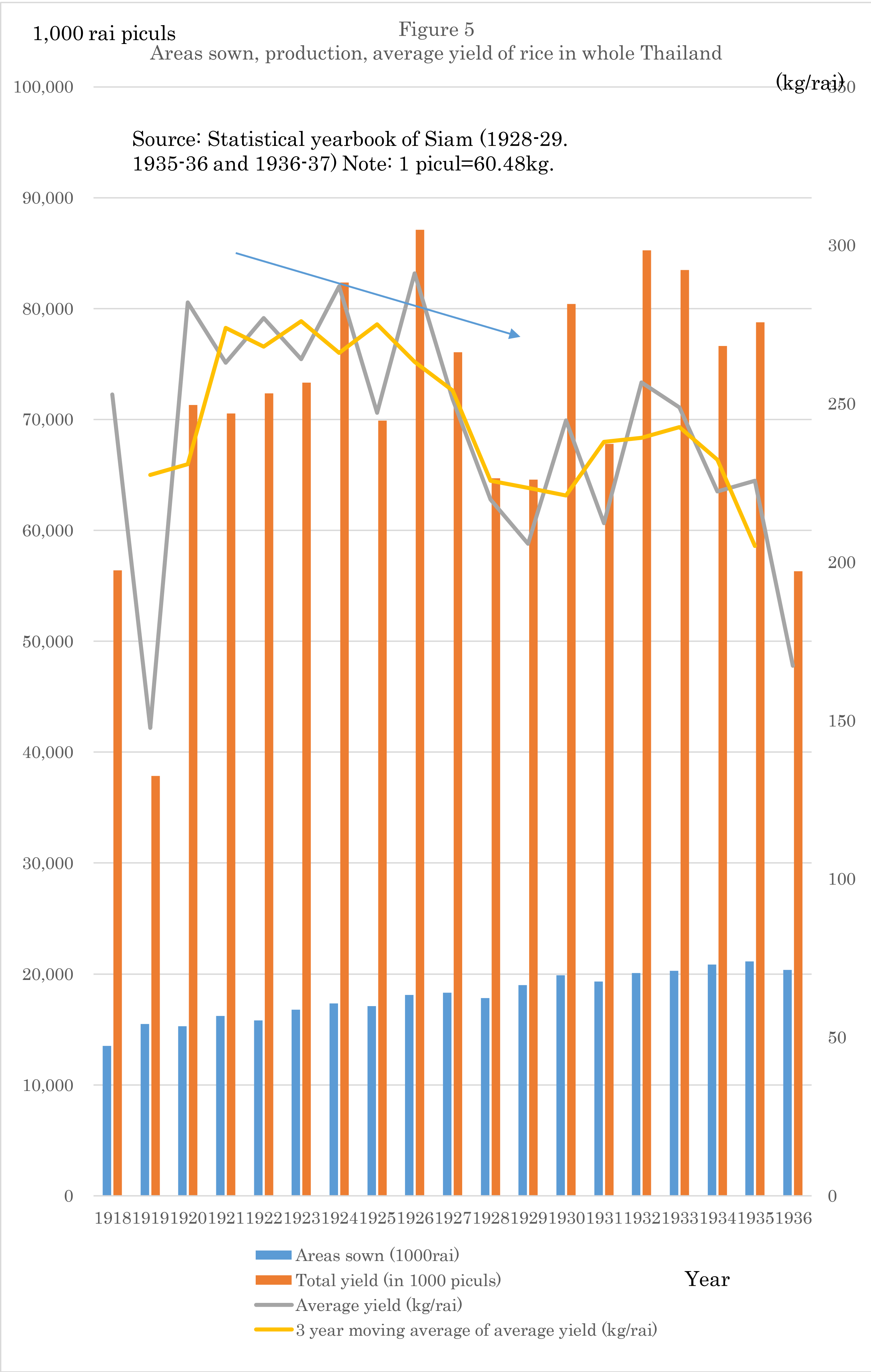
A, B, C, D

$(a_{Tj}^*, a_{Kj}^*, a_{Lj}^*) = (-,+,-), (-,+,+), (+,+,-), (-,-,+),\ \mathrm{j} = 1.2.$ (20)

I do not show the derivation of (20). We can derive (20) from the equation of Hj/pj <0.

For the definition of H_j, see Nakada (2015b, eq. (80), p15; eq. (82), p16)). For example, if sign C holds, this implies that the input-output-coefficient of land and capital in sector j increased, but the input-output-coefficient of labor in sector j decreased.

We estimate the sign of $a_{i1}{}^*$, that is, the rate of change in input-output coefficient in sector 1. Multiply the rate of change in average yield of rice by (-1), we can derive it. First, we observe the change in average yield of rice.



1,000 rai piculs
Figure 5
Areas sown, production, average yield of rice in whole Thailand
(kg/rai)
Source: Statistical yearbook of Siam (1928-29. 1935-36 and 1936-37) Note: 1 picul=60.48kg.
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
350
300
250
200
150
100
50
0
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
Areas sown (1000rai)
Total yield (in 1000 piculs)
Average yield (kg/rai)
3 year moving average of average yield (kg/rai)
Year

Figure 5 shows the production, area sown, and average yield of rice in Thailand (1918-1936). I also indicate the 3-year moving average of average yield.

Thus, the trend in the average yield of rice (kg/rai) may be determined as follows.

The average yield (kg/rai) decreased for the period 1920-1929.

Hence,

$a_{T1}* = (+)$, for 1920-1929. (21)

Similarly, we can estimate the sign of $a_{i2}*$. First, we observe the change in average yield of cotton.

Figure 6
Areas sown, production, and average yield of cotton in whole Thailand

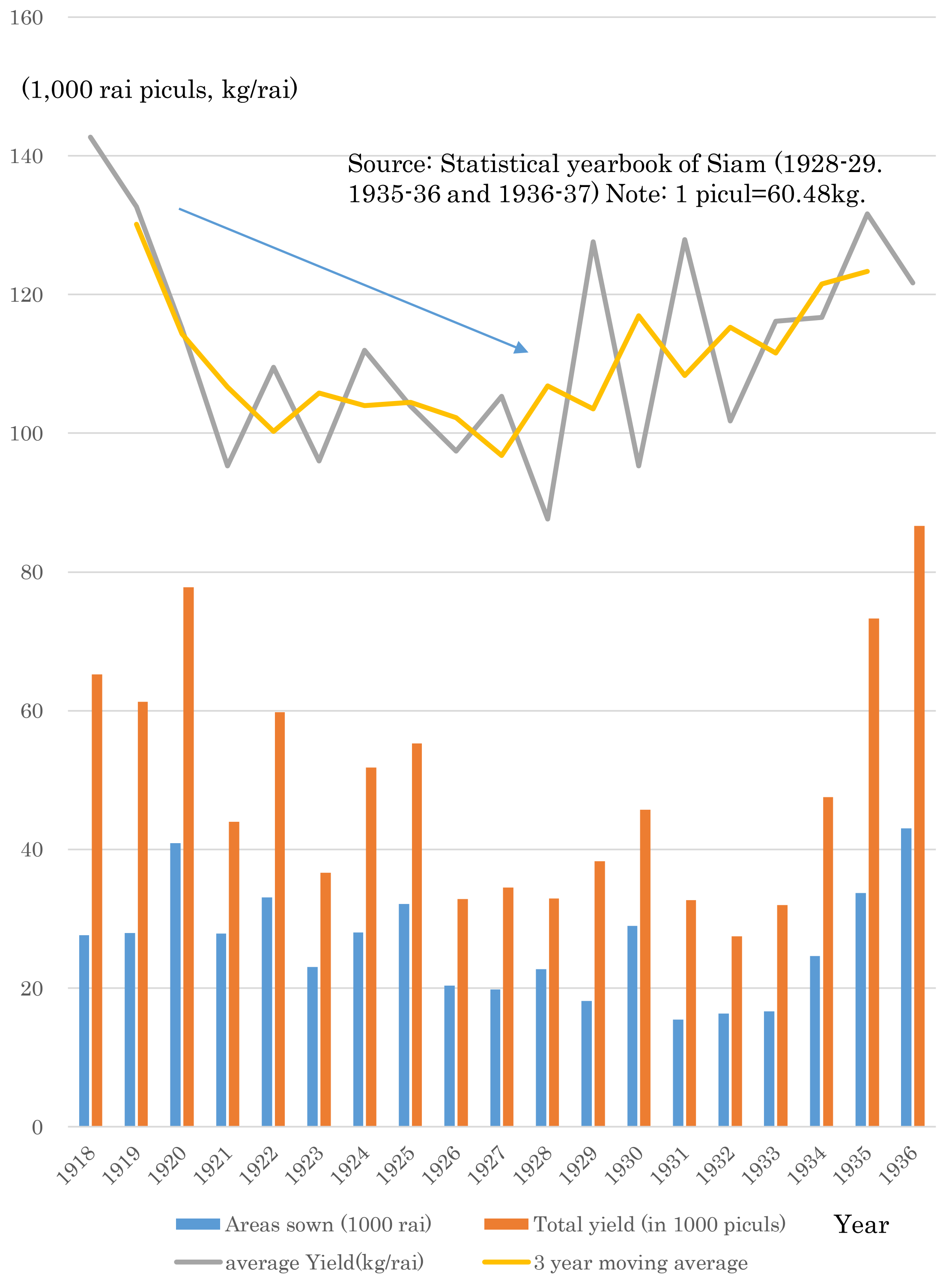


Figure 6 shows the production, area sown, and average yield (kg/rai) of cotton in Thailand during 1918-1936. I also indicate the 3-year moving average of the average yield.

Based on this information, we can decipher the trend in the average yield as follows.

The average yield decreased for the period 1918-1928.

Hence,

$a_{T2}* = (+)$, for 1918-1928. (22)

In sum, from (21) and (22), we derive in sector 1 and 2, respectively,

$a_{T1}* = (+)$, for 1920-1929. (23)

$a_{T2}* = (+)$, for 1918-1928. (24)

From (20) and(23), and from (20) and(24), we can derive, for around 1920-1929, respectively:

$(a_{T1}*, a_{K1}*, a_{L1}*) = (+,+,-)$. (25)

$(a_{T2}*, a_{K2}*, a_{L2}*) = (+,+,-)$. (26)

Substitute (25)and (26) in(10), we can derive for that period:

$(a_{T0}', a_{K0}', a_{L0}') = (+,+,-)$. (27)

From(27), (15) holds. Hence, we have shown that (13),(14), and(15) hold.

Section 4. Deriving the factor endowment-commodity output relationship

From the above, we have proved that (3)-(5) holds. From Theorem 2, this implies that extreme factors are economy-wide complements.

Hence, in this case, from Theorem 1, ‘a strong Rybczynski result’ holds necessarily. We determine Rybczynski sign patterns for each subregion (see(2)) as seen below.

$$\begin{array}{cccc} & \text{P1} \quad \text{P2} & & \text{P3} \\ \text{sign}[X_j^*/V_i^*]= & \begin{bmatrix} + & - & - \\ - & + & + \end{bmatrix} & \begin{bmatrix} + & - & + \\ - & + & + \end{bmatrix} & \begin{bmatrix} + & - & + \\ - & + & - \end{bmatrix}. \end{array} \quad (28)$$

Each sign pattern shows the factor endowment-commodity output relationship. Notably, the sign in Column 3 shows the labor endowment-commodity output relationship.

Therefore, we can make the following statement.

(i) If the EWS-ratio vector (S', U') exists in subregion P1, labor endowment affects commodity output in sector 1 negatively, and affects commodity output in sector 2 positively.

(ii) If the EWS-ratio vector exists in subregion P2, labor endowment affects commodity output both in sector 1 and 2 positively.

(iii) If the EWS-ratio vector exists in subregion P3, labor endowment affects commodity output in sector 1 positively, and affects commodity output in sector 2 negatively.

From (28), we derive, for example, in case of P1,P2, and P3, respectively:

$$X_1^*/V_L^* - X_2^*/V_L^* = (-)-(+)=(-), \quad (29)$$

$$X_1^*/V_L^* - X_2^*/V_L^* = (+)-(+)=(?), \quad (30)$$

or $$X_1^*/V_L^* - X_2^*/V_L^* = (+)-(-)=(+), \quad (31)$$

where

$$X_1^*/V_L^* - X_2^*/V_L^* = (X_1/X_2)^*/V_L^* . \quad (32)$$

The sign of (32) shows how labor endowment affected the commodity output in sector 1 relative to commodity output in sector 2. (29) is against the statement of Feeny. (30) might be contrary to it. (31) is not against it. At the very least, Feeny's statement (1982, p28) that the growth in the labor stocks would be responsible for the large growth of rice output relative to textile output which occurred, is not self-evident.

Section 5. Conclusion

In this paper, we assumed a certain pattern of factor intensity ranking, including that of middle factor. We can draw the following conclusions for the data pertaining to Thailand for the period 1920-1929 as follows. Land and capital, extreme factors, were economy-wide complements. Hence, ‘a strong Rybczynski result’ holds necessarily. We derived 3 Rybczynski sign patterns.

The results imply that the statement of Feeny (p28) that the growth in the labor (or middle factor) stock was responsible for the large growth in rice output relative to textile output in Thailand, might not hold necessarily.

To some extent, our resuts show how Chinese immigration affected commodity output in Thailand between 1920 and 1929. For example, Skinner stated, ‘[During 1918-1931], Chinese flocked into Siam at an unprecedented rate...This mass influx of Chinese resulted, quite simply, from favorable conditions in Siam and unfavorable conditions in south China. (see Skinner (1957, p172-174))'

However, if we wish to derive the sign of (32) with certainty, we would need to conduct the analysis differently.

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