Estimation of Households by Housing Types by the Model including the Change of Dwelling

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Abstract

Estimation model of households by housing types that incorporated the fluctuation of populationand the change of dwelling between housing types is constructed in this study. By using this model, the households by sex and housing type of Yamaguchi Pref.in 1993 is estimated, and the comparison with real value and Kawakami Model is carried out. Two changing ratio of dwelling between housing types is applied to the model.In case of changing ratio from 1983 to 1988,total accuracy of this model is 0.994 and the more accurate result is obtained than it of Kawakami model(0.952). About owned houses and rented houses owned by public corporstion, the accuracy becomes with 0.976 and 0.948. In case of the ratio from 1978 to 1983, the exactness is 0.999. About the issued houses,the rented houses owned privately and the owned houses,exactness of estimation improved to 0.865,0.944 and 0.985.

1. Introduction

Concerning the estimation of population or households, there are some popular methods like as the Cohort analysis , the modification rate of principal household method , and about the estimation of households by housing type, housing types distribution method applied life cyele matrix and Kawakami model that considered the change of dwellings between housing types. However, in the conventional estimation method, the fluctuation of population and dwelling change of Households are not considered simultaneously. In this study,estimation model of households by housing type that incorporated these two models is constructed. The outline of estimation with regard to households fluctuation is as follows. The prediction of the population of transfer, moving out and the deceased by sex and age of Yamaguchi Pref. is carried out by society movement rate and death rate estimation model. Next, transfer and moving out rate of household and the rate of principal household estimation model is prepared, and this is combined with the estimated population In this way, the number of transfer, moving out and the deceased households by age and housing type is estimated.

The outline of estimation of dwelling change is as follows. The process of change

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of dwelling is divided into 2 stages based on the research of Kawakami madel. The 1st stage is the change to new supply houses and the 2nd stage is the change to used houses. And the formalization of this model is carried out by defining the change ratio by age. At this time, transfer, moving out and the deceased households are incorporated. In this way, the households by age and housing types of Yamaguchi Pref. in 1993 is estimated, and this result is compared with the real number and the result of estimation with Kawakami model.

2. Framework of Estimation.

(1) The Framework of Households by Housing Types.

The method of Cohorto analysis is applied to estimation of population. This is the method that estimate the population in t+5 year, by adding and shifting increase and decrease for 5 years of the birth,death,transfer and moving out to the population in t year. Estimation model is explained by the flow chart of fig.-1 and table-1. The model of birth population is requested birth rate (RB(t)) by time series style, and birth ratio (RSs(t)) multipled by 20-34 year-old female population. In this way, the birth population by sex for 1 year is setimated, and the expression of which is(1).

The model of the deceased population is as follows. The death rate (RDs,k(t)) is given by time series analysis, and the rate multipled by the population makes the deceased population by sex and age (Ds,k(t)) for 1 year, which is given by (2).

Estimation model of transfer persons is as follows. The transfer rate (RMI(t)) is gained by time series anslysis, and this transfer rate multipled by the population by sex and age and the constitution ratio by sex and age (dMIs,k) makes transfer population (Is, k(t)) by sex and age for 1 year and it is expressed by (3). The moving out population (Os, K(t)) is estimated similary, it is expressed by (3). The population by sex and age in t+5 year (Js,k(t+5)) is estimated by adding or decreacing the Bs(t) for 5 years, Ds, K(t) for 5 years, Is,k(t) and Os,k(t) to the population in t year and it is expressed by (4).

Estimation method of households by housing types is as follows. The rate of principal household by sex and age (RPs,k(t+5)) is calcutated by time series analysis, then RPs,k(t+5) multipled by population (Js,k2(t+5)) makes principal households by sex and age (Ps,k2(t+5)), and the expression of which is (5).

The transfer rate of household by age and housing type (RHIi, k3) is the proportion of the transfer households to the transfer population by age with actural . These are calculated with the actural data of 1983～1988. This rate takes advantage of transfer persons by age Ik3(t) for 5 years. In this way, transfer households by age and housing type (HIi,k3) for 5 years are calculated. Moving out households (HOi, k3) are calculated by the same method.

The number of the deceased by sex and age (Ds,k2 (t)) is multiplied by 5 and taken advantage of the rate of principal household by sex and age (RPs,k2(t+5)) of t+5 year, and adjusted the age layers (F(k3)). The coustitution ratio by age and housing type (RHi,K3(t)) is calculated by time series dnalysis. F(k3) multiplied by constitution ratio (RHi,k3(t + 5)) of t + 5 year and single rate of households (ai,k3) makes the

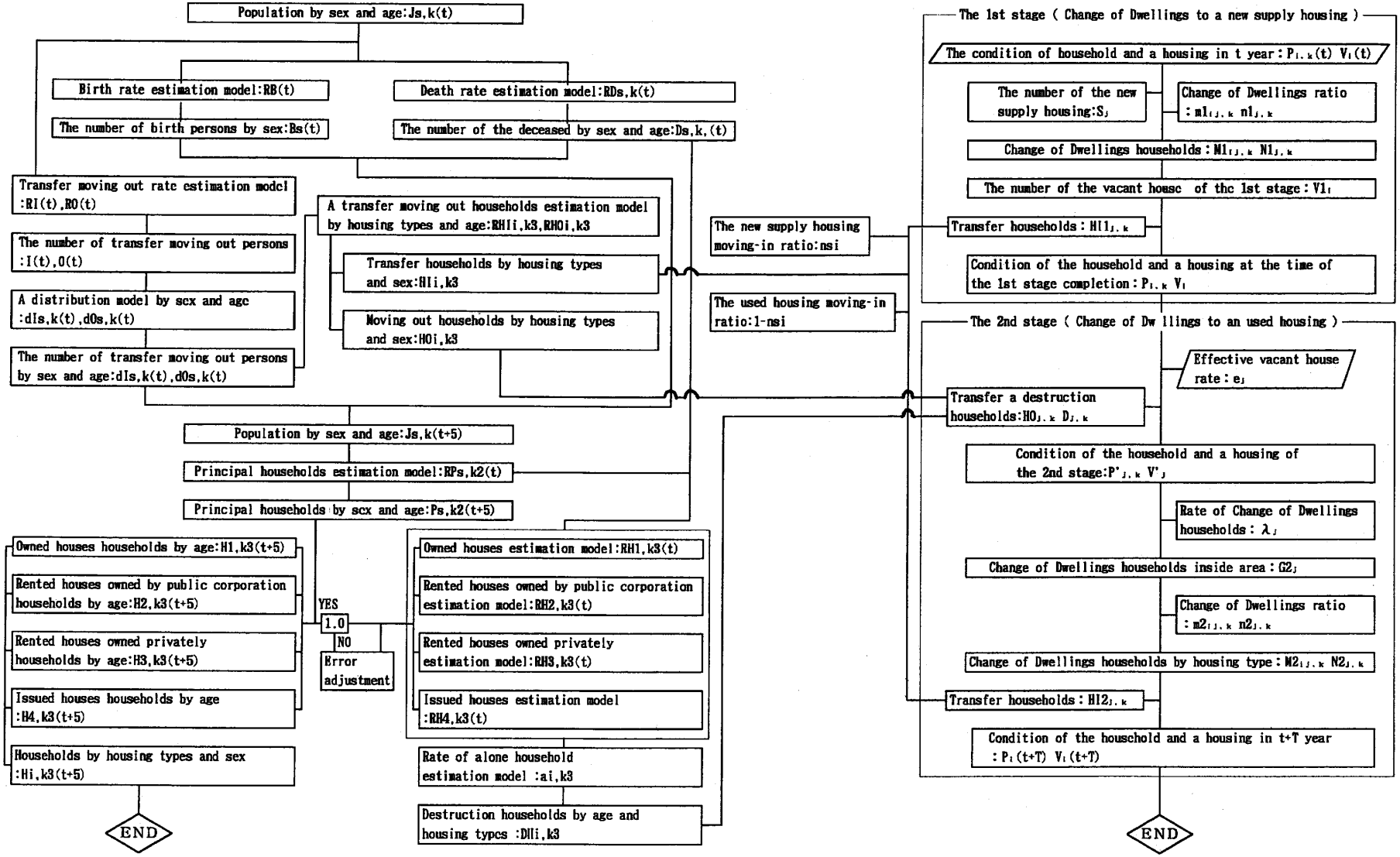

Fig.-1 Flow chart of estimation

Table-1 Frame work of estimation

i; housing kind, s; by sex (s=1; man, 2; woman) t; year (A.D. under 2 column)
k; an age layer (k=1,2,.. 18, 5 years old interval,18; 85 years old over)
i; a housing kind
(i=1; Owned houses, 2; Rented houses owned by public corporation, 3; Rented houses owned privately (wooden,facilities used exclusively), 4 ; Rented houses owned privately (wooden, facilities used jointly), 5; Rented houses owned privately (non-wooden), 6; Issued houses, 7; Lodging households, 8; Households living in other occupied buildings than dwelling)

Birth

RB (t); (the birth person total / woman 20～34years old populations)×1000)
RS_s (t); (the number of the birth person by sex) / (birth person total)

$$B_s(t)=(RB(t)\times\Sigma J_{2,k}(t)\times HB_s(t)/1000 \quad (1)$$

Death

$RD_{s,k}$ (t); (the deceased number by sex by age) / (population by sex by age) ×1000

$$D_{s,k}(t)=RD_{s,k}(t)\times J_{s,k}(t)/1000 \quad (2)$$

Transfer moving out

RI (t); (the transfer person total/population)×1000
RO (t); (the moving out person total/population)×1000
$dI_{s\,k}$; (the number of the transfer person by sex by age) /(transfer person total)
$dO_{s\,k}$; (the number of the moving out person by sex by age) / (moving out person total)

$$I_{s,k}(t)=RI(t)\times\Sigma\Sigma J_{s,k}(t)\times dI_{s,k}/1000$$
$$O_{s,k}(t)=RO(t)\times\Sigma\Sigma J_{s,k}(t)\times dO_{s,k}/1000 \quad (3)$$

Population by sex by age

$$J_{s,1}(t+5)=\Sigma B_s(t)\ (k=1)$$
$$J_{s,k}(t+5)=J_{s,k-1}(t)-5\times D_{s,k-1}(t)+\Sigma I_{s,k-1}(t)-\Sigma O_{s,k-1}(t)\ (k=2,..,17)$$
$$J_{s,18}(t+5)=\Sigma(J_{s,k}(t)-5\times D_{s,k}(t)+\Sigma I_{s,k}(t)-\Sigma O_{s,k}(t)) \quad (4)$$

Principal households by sex by age

k2=1,2,.., 15, 1; 0～19 years old, besides k similar
$RP_{s,k}$ (t);(the principal households by sex by age) / (population by sex by age)

$$P_{s,k2}(t+5)=RP_{s,k2}(t+5)\times J_{s,k2}(t+5) \quad (5)$$

Households by age and housing types

k3=1,2,.., 6, 1; 0～24 years old, 2; 25～29 years old, besides 10 years old interval, 6; 60 years old over
$RH_{i,k3}$ (t);(the households by age and housing types) / (principal households by age)

$$H_{i,k}(t+5)=RH_{i,k3}(t+5)\times P_{k3}(t+5)/ER_{k3}(t+5) \quad (6)$$
$$ER_{k3}(t+5)=\Sigma RH_{i,k3}(t+5)$$

Transfer moving out households by age and housing types

$RHI_{i\,k3}$; the transfer households ratio
$RHO_{i\,k3}$; moving out rate of households
ns_i; the new supply housing ratio

$$HI_{i,k3}=\Sigma I_{k3}(t)\times RHI_{i,k3} \quad (7)$$
$$HO_{i,k3}=\Sigma O_{k3}(t)\times RHO_{i,k3} \quad (8)$$
$$HI1_{i,k3}=ns_i\times\Sigma I_{k3}(t)\times RHI_{i,k3} \quad (9)$$
$$HI2_{i,k3}=(1-ns_i)\times\Sigma I_{k3}(t)\times RHI_{i,k3} \quad (10)$$

Destruction households by age and housing types

$a_{i,\ k3}$; (the households by age and housing types alone) / (households by age and housing types)

$F\ (s,\ k2)=RP_{s,\ k2}\ (t+5)\times 5\times D_{s,\ k2}\ (t)$

$F\ (k3)=F\ (s\ \ 1+2,\ k2\ \ k3)$

$$DH_{i,\ k3}=a_{i,\ k3}\times F\ (k3)\times RH_{j,\ k3}\ (t+5) \tag{11}$$

The 1st stage Change of Dwellings model

Housing types (1; Owned houses, 2; Rented houses owned by public corporation, 3; Rented houses owned privately, 4; Issued houses)

i; a previous residense,

j; a prsent residense (new supply housing)

$M1_{ij\ k3}$; (Change of Dwellings households by age and housing types (i) inside area) / (Change of Dwellings households by housing types (j) inside area)

$N1_{j\ k3}$; (New formation households by age inside area) / (Change of Dwellings households by housing types (j) inside area) (12)

$$Yet\ m1_{ij,\ k3}+n1_{j,\ k3}=1 \tag{13}$$

RNV_j; all 5% by housing type

$$M1_{ij,\ k3}=m1_{ij,\ k3}\times(S_j-NV_j-MIH1_j) \tag{14}$$

$$M1_{i\ k3}=M1_{ij,\ k3}$$

$$M1_{j,\ k3}=M1_{ij,\ k3} \tag{15}$$

$$N1_{j,\ k3}=n1_{j,\ k3}\times(S_j-NV_j-MIH1_j) \tag{16}$$

$$V1_{i,\ k3}=M1_{i,\ k3} \tag{17}$$

$$V1_j=V1_{j,\ k3} \tag{18}$$

$$MIH1_j=MIH1_{j\ k3}$$

$$P_{j\ k3}=M1_{j,\ k3}+N1_{j,\ k3}+MIH1_{j,\ k3}+P_{j,\ k3}\ (t')-V1_{j,\ k3}$$

$$Vj=Vj\ (t)+V1j \tag{19}$$

The 2nd stage estimation model

i; a previous residense (1 stage at the time of completion),

j; a prsent residense (2 stage at the time of completion)

e_j; an effective vacant house rate

λ_j; (the 2nd stage Change of Dwellings house holds by housing type inside area) / (Households by housing type inside area at the time of the 1st stage completion)

$$P'_{j,\ k3}=P_{j,\ k3}-DH_{j,\ k3}-MOH_{j,\ k3} \tag{20}$$

$$V_j'=e_j\times V_j \tag{21}$$

$$H_j=P'_{j,\ k3} \tag{22}$$

$$G2_j=\lambda_j\times H_j \tag{23}$$

$M2_{ij\ k3}$; (Change of Dwellings households by age by housing types (i) inside area) / (Change of Dwellings households by housing types (j) inside area)

$N2_{j\ k3}$; (New formation households by age inside area) / (Change of Dwellings households by housing types (j) inside area) (24)

$$M2_{ij,\ k3}=m2_{ij,\ k3}\times G2_j \tag{25}$$

$$M2_{i,\ k3}=m2_{ij,\ k3}\times G2_j \tag{26}$$

$$M2_{j,\ k3}=m2_{ij,\ k3}\times G2_j \tag{27}$$

$$N2_{j,\ k3}=n2_{j,\ k3}\times G2_j \tag{28}$$

$$K2_{j,\ k3}=M2_{j,\ k3}+N2_{j,\ k3}+MIH2_{j,\ k3} \tag{29}$$

$$U_{i,\ k3}=P'_{i,\ k3}-M2_{i,\ k3} \tag{30}$$

$$P_{i,k3}\ (t+T)=U_{i,\ k3}+K2_{i,\ k3}$$

$$V_i(t+T)=V_i'+P_{i,\ k3}-P_{i,\ k3}(t+T)+NV_i \tag{31}$$

decedsed households by age and housing type (DHi,k3), and the expresion of which is (11).

Estimation model of households by housing types is as follows. The constitution ratio by age and housing types (RHi,k3(t)) is calculated by time series analysis, then (RHi,k(t)) multipled by principal households (Pk3 (t+5)) makes households by age and housing types (Hi,k(t+5)).

(2) The framework of dwelling change model

Whole structure of this model is explained by the flow chart of fig.-1. The 1st stage shows the dwelling change to newly supplied houses, and the change is classified into the next 3 types by the pevious housing type and location,

① The dwelling change households by housing type in the same area
② The households formed newly in the same area
③ The transfer households from the outside area

About ① and ②, the number is formalized, by deciding the ratio of dwelling change between previous housing type and newly supplied houses. About ③, transfer households are estimated by using the results of population, transfer rate estimation. In the 2nd stage, are supplied as the objects dwelling of change the vacant houses that occured with the dwelling change in the 1st stage and existed in t year. Also in the 2nd stage, the households that move out to the outside area and disappears in the area are considered as the factor of fluctuation of households. Estimation model of transfer, moving out, the deceased and dwelling change households is explained in table-1.

1) Dwellings Change of Dwellings Model of 1st Stage

As the condition of ordinary households and housing in t year, the principal households they live in housing type i and the age layer of family is k are defined by Pi, k (t) and the number of vacant house is defined by Vi (t). Furthermore, the housing number of type j that is supplied newly for five years is defined by Sj. The houses left as the vacant house is defined by NVj, and the dwellings change of ratio to newly sapplied house is expressed by (12). The ratio defined here satisfied the expression (13). Also,transfer households by age and housing type to newly sapplied house (HI1j, k) is expressed by (9). The dwelling change households (M1ij, k3) from housing type i to j of age layer k3 is expressed by (14) and previous and present change of dwelling households (M1i, k, M1j, k) is expressed by (15). Similarly newly formed households is expressed by (16).

Therefore, previous number of vacant houses by age and housing type (V1i, k) that occurs hypothetically with the change dwellings in the 1st stage becomes (17). Also, total number of vacant houses by housing type (V1j) that occurs in the 1st stage is given by (18). Accordingly, at the time of completion of 1st stage , the condition of household and housing is expressed by (19). Here, Pj,k (t') is the condition of households after 5 years that does not consider the dwelling change of , newly formed, transfer, moving out and the deceased households destruction. It is calculated by shifting the households to upper five years age with the rate of principal household by sex and age of 1988.

2) Dwelling Change Model of 2nd Stage

At the completion of 1st stage , considering the households that move out and disappeare inside the area in the 2nd stage, households Pj,K3 is modifined as P'j,k3, the expression of which is (20), and these households are considered in the 2nd stage. Also, vacant houses regarded as the object of dwelling change in the 2nd stage is defined by (21). Households by housing type (Hj) at the time of the completion of 1st stage is expressed by (22). It is given by (23) that the total dwelling change household by housing type inside the area(G2j) in the 2nd.

Here, λj is defined as follows. From dwelling change households by housing type, the transfer households are subtracted and these are taken advantage of the used house moving-in ratio by housing type, next it is divided with households by housing type. Here, the moving-in ratio of used house is defined by reducing the ratio that divided the number of house built in 5 years with dwelling change households from one. Furthermore, λ j is the important ratio for the estimation in the 2nd stage, so λ of 4 points in 1968 , 78,83,88 are caluclated by the total households for expranatory variables and λ in 1991 is caluclated by the rate of increase of households and the regression analysis is carried out and by this method λ j in 1993 is estimated. Next, the dwelling change ratio in the 2nd stage is defined by (24). The transfer households to used houses (HI2j, k), the expression of which is (10), is defined by multiplying trsnsfer households (HIJ,K) in the 1st stage by the moving-in ratio (1-nsj) of used houses. When each ratio and households are determined as above, the households of age layer k3 that changes from housing type i to j (M2ij, k3) inside the area is expressed by (25). Among them, the households that housing type was i at the completion of 1st stage is expressed by (26). Simultaneously, the dwelling change households by present is showned by (27), also newly tormed households inside the area is given by (28). As a resurut, households of age layer k3 that changes to the housing type j in the 2nd stage (K2j, k) is expressed by (29),and the households living in housing type i in the same area at the completion of 2nd stage (Ui, k3) shown by (30). Finally, the condition of household and housing in time of t+5 is given by (31).

3. Results of estimation

In Table-2, the real number and estimated number of households by housing types in 1993 with this model and Kawakami model are shown. Because the change of dwelling between housing types are mobile, two types of dwelling change of ratio are prepaired for the estimation. In case of changing ratio from 1983 to 1988 ,the accuracy of total households with this model is 0.994 (+2986 Households) and the more accurate result is obtained than it of Kawakami model(0.952 (+25,790)). Even if the average accuracy of this model is 0.937 and the more accurate than Kawakami model (0.932). About owned houses and rented houses owned by public corporation, the estimative accuracy is fine with 0.976 (-8433),0.948 (+2144). About rented houses owned privately and issued houses,estimation acculacy is 0.859 (+15,461) and 0.784 (+5570). About the factor of these errors, the excessive estimation of rented houses owned privately and under estimation of owned houses are influenced by the movement of households in the period when the ratio was calculated. 1983 is the year of the second oil schock. It is

Table-2 Result of estimation

Rate of household movement in 1993

	Real households in 1993	Kawakami model		This model	
		Estimated households	Accuracy	Estimated households	Accuracy
Owned houses	353300	350801	0.993	344867	0.976
Rented houses owned public corporation	41300	48837	0.817	43444	0.948
Rented houses owned privately	109700	129340	0.821	125161	0.859
Issued houses	25800	28612	0.891	20230	0.784
Total	531800	557590	0.952	534786	0.994
Error and accuracy	-	32488	0.932	31608	0.937

Rate of household movement in 1988

	Real households in 1993	Kawakami model		This model	
		Estimated households	Accuracy	Estimated households	Accuracy
Owned houses	353300	355582	0.994	347962	0.985
Rented houses owned public corporation	41300	49704	0.797	45867	0.889
Rented houses owned privately	109700	130512	0.810	114843	0.953
Issued houses	25800	28353	0.901	22328	0.865
Total	531800	564151	0.939	532071	0.999
Error and accuracy	-	34051	0.929	18520	0.962

Appendix: Accuracy=1− | real households-estimated households | /real households

conceivable that the purchase number of owned houses decreased and households that lives in rented houses increased after this year. Furthermore, the estimation period from 1988 to 1993 includes the period of "bubble economics", and it is conceivable that the purchase rate of owned houses went up.

In case of the ratio from 1978 to 1983, the accuracy of total households with this model is 0.999 (+271). By housing types, accuracy of issued houses and rented houses owned privately improved to 0.865 (-3485) and 0.944 (+6185), and one of owned houses improved to 0.985 (-5350) also. From this result, it is desirable to apply the ratio from 1978 to 1983 for the estimation.

4. Conclusions

The prediction of population of the transfer, moving out and the deceased by sex and age in Yamaguchi Pref.was carried out by estimation model of society movement, birth and death rate. Next, estimation model of principal household was prepared, and this model was combined with the dwelling change model, in which the process is

divided into 2 stages, the 1st stage is the dwelling change to newly supplied house and the 2nd stage is the change to used house. By this model, the households by sex and housing types in 1993 was estimated. About the results of estimation, the total number of households was a fine value. However, a little errors were observed by housing types. The resson is as follow. Because of applying the change ratio in 1983～1988, parameters were influenced by the society movement in the period. Considering this point, the change change ratio was calculated in 1979～1983, and it was incorporated to the model. As a result, better accuracy was obtained. The problem of this model is that the housing change ratio is not considered the time fluctuation of economical factors in housing market, and this is a future question to improve.