On Distance from Home in Daily Activity Pattern

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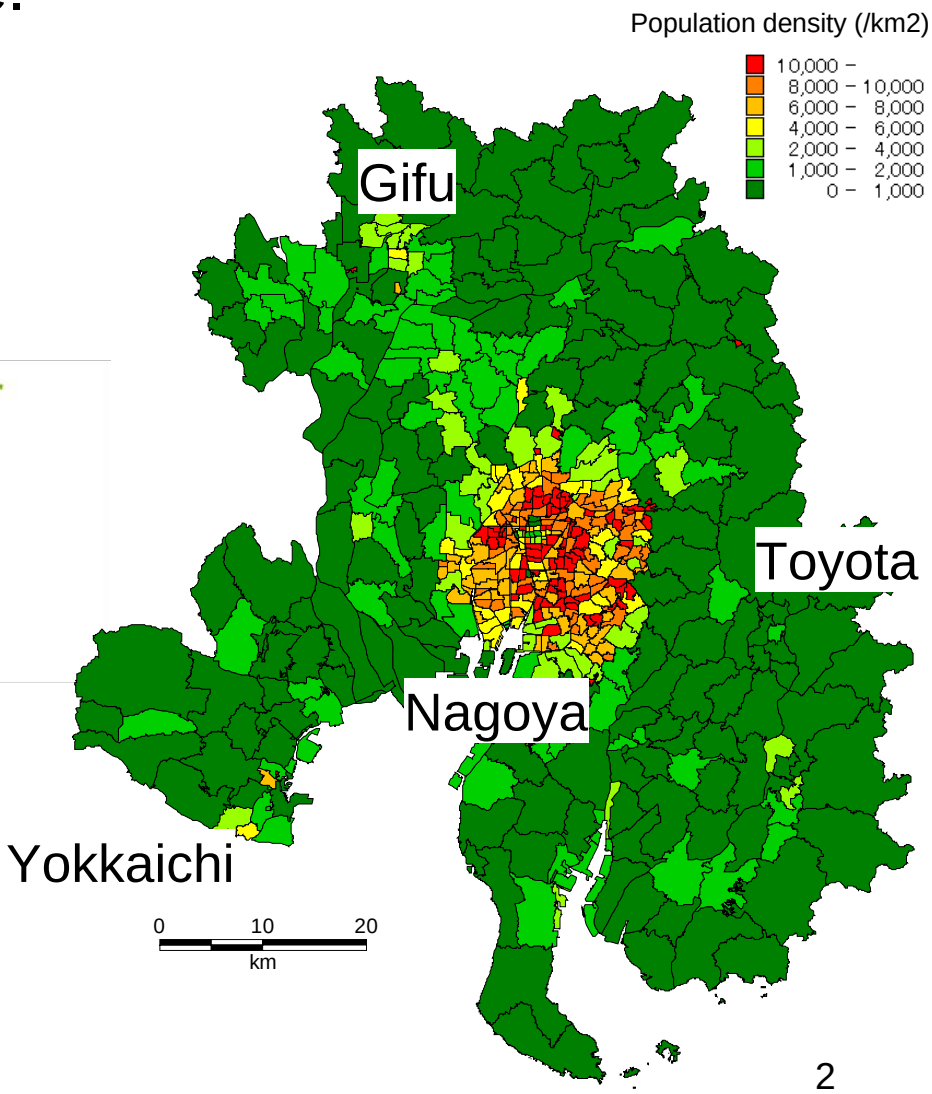
1. Background and Objective

Japan has experienced many earthquakes, typhoons and floods, and expect to come.

Big earthquakes periodically occurred at Nagoya area

- M7.9 in 1605
- M8.6 in 1707
- M8.4 in 1854
- M7.9 in 1944

M8.1 is anticipated in 30 years with 60% probability

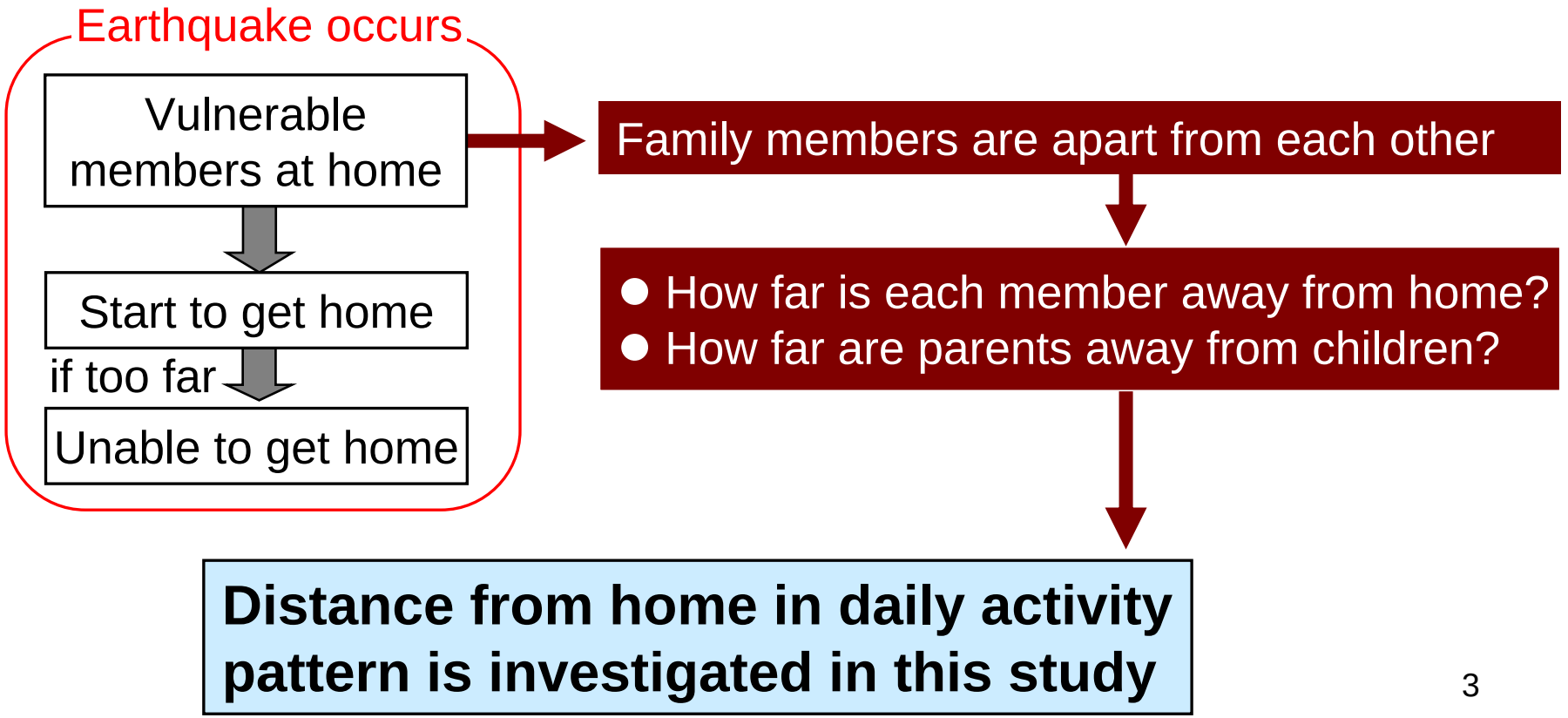


1. Background and Objective

Many people try to get home when the earthquake occurs

(The Cabinet Office, 2007)

Worker: 70-80 % when safety of family is not confirmed
80+ % when family members are seriously injured
Shopper: 60 % when safety of family is confirmed, 70 % not confirmed
Student: 60-80 % when safety of family is not confirmed



Distance from home in daily activity pattern is investigated in this study

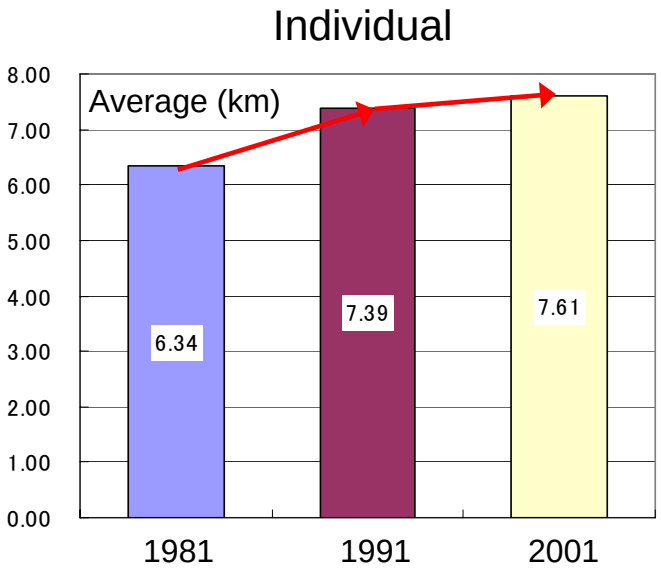
2. Outline

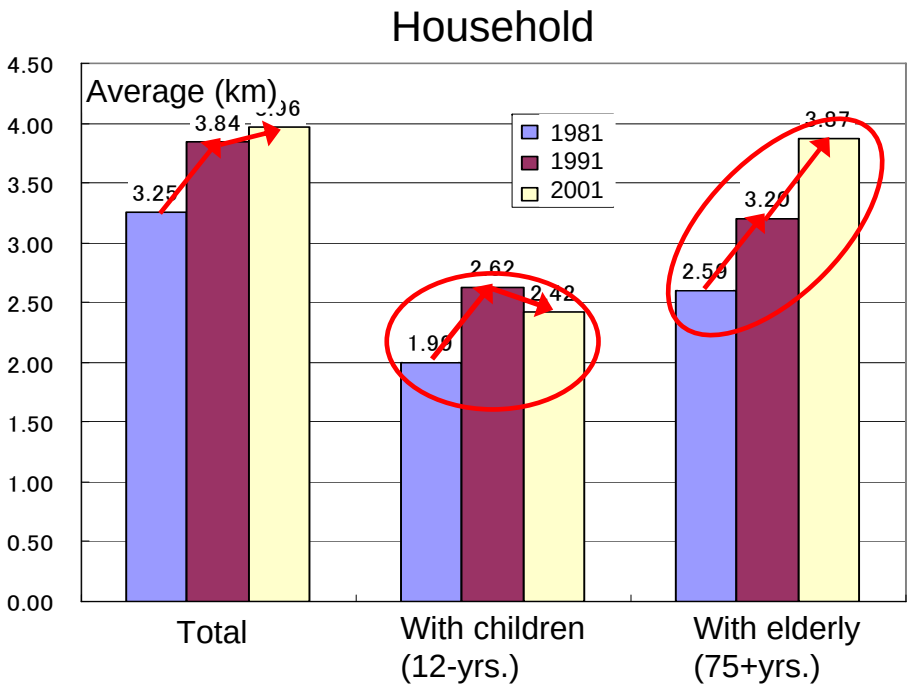
- Descriptive analysis
  - Individual: longest distance from home in the daily activity pattern
  - Household: longest distance from home of closer parent from home children are left
- Statistical analysis
  - Tobit models: limitation of zone level data
  - Find dominant factors
- Further analysis on the dominant factors
  - Bivariate tobit model: interaction of factors

3. Descriptive analysis: distance from home

Person trip survey data

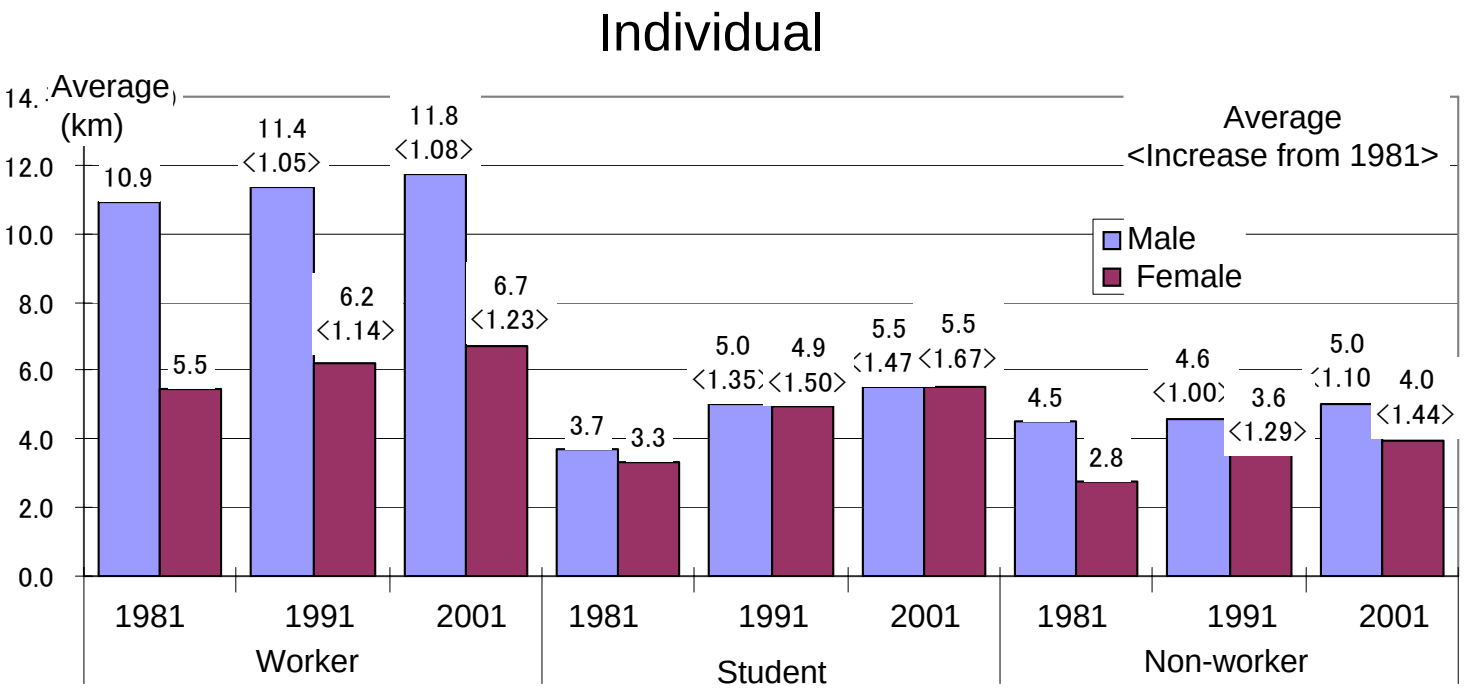
Year	Person	Household	HH w children (12- yrs.)	HH w elderly (75+ yrs.)
1981	244006	90150	19531	1648
1991	196201	74902	10905	2077
2001	224735	90435	11885	4861





- Individual: longest distance increases along time
- Household: longest distance of care givers increases at households with elderly of 75+ yrs.

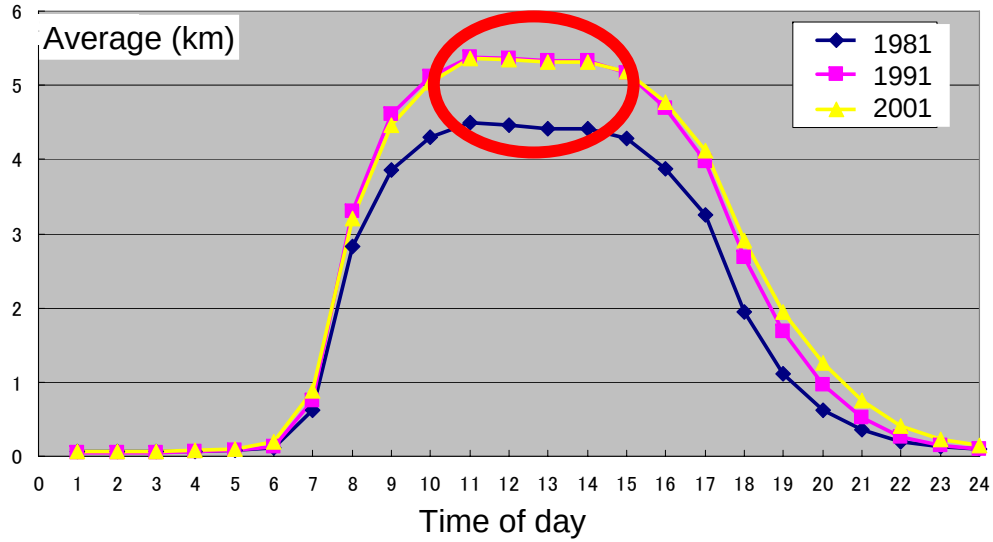
3. Descriptive analysis: distance from home



- Student increases the distance significantly
- Female has larger increase than male, suggesting the expansion of the activity space by women's participation in society

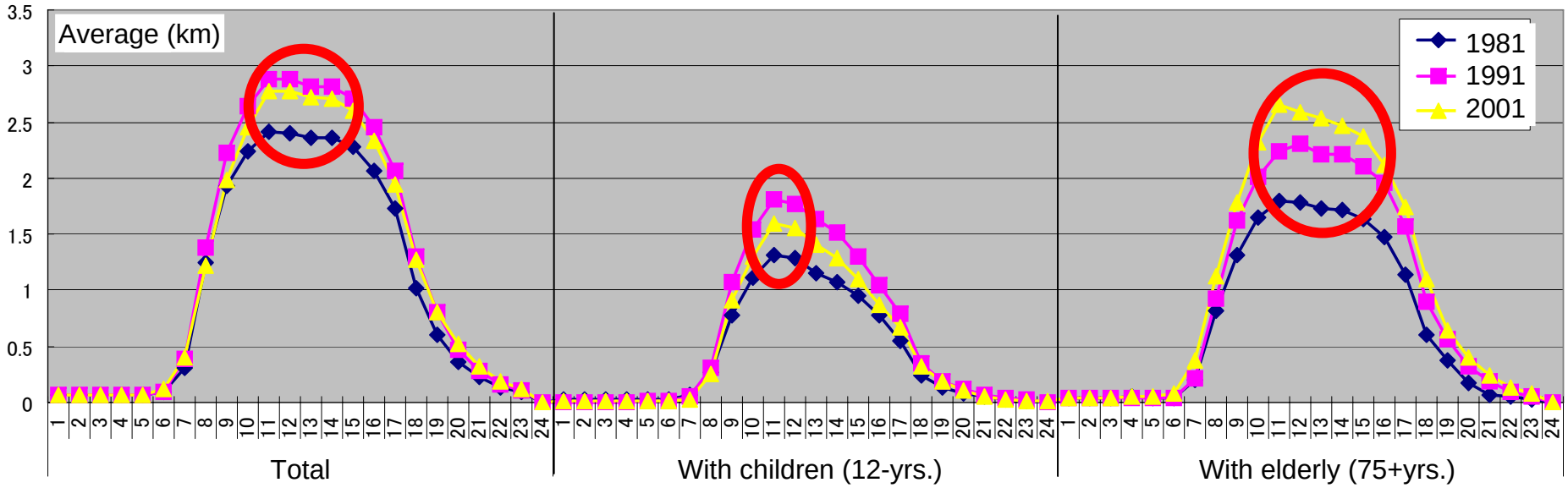
3. Descriptive analysis: distance from home

Individual

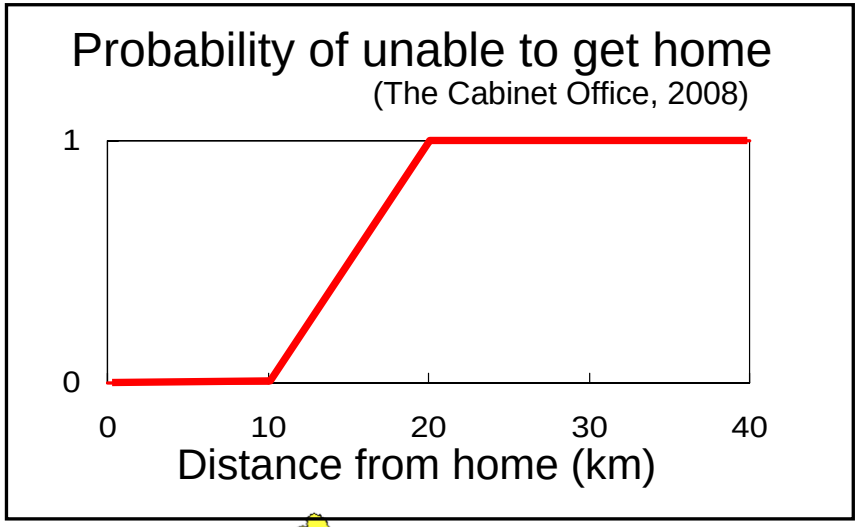


- Individual: longest in 11:00 to 14:00
- Household: longest in 11:00 but shorter duration at households with children

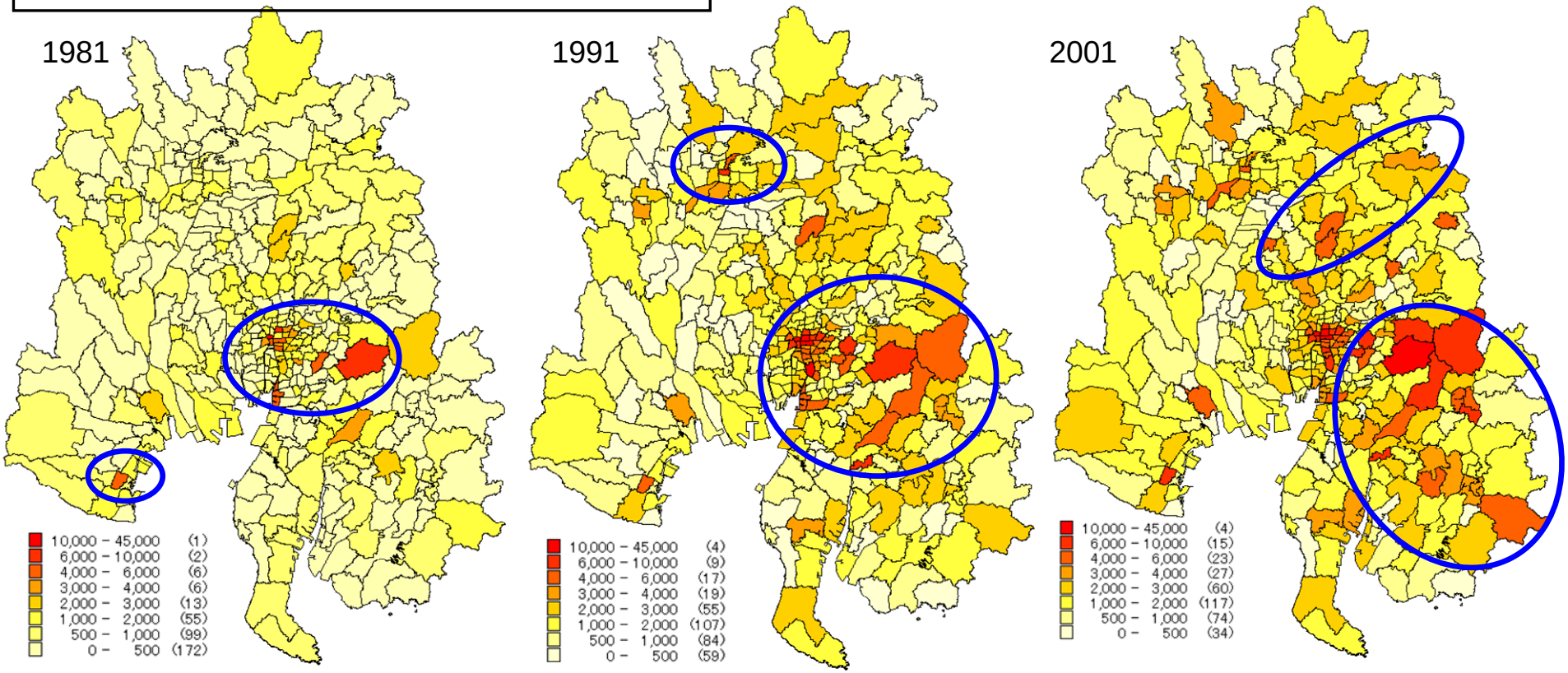
Household



3. Descriptive analysis: unable to get home



- Those who unable to get home increase, especially at zones with working places including Toyota, Kariya, etc.



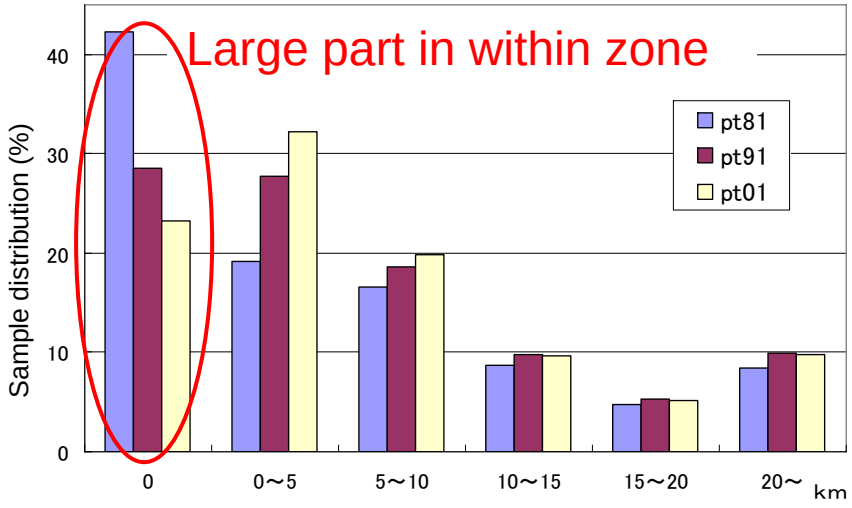
4. Statistical analysis: tobit model

Measurement of distance from home

Location is observed by zonal centroid as usual travel survey

If home and the activity location are within the same zone

=> Distance becomes 0



However,

- Actual distance is larger than 0
- Exact distance is unknown

Tobit model of distance from home

- Logarithm of distance (D) as dependent variable
- Diameter of the zone (Z) is used as threshold for the case of within the same zone

$$\ln(D^*) = \beta X + \varepsilon$$
$$\ln(D) = \ln(Z) \quad \text{if } \ln(D^*) \leq \ln(Z)$$
$$\ln(D) = \ln(D^*) \text{ if } \ln(D^*) > \ln(Z)$$

4. Statistical analysis: tobit model

Individual

		1981		1991		2001	
		Coef.	Elasticity	Coef.	Elasticity	Coef.	Elasticity
Constant		1.021		0.712		0.757	
Female		-0.167**	-0.00	-0.160**	-0.00	-0.174**	-0.00
60+ yrs.		0.028**	0.00	0.069**	0.00	0.089**	0.00
#Children		0.024**	0.00	-0.038**	-0.00	-0.046**	-0.00
#Elderly		0.035**	0.00	-0.009*	-0.00	-0.019**	-0.00
Two-income family		-0.025**	-0.00	-0.013**	-0.00	-0.028**	-0.00
#Vehicles		0.074**	0.00	0.073**	0.01	0.065**	0.02
Employment	Agriculture	-0.124	-0.00	0.338**	0.00	0.319**	0.00
	Construction	-0.016	-0.00	0.158**	0.00	0.196**	0.00
	Manufacturing	-0.295**	-0.00	-0.187**	-0.00	-0.165**	-0.00
	Finance	-0.271**	-0.00	-0.055**	-0.00	-0.027*	-0.00
	Transport	0.094**	0.00	0.091**	0.00	0.110**	0.00
	Management	0.077**	0.00	0.112**	0.00	0.092**	0.00
	Government	-0.341**	-0.00	-0.152**	-0.00	-0.136**	-0.00
	Student	-0.213**	-0.00	-0.263**	-0.00	-0.227**	-0.00
	Housewife	-0.325**	-0.00	0.231**	0.00	0.194**	0.00
ln(Commute dist.) (km)		0.339**	0.01	0.554**	0.10	0.544**	0.11
ln(Distance between city center and home) (km)		0.286**	0.01	0.187**	0.05	0.204**	0.06
ln(Distance between city center and workplace) (km)		0.045**	0.00	-0.036**	-0.01	-0.065**	-0.01
Distance from station (km)		0.087**	0.00	0.036**	0.01	0.023**	0.00
Sample size		243949		196135		224618	
Adjusted ρ^2		0.776		0.785		0.745	

4. Statistical analysis: tobit model

Individual

	Elasticity		
	1981	1991	2001
ln(Commute dist.) (km)	0.01	0.10	0.11
ln(Distance between city center and home) (km)	0.01	0.05	0.06

- Dominant factor is commute distance
- Effect of commute distance increases along time
- Next dominant factor is the distance between city center and home

4. Statistical analysis: tobit model

Household with children

		1981		1991		2001	
		Coef.	Elasticity	Coef.	Elasticity	Coef.	Elasticity
Constant		0.402		343		0.555	
#Children		0.001	0.00	-0.047**	-0.01	-0.015	-0.00
#Elderly		-0.126	-0.00	-0.123**	-0.00	-0.070	-0.00
Two-income family		0.100	0.00	0.207	0.01	0.046	0.00
#Vehicles		0.087**	0.00	0.087**	0.02	0.010	0.00
Employment	Agriculture	-0.063	-0.00	-0.306**	-0.00	-0.201**	-0.00
	Construction	0.014	0.00	0.002**	0.00	-0.019	-0.00
	Manufacturing	-0.090**	-0.00	-0.111	-0.01	-0.074**	-0.00
	Finance	-0.027	-0.00	-0.070**	-0.00	0.002	0.00
	Transport	-0.023	-0.00	-0.094*	-0.00	-0.055	-0.00
	Management	-0.005	-0.00	-0.016**	-0.00	-0.054**	-0.00
	Government	-0.080**	-0.00	-0.069	-0.00	-0.122**	-0.00
ln(Distance between city center and home) (km)		0.257**	0.03	0.191**	0.07	0.161**	0.06
ln(Commute dist. of husband) (km)		0.091**	0.01	0.127**	0.03	0.088**	0.02
ln(Commute dist. of wife) (km)		0.334**	0.01	0.390**	0.03	0.400**	0.04
ln(Distance between city center and workplace of husband) (km)		-0.050**	-0.00	-0.061**	-0.02	-0.034**	-0.01
ln(Distance between city center and workplace of wife) (km)		-0.074**	-0.00	-0.123**	-0.02	-0.085**	-0.01
Distance from station (km)		0.073**	0.00	0.044**	0.01	0.047**	0.01
Sample size		19531		10905		11885	
Adjusted ρ^2		0.297		0.319		0.372	

4. Statistical analysis: tobit model

Household with children

	Elasticity		
	1981	1991	2001
ln(Distance between city center and home) (km)	0.03	0.07	0.06
ln(Commute dist. of husband) (km)	0.01	0.03	0.02
ln(Commute dist. of wife) (km)	0.01	0.03	0.04

- Dominant factor is the distance between city center and home
- Commute distance of wife has a larger effect than that of husband in 2001

5. Further analysis: bivariate tobit model

Distance from home is heavily dependent on commute dist.

Commute distances of husband and wife are investigated

Commute dist. of husband (D_h) ⟷ Interaction ⟷ Commute dist. of wife (D_w) (Phina, 2006)

Bivariate tobit model

Husband part

$$\ln(D_h^*) = \beta X + \gamma \ln(D_w) + \varepsilon$$
$$\ln(D_h) = \ln(Z) \quad \text{if } \ln(D_h^*) \le \ln(Z)$$
$$\ln(D_h) = \ln(D_h^*) \quad \text{if } \ln(D_h^*) > \ln(Z)$$

Wife part

$$\ln(D_w^*) = \beta X + \gamma \ln(D_h) + \varepsilon$$
$$\ln(D_w) = \ln(Z) \quad \text{if } \ln(D_w^*) \le \ln(Z)$$
$$\ln(D_w) = \ln(D_w^*) \quad \text{if } \ln(D_w^*) > \ln(Z)$$

Simultaneous estimation as bivariate tobit model

5. Further analysis: bivariate tobit model

Commute distance of household with two-earner

		Husband	Wife
		Coef.	Coef.
Constant		1.38**	0.78**
#children		0.04**	-0.03**
#elderly		0.05**	0.01
#vehicle		0.01*	0.02**
Driver lisence		0.16*	0.24**
Employment	Agriculture	-0.58**	-0.34**
	Manufacturing	-0.01	-0.04**
	Finance	0.14**	0.21**
	Security	0.10**	0.19
	Management	0.12**	0.17**
	Government	0.07**	0.19**
Workplace zone	Nagoya	0.34**	0.47**
	Toyota	-0.18**	-0.04
	Gifu	0.00	0.22**
	Yokkaichi	0.07	0.25**
	Toyohashi	-0.08	0.07
Residence zone	Nagoya	-0.46**	-0.59**
	Toyota	-0.13**	-0.11**
	Gifu	-0.01	-0.13
	Toyohashi	0.35**	0.46**

	Husband	Wife
	Coef.	Coef.
ln(Distance between city center and home) (km)	0.25**	0.29**
Distance from station (km)	0.00	0.01**
ln(Commute dist. of husband) (km)		-0.07**
ln(Commute dist. of wife) (km)	-0.04**	
Correlation	0.28**	
Sample size	23294	
Adjusted ρ^2	0.108	

5. Further analysis: bivariate tobit model

Commute distance of household with two-earner

	Husband	Wife
	Coef.	Coef.
#children	0.04**	-0.03**
ln(Distance between city center and home) (km)	0.25**	0.29**
ln(Commute dist. of husband) (km)		-0.07**
ln(Commute dist. of wife) (km)	-0.04**	
Correlation	0.28**	

- Wife decreases the commute distance for children
- Living in suburb increases the commute distance
- Commute distance of husband has a larger effect on that of wife than vice versa