RETHINKING THE PRODUCTIVITY OF JAPANESE AGRICULTURE IN 1930S

A PANEL DATA ANALYSIS USING THE THIRD PERIOD MAF SURVEY OF FARM HOUSEHOLD ECONOMY

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1. INTRODUCTION

- Japan experienced the **Showa Depression** in 1930 – in the midst of the interwar period.
- It had large impact on farm economy.
  In 1931, rice price and farm income per labor hour scored the lowest level of the interwar period (Fujie and Senda 2011, Sakane 2010).
- Also, environments surrounding agricultural production changed in the interwar period.

1. INTRODUCTION

- People migrated to urban area came back to rural area. ⟹ oversupply of agricultural labor.
- Landlord–tenant system collapsed and tenancy disputes occurred (Kojima 2008, Sakane 2011).
- Number of Landed-tenant farmers with medium size of land increased, and the size of managed land converged to about 2 ha (Kurihara 1948).

Need for measuring productivity of inputs.

2. LITERATURE REVIEW

Table 1. Production elasticity of previous studies

	Akino and Hayami 1974, Hayami 1973, (Akino 1972)		Shintani 1983	Minami 1981	
	1930-1935	(1930-1935)	1934-1936	1931-1935	1936-1940
Land	0.15	0.38	0.4	0.63	0.57
Labor	0.4	0.31	0.45	0.21	0.29
Capital	0.15	0.06	0.15	0.15	0.13
Misc. goods	0.3	0.26			

Note:
Akino and Hayami 1974, Hayami 1973, and Akino 1972 used prefectural level data.
Shintani 1983 used the same database as ours, however the use of the data was limited. Shintani did not impose CRS at the time of estimation.
Minami 1981 used prefectural data.

2. LITERATURE REVIEW

- Relatively large variations in estimates.
- Agriculture might adjust to adopt labor-intensive and -responsive production technology (Shintani 1983).
- ⟺Industries already needed a certain amount of labor before the Depression. Fertilizer-using technology was also important for production in the interwar period (Hayami 1973).
- The variations might also be caused by data availability and difference in specifications.

2. LITERATURE REVIEW

- In addition to the variations in estimates, these studies have one feature: assumption of **constant returns to scale (CRS)**
- Reasons are limitation in data availability and computational circumstance.
- In recent years, Hitotsubashi University has been constructing panel database of farm household surveys in this period. This study provides experimental research on agricultural production function.

3. THE MAF SFHE DATABASE

In Japan, data on farm household economy has been collected since 1890s.

- The Mankichi Saito survey, 1909–1920
- The Teikoku Nokai survey, 1913–1915
- The MAF survey (first period), 1921–1923
- The MAF survey (second period), 1924–1930
- **The MAF survey (third period), 1931–1941**
- The MAF survey (fourth period), 1942–1948

(MAF: Ministry of Agriculture and Forestry, SFHE: Survey of Farm Household Economy)

3. THE MAF SFHE DATABASE

Our Data (the third period MAF survey)

- 16 prefectures and 11 years.
- 1079 observations (224 households), with basically six or nine households in each prefecture per year.

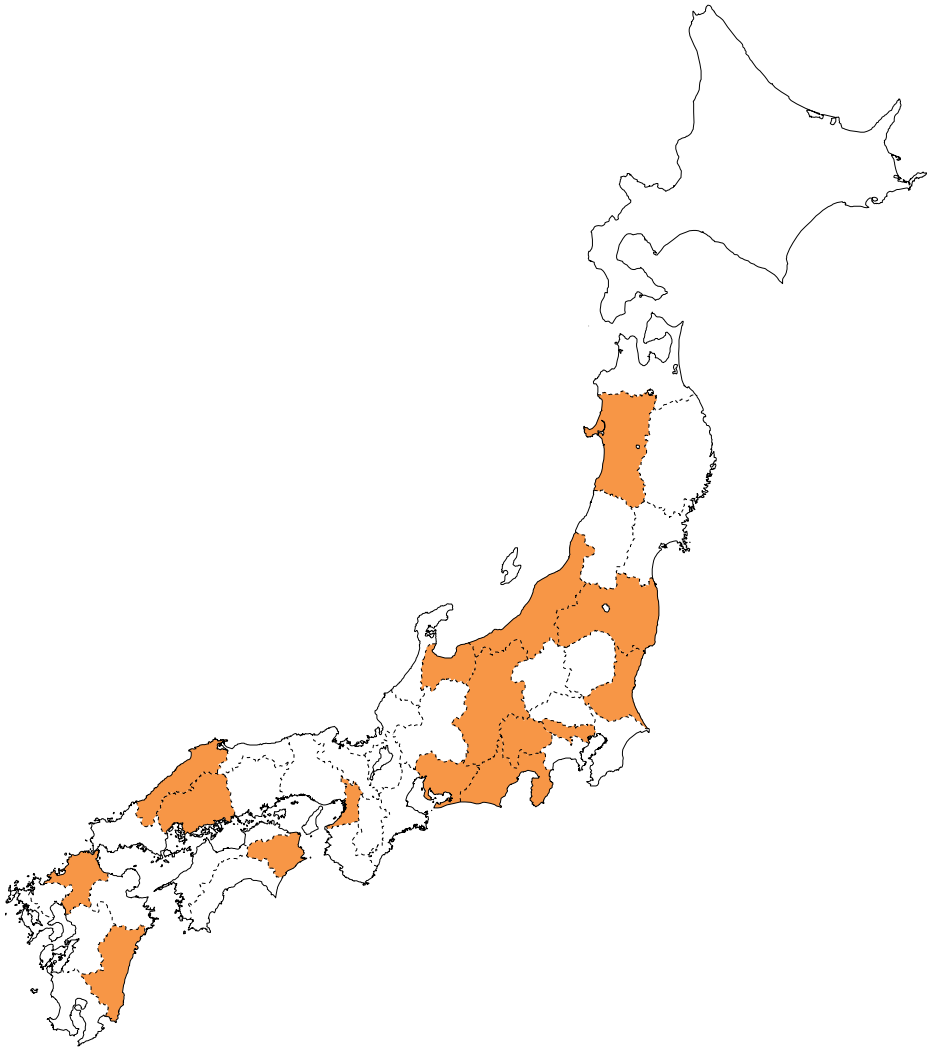

Figure 1. Locations of prefectures used in our data (Orange)

3. THE MAF SFHE DATABASE

Our Data (the third period MAF survey)

- NOT random sampling and NOT balanced.
- Since bookkeeping requires literacy, selected farmers tended to manage relatively larger areas of land than average.
- However, upward bias is smaller than other surveys (Senda and Kusadokoro 2009)

4. STATIC MODELS

- **Estimation without assumption of CRS**
- Standard Cobb-Douglas production function to compare results with previous studies.
- Estimated models
  - Pooled OLS
  - Random effect model (RE)
  - Fixed effect model (FE)
- No assumption of CRS

4. STATIC MODELS

- $y_{it} = \beta_l l_{it} + \beta_h h_{it} + \beta_c c_{it} + \beta_g g_{it} + u_{it}$ (1)

Variables

y_{it} : log of Y_{it}

l_{it} : log of L_{it}

h_{it} : log of H_{it}

c_{it} : log of C_{it}

g_{it} : log of G_{it}

u_{it} : error term

Table 2. Descriptive statistics

(Obs. 1079)

	Description (unit)	Mean	S.D.
Y_{it}	Value of farm output (1,000JPY)	1.167	0.563
L_{it}	Cultivated land (cho)	1.311	0.576
H_{it}	Labor hour (1,000 hour)	5.271	2.191
C_{it}	Value of capital (1,000JPY)	1.043	0.853
G_{it}	Value of miscellaneous goods (1,000JPY)	0.229	0.216

Source: The third period MAF survey.

Note: Unit 'cho' is approximately 9917 m^2.

Table 3. Estimation results of static models

	OLS		RE		FE	
Land (β_l)	0.401	***	0.299	***	0.118	***
	(0.020)		(0.027)		(0.042)	
Labor (β_h)	0.221	***	0.250	***	0.239	***
	(0.022)		(0.023)		(0.027)	
Capital (β_c)	0.051	***	0.098	***	0.097	***
	(0.013)		(0.019)		(0.032)	
Misc. goods (β_g)	0.282	***	0.261	***	0.234	***
	(0.012)		(0.014)		(0.017)	
Adj. R-squared	0.777					
Breusch Pagan test			774.85			
(p-value)			0.000			
F-test					6.68	
(p-value)					0.000	
Hausman test				20.48		
(p-value)				0.116		
Elasticity of scale	0.955		0.908		0.688	
CRS (p-value)	0.012		0.001		0.000	

Note: ***, **, and * indicate significance at 1%, 5%, and10% level respectively.

4. STATIC MODELS

- Each value scores the lowest level of previous studies, and CRS is rejected in all models.
- In FE, β_l is low. Just absorbed by fixed effect (caused by conversion of land size to 2ha)?

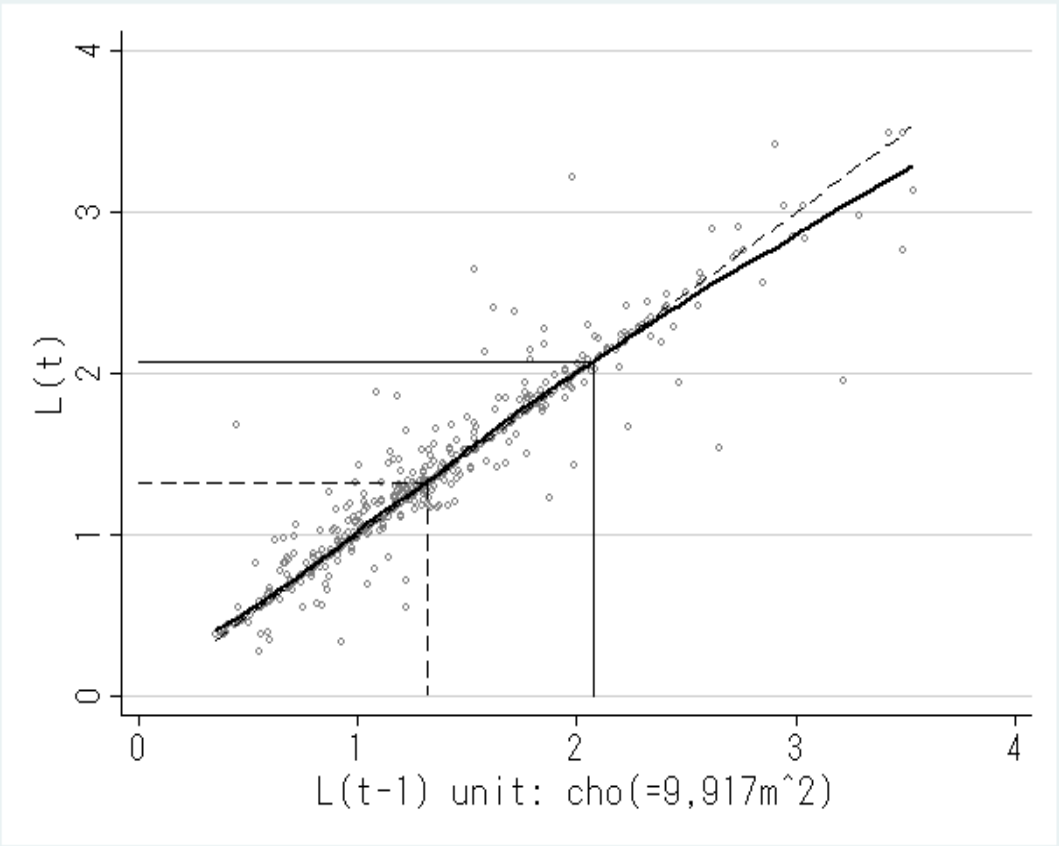

Figure 2. Nonparametric estimation of cultivated land

Source: Kusadokoro, Maru and Takashima 2012

4. STATIC MODELS

- **Estimation with imposing CRS**
- Regress output per land (Y_{it} / L_{it}) to inputs per land (H_{it}/L_{it}, C_{it}/L_{it}, G_{it}/L_{it}).
- $$y_{it} - l_{it} = \beta'_h(h_{it} - l_{it}) + \beta'_c(c_{it} - l_{it}) + \beta'_g(g_{it} - l_{it}) + u'_{it}$$
- After estimation, elasticity value of land (β'_l) is calculated.

Table 4. Estimation results of static models (CRS)

	OLS		RE		FE	
Land (β'_l)	0.417		0.344		0.276	
Labor (β'_h)	0.246	***	0.278	***	0.289	***
	(0.020)		(0.022)		(0.026)	
Capital (β'_c)	0.058	***	0.115	***	0.184	***
	(0.013)		(0.018)		(0.029)	
Misc. goods (β'_g)	0.279	***	0.263	***	0.251	***
	(0.012)		(0.014)		(0.017)	
Adj. R-squared	0.577					
Breusch Pagan test			790.36			
(p-value)			0.000			
F-test					6.33	
(p-value)					0.000	
Hausman test				45.78		
(p-value)				0.000		

Note: ***, **, and * indicate significance at 1%, 5%, and10% level respectively.
β_l is calculated after the estimation.

4. STATIC MODELS

Table 5. Result comparison of static models

	Not-imposing CRS			Imposing CRS		
	OLS	RE	FE	OLS	RE	FE
Land	0.401	0.299	0.118	0.417	0.344	0.276
Labor	0.221	0.250	0.239	0.246	0.278	0.289
Capital	0.051	0.098	0.097	0.058	0.115	0.184
Misc. goods	0.282	0.261	0.234	0.279	0.263	0.251

4. STATIC MODELS

- **Without assumption of CRS**
  RE is adopted and CRS is rejected.
  β_l is low in FE.
- **With assumption of CRS**
  Elasticity values are boosted (especially in FE).
  Each elasticity value shows relatively large difference among models.

- Dynamic model (Blundell and Bond 2000)

5. DYNAMIC MODEL

Methodology

System GMM (Blundell and Bond 2000)

- Error term in equation (1) is specified as

$$u_{it} = \gamma_t + (\eta_i + v_{it} + m_{it}),$$
$$v_{it} = \rho v_{i,t-1} + e_{it},\ |\rho| < 1,\ e_{it}, m_{it} \sim MA(0)$$

γ_t : year-specific intercept
η_i : unobserved farm-specific effect
v_{it} : possibly autoregressive shock
m_{it} : serially uncorrelated measurement error
e_{it} : productivity shock

5. DYNAMIC MODEL

- To estimate the parameters of the restricted model (1), a dynamic (common factor) representation of (1) is adopted as

$$
\begin{aligned}
y_{it} = {} & \beta_l l_{it} - \rho\beta_l l_{i,t-1} + \beta_h h_{it} - \rho\beta_h h_{i,t-1} \\
& + \beta_c c_{it} - \rho\beta_c c_{i,t-1} + \beta_g g_{it} - \rho\beta_g g_{i,t-1} \\
& + \rho y_{it-1} + (\gamma_t - \rho\gamma_{t-1}) \\
& + \{\eta_i(1-\rho) + e_{it} + m_{it} - \rho m_{it-1}\}
\end{aligned}
$$

5. DYNAMIC MODEL

- Or, an unrestricted model expression

$$y_{it} = \pi_1 l_{it} + \pi_2 l_{i,t-1} + \pi_3 h_{it} + \pi_4 h_{i,t-1} + \pi_5 c_{it} + \pi_6 c_{i,t-1} + \pi_7 g_{it} + \pi_8 g_{i,t-1} + \pi_9 y_{it-1} + \gamma_t^* + (\eta_i^* + w_{it})$$

- Common factor restrictions

$$\pi_2 = -\pi_1\pi_9,\ \pi_4 = -\pi_3\pi_9,\ \pi_6 = -\pi_5\pi_9,\ \pi_8 = -\pi_7\pi_9$$

- $\gamma_t^* = \gamma_t - \rho\gamma_{t-1},\ \eta_i^* = \eta_i(1-\rho),$

$$w_{it} = \begin{cases} e_{it} \sim MA(0) \\ e_{it} + m_{it} - \rho m_{it-1} \sim MA(1) \end{cases}$$

Table 7. Result of dynamic model

Unrestricted Model	Lag: t-2		Lag: t-3	
Land (π_1)	0.104	(0.117)	0.216	(0.135)
- Lagged (π_2)	0.006	(0.065)	0.107	(0.148)
Labor (π_3)	0.280	(0.123) **	0.137	(0.114)
- Lagged (π_4)	0.083	(0.108)	-0.023	(0.118)
Capital (π_5)	0.059	(0.118)	0.126	(0.128)
- Lagged (π_6)	-0.139	(0.120)	-0.187	(0.129)
Misc. goods (π_7)	0.224	(0.065) ***	0.264	(0.070) ***
- Lagged (π_8)	-0.020	(0.052)	-0.124	(0.067) *
Lagged Output (π_9)	0.237	(0.080) ***	0.333	(0.124) ***
AR (1) (p-value)		0.000		0.000
AR (2) (p-value)		0.752		0.160
Hansen OID (p-value)		0.348		0.357

Note: ***, **, and * indicate significance at 1%, 5%, and10% level respectively.

Table 7. Result of dynamic model (continued)

Restricted Model	Lag: t-2		Lag: t-3	
Land (β_l)	0.101	(0.111)	0.261	(0.103) **
Labor (β_h)	0.362	(0.094) ***	0.154	(0.093) *
Capital (β_c)	0.006	(0.078)	0.058	(0.088)
Misc. goods (β_g)	0.229	(0.061) ***	0.242	(0.056) ***
ρ	0.364	(0.057) ***	0.476	(0.078) ***
Comfac (p-value)	0.205		0.660	
CRS (p-value)	0.009		0.003	

Note: ***, **, and * indicate significance at 1%, 5%, and10% level respectively.

Comfac is a minimum distance test for common factor restrictions.

CRS is a test for Constant Returns to Scale.

Table 8. Result comparison with previous studies

	Sys GMM (Lag: t-3)			Akino and Hayami 1974, Hayami 1973, (Akino 1972)		Shintani 1983	Minami 1981	
		Conv CRS	Conv CRS	1930-1935	(1930-1935)	1934-1936	1931-1935	1936-1940
Land	0.26	0.36	0.55	0.15	0.38	0.40	0.63	0.57
Labor	0.15	0.22	0.33	0.40	0.31	0.45	0.21	0.29
Capital	0.06	0.08	0.12	0.15	0.06	0.15	0.15	0.13
Misc. goods	0.24	0.34		0.30	0.26			

Note: Values in 'Conv CRS' means ratio of elasticity value of each input to total.

5. DYNAMIC MODEL

- In unrestricted model, both t-2 and t-3 specifications satisfy AR test and Hansen OID test.
- However, t-2 specification does not satisfy common factor restriction well ⟶ t-3.
- In t-3, β_l recovers to around 0.26 (get close to RE) and ratio of each elasticity value to total is similar to previous studies.
- However, CRS test is rejected again.

6. CONCLUSION

Static models

1) RE is adopted.
   In FE, value of land elasticity is lower than OLS and RE, and aggregated value of elasticity decreases to under 0.7.

2) CRS is rejected.
   Imposing CRS ununiformly increases coefficients.

6. CONCLUSION

Dynamic model

1) Value of land elasticity recovers.
   Ratio of each elasticity value to overall is at an average of previous studies.
2) However, CRS is rejected again.

Decreasing returns to scale can be considered as a supporting evidence for the convergence to medium-scale farmers.

6. CONCLUSION

Remaining issues

1) Specification

- Functional forms
- Number of instruments

2) Sampling

- Not balanced, with upward bias
- On-going database

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