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AN ECONOMETRIC ANALYSIS OF THE PREWAR JAPANESE ECONOMY

— Reestimation of the Data and Main Functions —*

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1. Introduction

Econometric analyses of the prewar Japanese economy were attempted in the two articles: e.g., Odaka-Ishiwata [1973] and Ishiwata-Odaka [1975]. Revisions of the time series data adopted in the last model induce us to reestimate macroeconomic functions in the model.

The reestimation of the data is based not on the availability of new statistical sources but on the introduction of new condition that should be fulfiled between variables. We denote the new condition, for the time being, the 'flow-stock condition'. This condition is derived from a mathematical analysis of capital formation and capital stock in order to solve problems related to the capital formation and capital stock estimation of the prewar Japanese agriculture; that is, how to estimate a consistent series of capital formation from the Umemura-Yamada estimates of agricultural capital stock. The change-in-stock method was naturally adopted at first, but we only obtained a poor result. Secular decline in number of farm households in prewar Japan, on which the Umemura-Yamada series depend, resulted in low and often negative levels of capital formation. Negative figures are theoretically unacceptable, if they are assumed to be nearly equivalent to gross capital formation.(1)

In the next section we will discuss the 'flow-stock condition' and new estimates we obtained through the examination of the previous estimates. Section 3 provides a brief summary of our econometric reestimation of main macroeconomic functions, and in section 4 some reestimated results are to be taken up for discussion.

2. "Flow-Stock Condition" and New Estimates of Capital Formation

2.1 Consistency of estimates between capital formation and capital stock

In Ishiwata [1981] conditions of consistency in measurement between capital formation and capital stock were examined taking the case of prewar Japan as an example. In the following sections we call the condition as the 'flow-stock condition'. Under the condition a new measurement of capital formation was attempted. And the result of this attempt provides a clear and substantive difference in the level of gross capital formation and its secular trend from the existing series as shown in figure 1 below.

The 'flow-stock condition' becomes problematic especially in agriculture and residential houses. The Umemura-Yamada estimates originally provide net capital stock of agriculture. (Umemura-Yamada [1962]) The Umemura-Yamada estimates have the following characteristics of estimation: (1) the estimates of capital stock are available but there is no corresponding estimates of capital formation; (2) the estimates are at 1955 prices and in terms of net concept; and (3) the estimates are based on the same valuation method and the number of farm households in prewar and postwar Japan. There are the Umemura-Yamada estimates of gross capital stock as well as net capital stock at 1934-36 prices in (Ohkawa-Ishiwata-Yamada-Ishi [1967]). The latter Umemura-Yamada estimates are to be called the Yamada estimates here in order to distinguish from the original ones.

2.2 Trap of the change-in-stock method

Based on the available statistical sources, there are three methods of estimating capital stock in Ohkawa-Ishiwata-Yamada-Ishi [1967] : (a) the perpetual inventory method, (b) the benchmark year method, and (c) the stock method. Since the former two methods depend mainly on capital formation series as basic series of estimation, the 'flow-stock condition' is basically fullfiled. While in case of the stock method that utilizes stock of assets series as basic series of estimation, the method easily falls into a trap when capital formation series are further estimated from the estimates of capital stock. The estimation method mentioned immediately before is called the change-in-stock method. Let us explain the problem by some mathematical equations. We can define in the following:

$$(1)\quad GK_t=\sum_{k=t-n+1}^{t} GI_k ,$$

$$(2)\quad GI_t=NWI_t+R_t ,$$

$$(3)\quad NWI_t=GK_t-GK_{t-1} , \text{ and}$$

$$(4)\quad D_t=GK_t/n ,$$

where GK = gross capital stock, GI = gross capital formation, NWI = new capital formation, R = replacement investment, D = depreciation, n = useful lifetime, and subscripts t and k denote year.

From equations (2) and (3) we get

$$(5)\quad GI_t=(GK_t-GK_{t-1})+R_t .$$

When we estimate gross capital formation by the change-in-stock method shown in equation (5), the second term of the right hand side of the equation should not be neglected in order to avoid the trap of the change-in-stock method.(2) This term is a main cause of the violation of the 'flow-stock condition'. If the first four equations, i.e. equations (1) to (4) are strictly held between flow and stock variables, then we get

$$(6)\quad R_t=GI_t-NWI_t$$
$$=GI_{t-n} .$$

Naturally equation (6) is consistent with the definition of gross capital stock as denoted in equation (1).

2.3 A theoretical treatment of the ratio between new and gross capital formations

Denote α as ratio between new and gross capital formations. Then we have

$$(7) \quad \alpha=(GI_t-GI_{t-1})/GI_t \ .$$

Simple arithmetic means of α for producers' durable equipment and public utilities are shown in table 1. In producers' durable equipment there is a great discrepancy in the ratio between Series A and B.[3] From this fact the trap of the change-in-stock method is implicitly rooted in the other methods of estimation in capital stock. Empirically we can also find that α-value has a wider variance when usefull lifetime is longer than that of producers' durables as shown in public utilities.

Let us try to examine the distribution of α-value in a different way. Under a constant growth rate of gross capital formation (g), we obtain

$$(8) \quad GK_t=GI_t+GI_t(1-g)+ \cdots +GI_t(1-g)^{n-1}$$
$$=[\ \{1-(1-g)^n\}/g]GI_t \ , \text{ and}$$

$$(9) \quad \alpha=1-(1-g)^n \ .$$

From equation (9) we have $d\alpha/dg>0$ and $d^2\alpha/dg^2<0$. Table 2 shows the distribution of α-value when n = 17 or 50 and g = 0.01 to 0.20. The result suggests us that as estimates of replacement investment some other assumptions such as weighted moving averages are to be considered instead of the present assumption of 'sudden' death.[4]

2.4 New estimates of gross capital formation

Our new estimates are, to be more exact, merely an adjustment of the existing ones. A brief explanation is given below in order to give some information how we have made adjustment on the estimates of

LTES. Two equations adopted for our measurement are as follows:

(10) $NI_t = NK_t - NK_{t-1}$, and

(11) $GI_t = NI_t + D_t = (NK_t - NK_{t-1}) + GK_t/n$,

where NI = net capital formation and NK = net capital stock.

Primary industry

Since our adjustment depends on the Yamada estimates, we assume the same years of lifetime for individual assets of primary industry. Net capital stock series are the Yamada estimates. (Ohkawa-Ishiwata-Yamada-Ishi [1967, Table 2, pp.152-3]) Applying the net capital stock series to equation (10), a net capital formation series is derived. Then a gross capital formation series is resulted from equation (11) with the net capital formation series and independent estimates of depreciation series based on the Yamada's gross capital stock. Our 'flow-stock condition' can be extended to the consistency of the four variables;

Table 1 α–Value (National total and central government)

Asset Item	α–Value
Producers' durables	
(excluding Ships)	
A Series	0.633
General machinery	0.654
Rolling stock	0.602
Tools, fixture, etc.	0.641
Automobile, others	0.682
Repairs	0.587
B Series	0.889
Public utilities	
Roads & bridges	0.900
Harbors	0.980
Riparian works	0.816
Water works	0.736

Source: Ishiwata [1981, tables 3-6, pp. 9-10]

Table 2 Growth rate of gross capital formation (g) and ratio of new capital formation to gross capital formation (α)

g	α-Value	
	n=50	n=17
0.01	0.3590	0.1571
0.02	0.6358	0.2907
0.03	0.7819	0.4042
0.04	0.8701	0.5004
0.05	0.9231	0.5819
0.10	0.9948	0.8332
0.15	0.9997	0.9369
0.20	0.9999	0.9775

Note: $\alpha=1-(1-g)^n$

gross and net capital stocks and gross and net capital formations.

Residential houses

Depending on the existing series of gross and net capital stocks (We call the series the Ishi estimates, hereafter.), the same method is used as in primary industry. (Ohkawa-Ishiwata-Yamada-Ishi [1967, table 1, pp.148-51]) The Ishi estimates depend on number of households as a stock variable, and therefore have a strong bias of the 'flow-stock condition'.

Comparison with the existing series of gross capital formation

Let us make a graphic comparison between the Ohkawa series (Ohkawa-Takamatsu-Yamamoto [1974, Table 21, p.221]) and our new estimates. (See figure 1.) From figure 1 we find that (a) there is a meaningful difference between the two series over the observation period of 1885-1940, and (b) the difference is larger in the early years of the observation period. The result leads us toward a new task that will be attempted in the following sections.

3. Reestimation of Main Macroeconomic Functions

Following the new estimates of capital formation through the above

Figure 1 Gross capital formation series, 1885-1940

1934-36 prices; Unit=billion yen

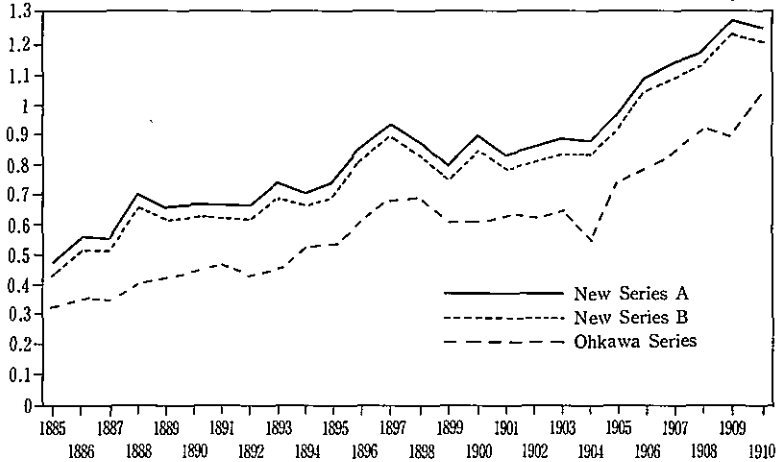

Fig. (a) 1885-1910

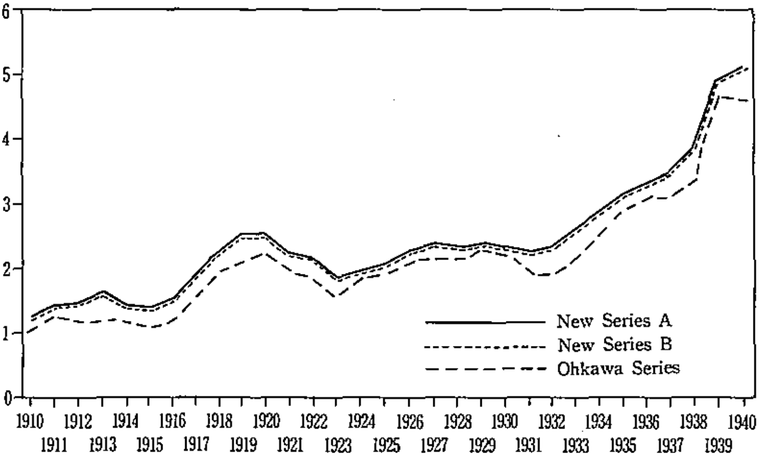

Fig. (b) 1910-1940

'flow-stock condition', other macroeconomic data are naturally to be revised. Our reestimation of individual functions of the macro econometric model of prewar Japan is worth-while trying due to reasons that our model has had its own problems to be solved, as well as due to what has been mentioned immediately before.[5]

A brief summary will provide a good orientation to our macroeconomic functions.

Consumption function

Real money balance is an important variable to be introduced in this equation. Some of our previous trials failed to estimate this effect in a significant way. The role of population as an explaining variable is also further analyzed.

Investment function

Acceleration principle is a subject to be tested in this function. Some of our previous results showed that it was not an effective hypothesis during our period of observation in prewar Japan. Further estimation is done on the basis of profit principle supported in our previous measurements.

Export function

Like import function below, the function is specified under the assumption of standard income and price effects. Introduction of such a variable of capital stock as supply side condition, therefore, should be abolished, and the function then can be transformed from reduced form equation to demand function.

Import function

Import function will again be measured due to the revision of GNE series through the reestimation of gross capital formation series.

Production function

Reestimation of the function is done mainly by the following two reasons. First, revision of some main macro series as explained above. Secondly, though fixed coefficient production function was adopted in the previous two attempts, alternative function based on the neoclassical production function is to be measured. If this trial provides a successful result, the previous model system is to be reformulated under the different paradigm.

Money demand function

Money demand with speculative motive as well as precautionary and transaction motives is investigated.

A common problem for some functions mentioned above is how to use dummy variables in an appropriate way. Through our observation period of thirty-three years, the presumption to hold coefficients of the main variables constant is too simple to apply to the Japanese economy.

4. Results of Estimation

In the following the specification of functions and their estimated results are discussed.

1) Personal consumption function

Our previous result is as follows:

$$C/N = 10.83 + 0.096YD/N + 0.845C/N_{-1}$$
$$(1.942) \quad (1.650) \qquad (11.10)$$
$$R^2 = 0.958, \ DW = 2.144.$$

In this attempt two types of the function are estimated. (See table 3.1 and table 3.2) As explained variables both personal consumption (C) and

Table 3.1 Personal consumption function (C)

No	Const	YP	C_{-1}	N	MO	MO/P	R^2	S^2	DW
1	-313.6	0.1411	0.7767	19.60			0.9879	277.3	2.0619
	-0.212	2.264	6.907	0.435					
2	-2289	0.1061	0.4675	96.43	0.1848		0.9889	265.7	1.9283
	-1.303	1.698	2.629	1.629	1.897				
3	-310.6	0.1451	0.7944	18.25		-0.0371	0.9875	282.0	2.0925
	-0.207	2.187	5.535	0.394		-0.204			

Note: YP=private GNP, C=personal consumption, N=number of population, MO=current money balance, P=GNP price deflator, R^2=adjusted least square, S^2=standard error of equation, DW=Durbin-Watson.
Figures in the second row of each equation denote t-values.

Table 3.2 Per capita personal consumption function (C/N)

No	Const	YP/N	C/N_{-1}	MO/N	MO/P*N	R^2	S^2	DW
1	21.57	0.1724	0.6322	0.1462		0.9689	4.318	2.2440
	2.509	3.421	6.700	1.939				
2	9.396	0.1687	0.7479		0.05481	0.9649	4.582	2.1450
	1.242	2.920	7.441		0.309			

Note: See [Note] of table 3.1.

per capita personal consumption (C/N) are adopted. Explaining variables selected are personal income (YP), one-year-lagged personal consumption (C_{-1}) and number of population (N) at one hand, and their per capita equivalents (YP/N, C/N_{-1}) on the other.

Our next investigation is to introduce a new variable such as real money balance (MO/P). A measurement is done in the second type of our specification of the function. Per capita nominal money balance (MO/N) is also adopted and provides the best result statistically. From

Table 4 Private investment function (IP)

No	Const	R/IN_{-1}	KP_{-1}	DI	DY	R^2	S^2	DW
1	97.48	289.2	0.02590			0.4420	263.3	0.8411
	0.438	4.422	3.304					
2	-387.3	372.5	0.04947	-424.6		0.5357	240.2	0.9725
	-1.418	5.526	4.340	-2.655				
3		312.1	0.02815			0.9590	259.9	0.8394
		8.067	4.816					
4		292.4	0.03612	-273.1		0.9638	244.2	0.8949
		7.822	5.532	-2.258				
5	896.3		0.01764		0.1321	0.1510	324.8	0.7248
	5.437		1.776		1.602			
6	839.3		0.02234		0.1423	0.1285	329.1	0.7436
	4.084		1.584		1.650			
7			0.06716		0.1147	0.8770	450.3	0.3746
			12.23		1.005			
8			0.07649	-571.4	0.1825	0.9000	406.1	0.6018
			12.88	-2.847	1.726			

Note: R=the rate of capital return, I=interest rate, KP=private gross capital stock, DI=1 in 1905-21 or =0 otherwise, $DY=Y-Y_{-1}$.

the estimated result two problems arise. One is what is the most plausible price deflator for real balance, and the other is what hypothesis can fully explain the result. In the present paper reference is only to be made to the result that nominal balance provides better estimates than real balance does.

2) Private investment function

Two hypotheses tested are (1) profit principle and (2) acceleration principle as in the previous attempt. The function selected for simulations in the previous case is as follows:

$$IP = -3352 + 317.3R/IN_{-1} + 0.069KP_{-1} + 2729ROH$$
$$(-4.510)\ (5.377)\qquad (11.46)\qquad (2.989)$$
$$R^2 = 0.848,\ DW = 0.744.$$

One-year-lagged private capital stock (KP_{-1}) is also adopted in our cases. (See table 4.) Lagged capital stock is a variable that denotes the effect of existing capital equipments over future investment plan, and positive sign(+) of its coefficient means under capacity phase and negative sign(−) excess capacity phase. Previous and present estimated results may lead to a conclusion that it is always positive in the case of prewar Japan.

Table 4 gives the following findings: (1) equations from the origin provide better results, (2) introduction of dummy variables improves our results, and (3) the acceleration principle cannot be completely denied as in equation No. 8.

3) Export function

Our previous equation adopted is a kind of reduced form equation of both export demand and supply equations: e.g.,

$$X = -5081 + 0.132YW + 2509PW/PE_{-1} + 0.104K + 2.179Z_4$$
$$(-21.08)\ (0.372)\qquad (10.21)\qquad (25.49)\qquad (2.16)$$
$$R^2 = 0.978,\ DW = 1.740.$$

Exclusion of private capital stock(KP) as in equation No. 1 of table 5

Table 5 Export function (X)

No	Const	YW	PW/PE_{-1}	KP	D2	D3	R^2	S^2	DW
1	-3755	5022	903.9				0.3029	1031	0.1975
	-1.939	3.872	0.791						
2	-5149	88.60	3204	0.2249			0.9349	315.1	1.1303
	-8.617	0.181	8.560	17.090					
3	-1280	1963	566.8		474.8	2542	0.8606	461.0	0.6204
	-1.426	2.330	0.825		1.257	8.863			
No		**YW**	**PW/PE_{-1}**	**D1**	**D2**		**R^2**	**S^2**	**DW**
4	5843	-3257		-2090			0.8218	882.7	0.5915
	6.320	-4.149		-3.985					
5	2760	1002	-2383	-1983			0.9517	466.1	0.5404
	4.798	1.656	-9.109	-0.488					

Note: YW=index of world income, PW=index of world prices, E=index of exchange rate, D2=1 in 1923-31 or =0 otherwise, D3=1 in 1932-38 or=0 otherwise.

Table 6 Import function (M)

No	Const	Y_{-1}	PM/P_{-1}	Y	PM/P	R^2	S^2	DW
1	-54.31	0.2981	-853.9			0.9422	302.3	0.8290
	-0.102	13.67	-3.151					
2	427.0			0.2663	-1036	0.9137	368.3	1.2350
	0.681			10.79	-3.188			
3		0.2961	-879.8			0.9876	297.5	0.8330
		31.72	-9.557					
4				0.2814	-828.3	0.9808	365.2	1.2262
				25.89	-7.516			

Note: PM=index of import prices.

results in a low adjusted least squares (0.3029), while the inclusion of the variable leads to the fact that the coefficient of YW is not significantly different from zero as in the previous case. Equation No. 5 provides us the best result for this time.

4) Import function

In table 6 equation No.1 takes exactly the same form as the previous

Table 7.1 Private production function (LYPC)

No	Const	LLP	LKP	T	T1	T2	T3	R^2	S^2	DW
1		1.260	0.5495					0.9999	0.0602	1.030
		9.587	12.35							
2	-1.443	2.007	0.4462					0.9636	0.0595	1.131
	1.135	3.524	5.049							
3	6.240	0.307	0.1881	0.0212				0.9643	0.0590	1.105
	1.002	0.209	0.840	1.252						
4	5.183	-0.445	0.5745		0.0078	0.0059	0.0114	0.9776	0.0467	2.255
	1.002	-0.336	2.847		0.565	0.424	0.833			

Note: LLP=ln(LP), LKP=ln(KP), T=year (1905=0), Ti=T*Di(i=1,2,3) where Di=1 when i=1(1905-1922), 2(1923-1931), and 3(1932-1938).

Table 7.2 Private productivity function (LYPC-LLP)

No	Const	LKPLP	T	T1	T2	T3	R^2	S^2	DW
1	1.714	0.6953					0.9299	0.06648	0.8258
	5.319	20.94							
2	4.338	0.2414	0.01624				0.9465	0.5809	1.1152
	5.319	1.718	3.304						
3	2.060	0.6381		0.0008	-0.0015	0.0038	0.9662	0.04615	2.2136
	2.096	3.721		0.104	-0.217	0.645			

Note: LKPLP=ln(KP/LP).

one, though some estimated statistics of it such as t-value of constant term and Durbin-Watson statistic are poorer than before.

5) Private production function

Instead of fixed-coefficient type of production function as adopted in the previous model, a Cobb-Douglas type of production function is estimated. But there is no equation in table 7.1 that satisfies necessary conditions of statistics due to possible multicollinearity. While in table 7.2 productivity function is better fitted and a good candidate for future simulation tests.

6) Money demand function

Introduction of interest rate (IN) is not successful this time also. Various dummy variables are introduced in estimating the equation based on some ad hoc methods, but there is no improvement in estimating the equation to do so.

5. Concluding Remark

Revision of capital formation series based on the 'flow-stock condition' brings overall leveling up the previous series and some substative differences in estimated macroeconomic equations. However, further works are to be requested in order to complete a macro econometric model in another revised form.

Systematic recalculation of capital formation in agriculture with computer is essential to avoid inconsistency in assumptions about useful lifetimes, scrap values and scope of assets. It is also essential that we should try to keep consistency not only between capital formation and gross or net capital stock, but also between net capital formation and net capital stock as well as between new capital formation and gross capital stock.

Notes

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(1) To be more exact, this is the case where the change-in-stock method is applied to gross capital stock series.

(2) This trap is originally led from the 'stock' method.

(3) For the two series of producers' durables see Ohkawa-Ishiwata-Yamada-Ishi [1967].

(4) See, for example, Ishiwata [1967] and Bailey [1981].

(5) See Ishiwata-Odaka [1975].

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戦前日本経済の計量経済学的分析

—データと主要関数の再推計—

〈要　　約〉

石渡　　茂

本稿は2つの作業から成り立つ。1つは,「フロー・ストック条件」に基づく資本形成系列の改訂の枠組みの説明と,計測結果の検討であり,もう1つは,資本形成系列の改訂の結果,定義的に決定される主要マクロ系列の改訂が同時に必要となり,この改訂が,マクロ・モデルを構成する主要マクロ関数にどのような影響を与えるかという検討である。

「フロー・ストック条件」の問題点は,「ストック変化法」(the change-in-stock method)により資本形成系列を推計するときに生ずる誤差である。この誤差は,資本形成と資本ストックの間に成立すべき恒等関係に影響を与えた。特に,農業資本ストック系列の梅村—山田推計に対応する資本形成系列の計測を不可能にする点でもあった。われわれの検討結果は,粗資本形成系列のかなり大幅な上方改訂となった。したがって,他の主要マクロ変数にも無視できない改訂となっている。

主要マクロ関数の再推計の結果は,本稿を脱稿する段階では充分ではない。シミュレーションを行うのに充分な統計的な精度にも若干の課題が残され,また関数の理論的枠組みについても,なお検討の余地を残していると判断した。したがって,シミュレーション分析を中心とした戦前期の日本経済についての新しい分析を,今回は断念せざるを得なかった。外国貿易を中心としたシミュレーション分析が,小島教授の記念論文集に最もふさわしいものとなったであろう。その作業は,将来の課題とすることを明記しておきたい。