SOCIOECONOMIC MICRODATA FOR ACTIVITY-BASED AGENT SIMULATION IN THE GREATER TOKYO AREA

TAKUMA MITANI[1], PHATHINAN THAITHATKUL (LAMP)[2], TAKAHIKO KUSAKABE[1]

1 CENTER FOR SPATIAL INFORMATION SCIENCE, THE UNIVERSITY OF TOKYO, JAPAN

2 TRANSPORTATION INSTITUTE, CHULALONGKORN UNIVERSITY, THAILAND

INTRODUCTION

- IoT has facilitated many transport modes
  - On-demand ride-hailing/sourcing system
  - Car-sharing system
  - Ride-sharing system
  - Autonomous vehicle ride-sharing system

To analyze these kinds of transport modes (e.g., operation policies, pricing systems), it requires high resolution travel demand information, household composition data, and personal socioeconomic attributes.

INTRODUCTION

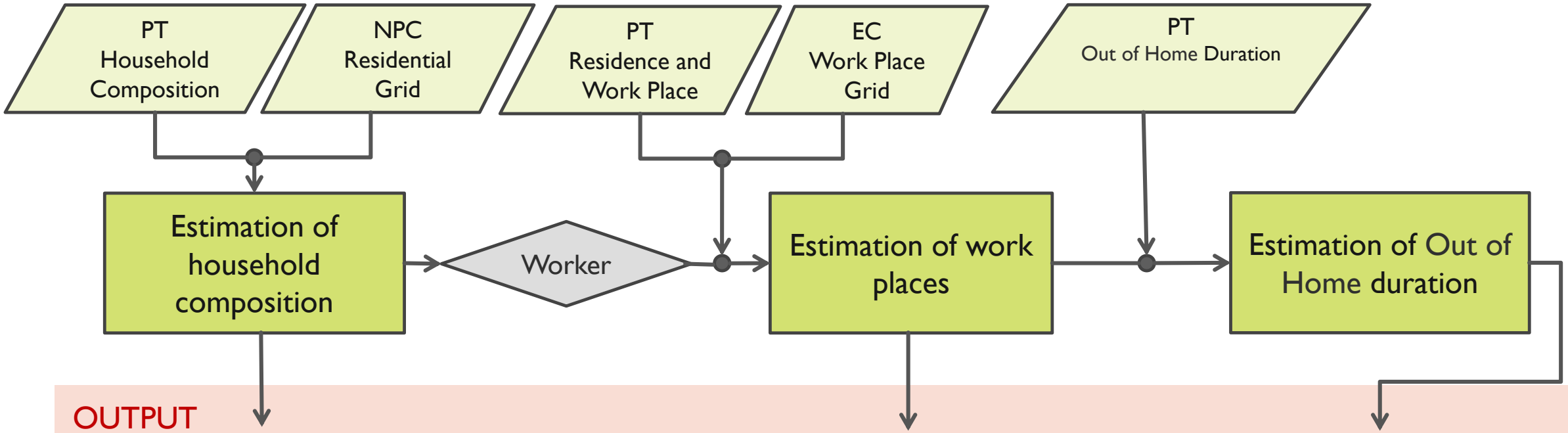
Normally, travel demand information and personal attributes can be obtained from various sources which have different good points. For example, in Japan,

	SAMPLE DATA(2%)	CENSUS DATA(100%)	
	Person Trip Survey (PT)	National Population Census (NPC)	Economic Census (EC)
Household Composition	○	-	-
Multiple Personal Attributes (Gender, Age, Occupation)	Joint Distributions	Marginal Distribution	Marginal Distribution (Gender)
Residence Places	Zone (~5km wide)	Grid (500m)	-
Residence Places and Work places	Zone (~5km wide)	-	-
Work places	Zone (~5km wide)	-	Grid (500m)
Out of Home Duration	○	-	-

OBJECTIVE

To create high resolution travel demand with socioeconomic microdata of the Greater Tokyo Area for activity-based multi-agent transport simulation

METHODOLOGY TO ESTIMATE SOCIOECONOMIC MICRODATA BASED ON ITERATIVE PROPORTIONAL FITTING (IPF)



OUTPUT

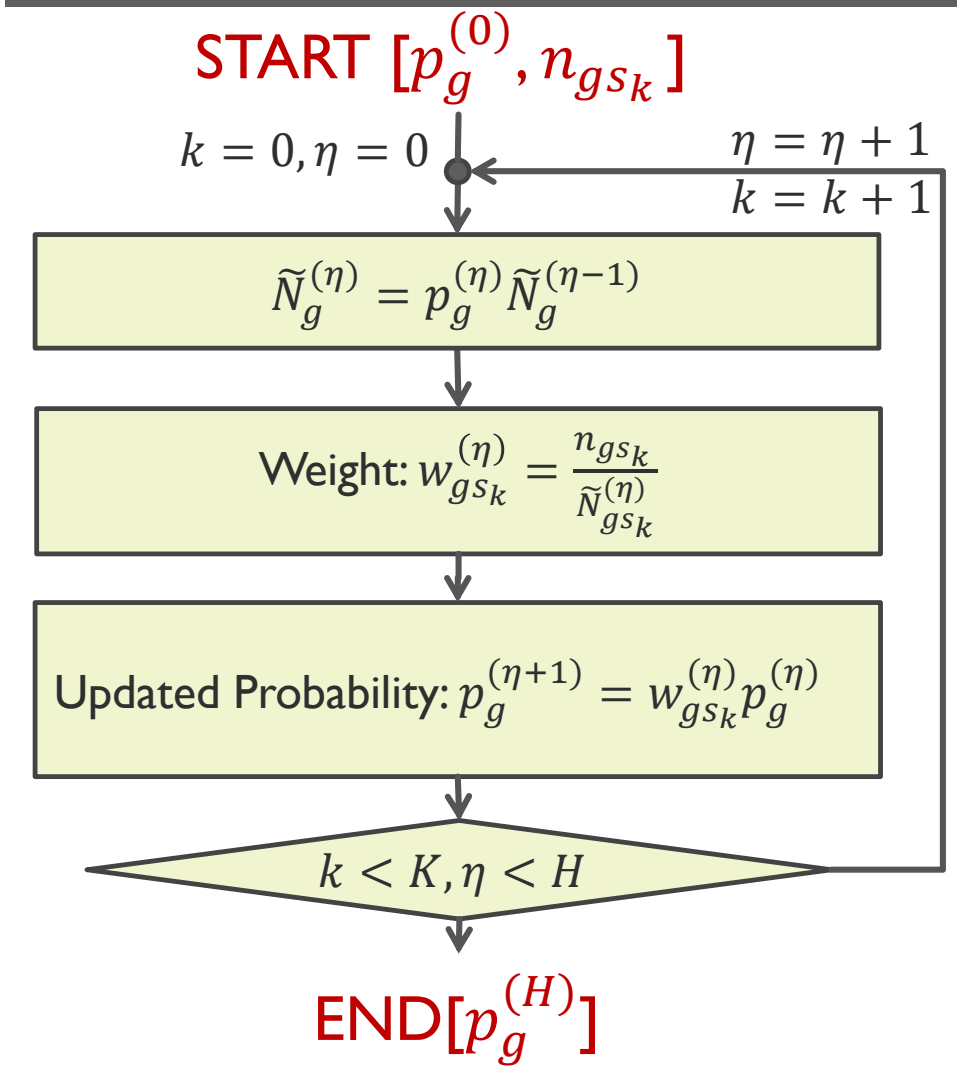
Household: Members, Residential Grid
Person: Gender, Age, Occupation

Worker: Work Place

Worker: Out of Home Duration

Household(members, Residential Grid)
Worker(Personal Attributes, Work Place Grid, Out of Home Duration)
None Worker(Personal Attributes)

ITERATIVE PROPORTIONAL FITTING(IPF)



Joint distribution

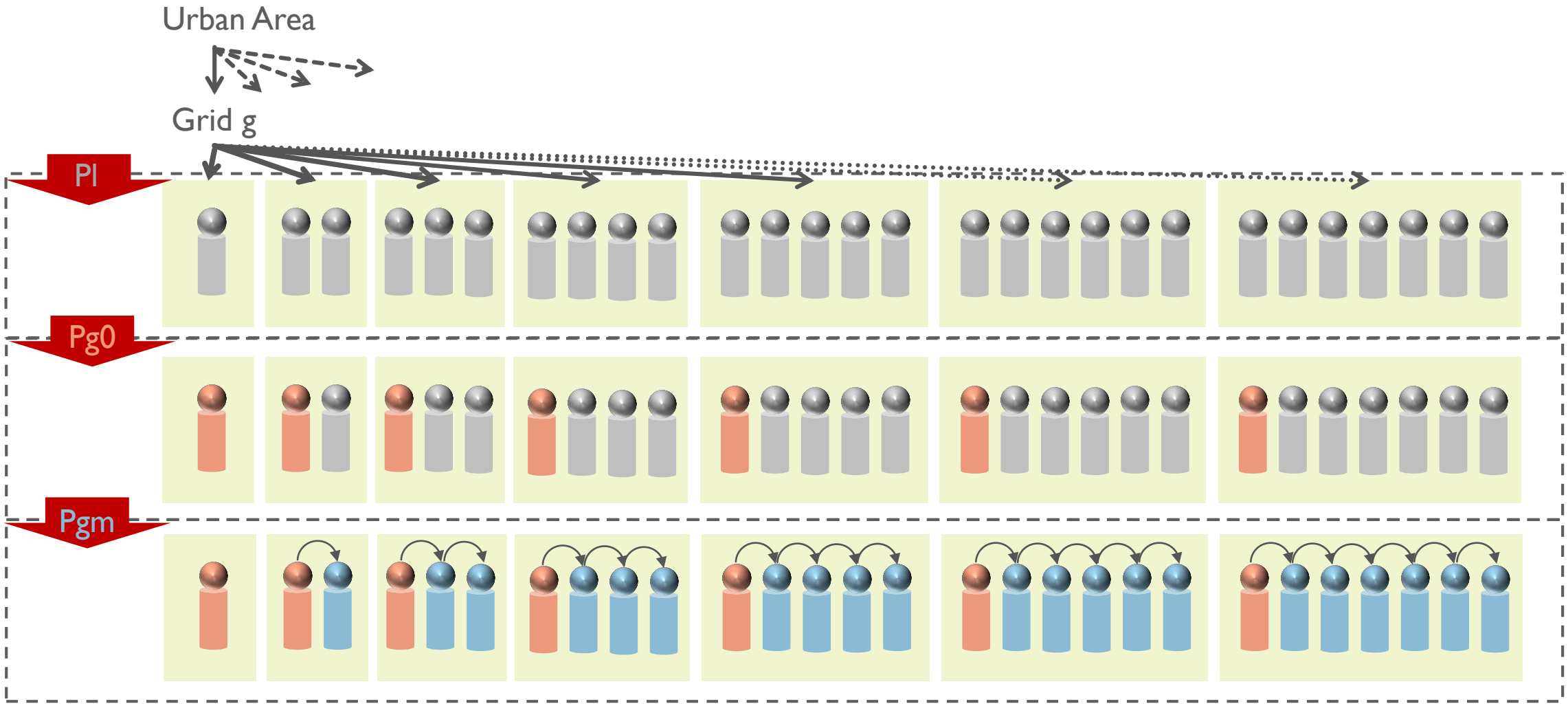
Grid g		k_2			n_2
		s_1	s_2	s_3	
k_1	s_1	$p_{11}^{(0)}$	$p_{12}^{(0)}$	$p_{13}^{(0)}$	$\widetilde{N}_{gs_k}^{(\eta)}$
	s_2	$p_{21}^{(0)}$	$p_{22}^{(0)}$	$p_{23}^{(0)}$	$\widetilde{N}_{gs_k}^{(\eta)}$
	s_3	$p_{31}^{(0)}$	$p_{32}^{(0)}$	$p_{33}^{(0)}$	$\widetilde{N}_{gs_k}^{(\eta)}$
n_1		$\widetilde{N}_{gs_k}^{(\eta)}$	$\widetilde{N}_{gs_k}^{(\eta)}$	$\widetilde{N}_{gs_k}^{(\eta)}$	

Marginal distribution

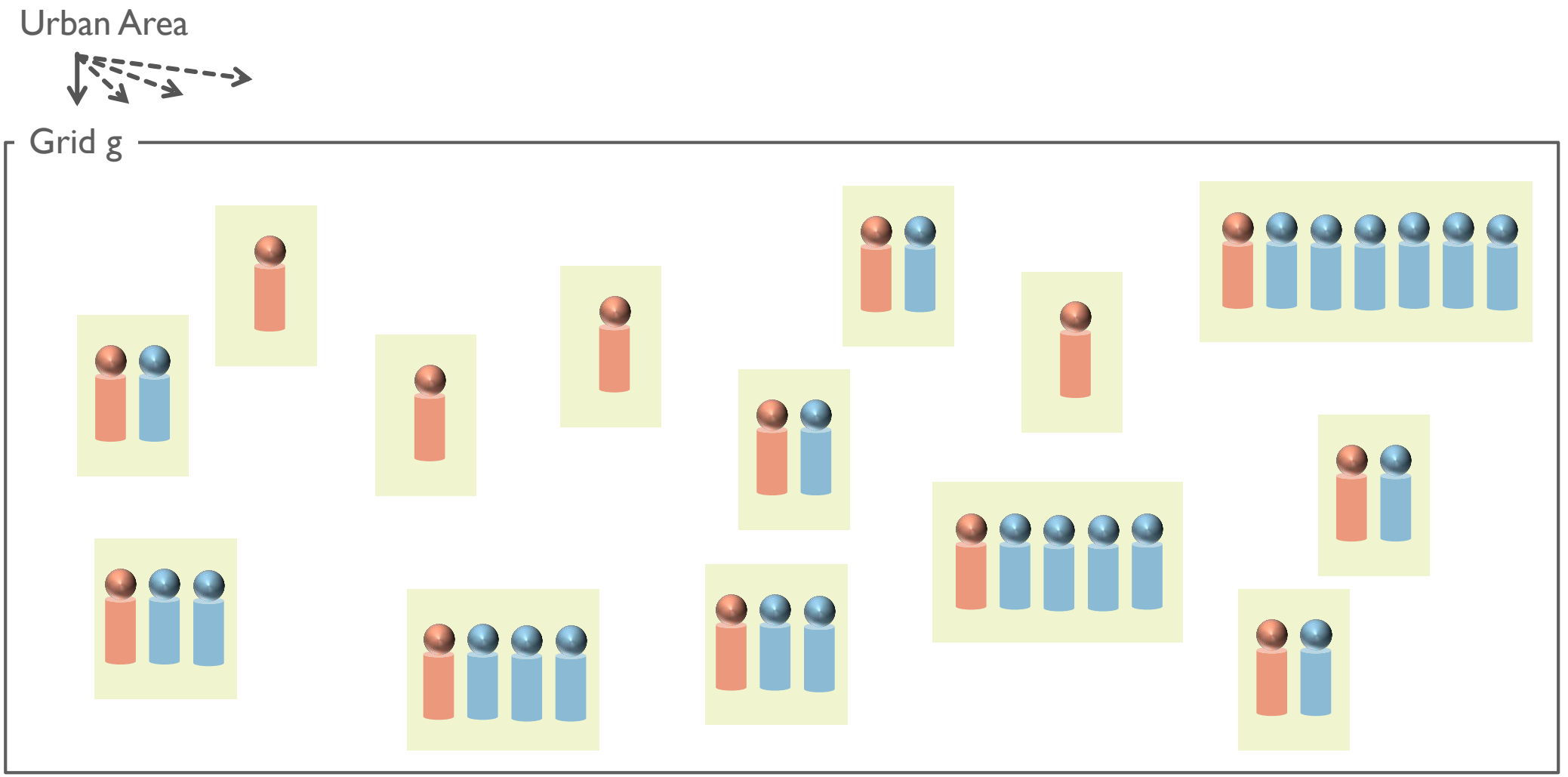
Grid g		k_2			n_2
		s_1	s_2	s_3	
k_1	s_1				$n_{s1,k1}$
	s_2				$n_{s2,k1}$
	s_3				$n_{s3,k1}$
n_1		$n_{s1,k2}$	$n_{s2,k2}$	$n_{s3,k2}$	

Grid g		k_2			n_2
		s_1	s_2	s_3	
k_1	s_1	$p_{11}^{(H)}$	$p_{12}^{(H)}$	$p_{13}^{(H)}$	
	s_2	$p_{21}^{(H)}$	$p_{22}^{(H)}$	$p_{23}^{(H)}$	
	s_3	$p_{31}^{(H)}$	$p_{32}^{(H)}$	$p_{33}^{(H)}$	
n_1					

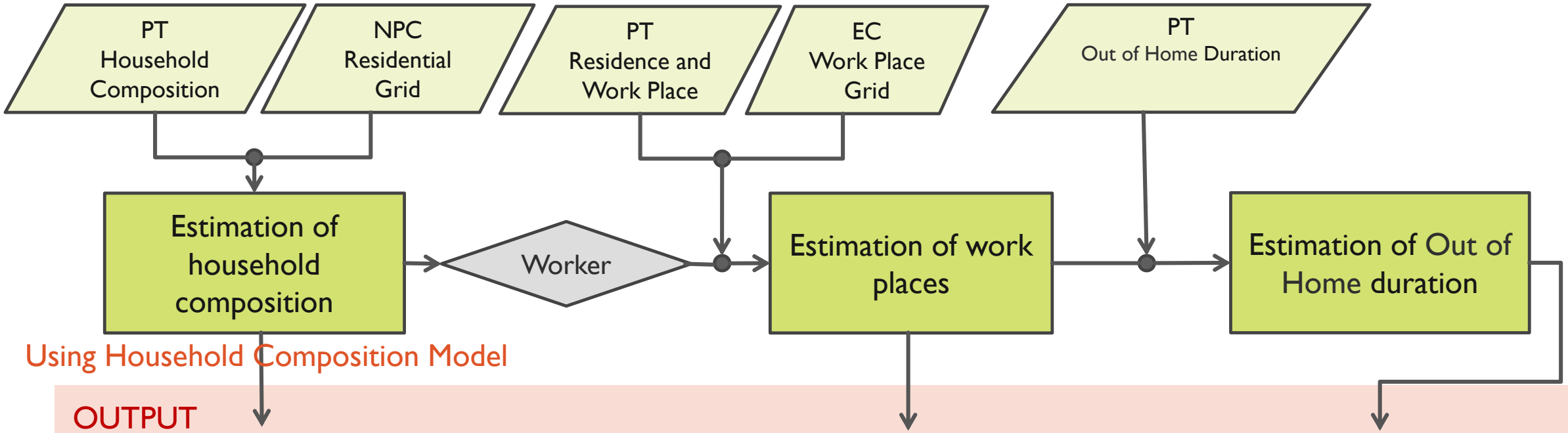
ESTIMATION OF HOUSEHOLD COMPOSITION
HOUSEHOLD COMPOSITION MODEL



ESTIMATION OF HOUSEHOLD COMPOSITION
HOUSEHOLD COMPOSITION MODEL



METHODOLOGY TO ESTIMATE SOCIOECONOMIC MICRODATA BASED ON ITERATIVE PROPORTIONAL FITTING (IPF)



Household(members, Residential Zone)
Worker(Personal Attributes, Work Place Grid, Out of Home Duration)
None Worker(Personal Attributes)

ESTIMATION OF HOUSEHOLD COMPOSITION

START

$k = 0, \eta = 0$

$$N_{gs_k} = \sum_{u \in U} \sum_{0 \le j < |u|} \delta\left(\Theta_{g_{age}(j,u)}, s_k\right) p_{g_{age}(j,u)}\left(\Theta_{g_{age}(j,u)} || u|\right)$$

$$w_{gs_k}^{(\eta)} = \frac{n_{gs_k}}{N_{s_k}^{(\eta)}}$$

$$p_{g0}^{(|K|\eta+k)}\left(\Theta_{g_{age}(0,u)}|l\right) = \delta\left(\Theta_{g_{age}(0,u)}, s_k\right) w_{gs_k}^{(\eta)} p_{g0}^{(|K|\eta+k-1)}\left(\Theta_{g_{age}(0,u)}|l\right)$$

$$p_{gj}^{(|K|\eta+k)}\left(\Theta_{g_{age}(j,u)}|l, \theta_{k^* g_{age}(j-1,u)}\right) = w_{gs_k}^{(\eta)} p_{gj}^{(|K|\eta+k-1)}\left(\Theta_{g_{age}(j,u)}|l, \theta_{k^* g_{age}(j-1,u)}\right)$$

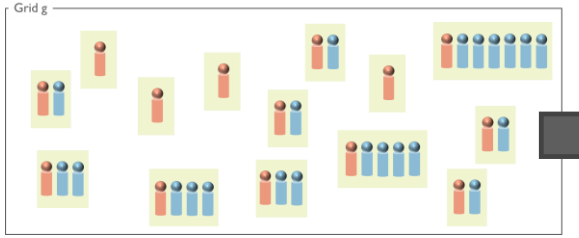
$k < K, \eta < H$

$\eta = \eta + 1$

$k = k + 1$

END

Household Composition Model



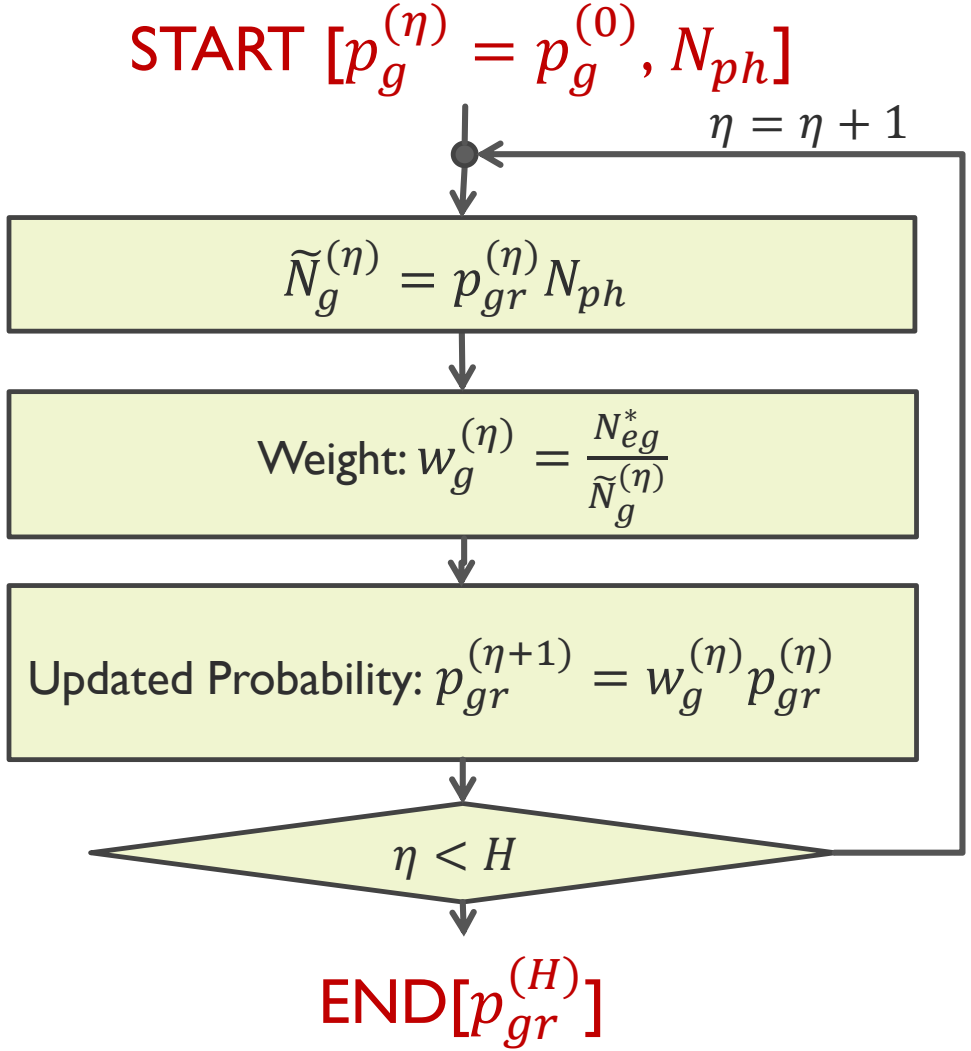
Grid g		k_2			n_2
		s_1	s_2	s_3	
k_1	s_1	$p_{11}^{(0)}$	$p_{12}^{(0)}$	$p_{13}^{(0)}$	$\tilde{N}_{gs_k}^{(\eta)}$
	s_2	$p_{21}^{(0)}$	$p_{22}^{(0)}$	$p_{23}^{(0)}$	$\tilde{N}_{gs_k}^{(\eta)}$
	s_3	$p_{31}^{(0)}$	$p_{32}^{(0)}$	$p_{33}^{(0)}$	$\tilde{N}_{gs_k}^{(\eta)}$
n_1		$\tilde{N}_{gs_k}^{(\eta)}$	$\tilde{N}_{gs_k}^{(\eta)}$	$\tilde{N}_{gs_k}^{(\eta)}$	

Estimating attributes k: Gender, Age, Occupation

Outputs

Residential grid: # Households and members
male/female
persons in each age range
worker/non-worker

ESTIMATION OF WORK PLACES



Estimation of work places:

Workers (from estimated residential grid) are assigned their work place.

Note: calculate male and female separately

Grid g		Residential Grid s_1	s_2	s_3	n_2
Work Place Grid	s_1	$p_{11}^{(0)}$	$p_{12}^{(0)}$	$p_{13}^{(0)}$	$\widetilde{N}_{gs_k}^{(\eta)}$
	s_2	$p_{21}^{(0)}$	$p_{22}^{(0)}$	$p_{23}^{(0)}$	$\widetilde{N}_{gs_k}^{(\eta)}$
	s_3	$p_{31}^{(0)}$	$p_{32}^{(0)}$	$p_{33}^{(0)}$	$\widetilde{N}_{gs_k}^{(\eta)}$
n_1		$\widetilde{N}_{gs_k}^{(\eta)}$	$\widetilde{N}_{gs_k}^{(\eta)}$	$\widetilde{N}_{gs_k}^{(\eta)}$	

Grid g		Residetial Grid s_1	s_2	s_3	n_2
Work Place Grid	s_1				$n_{s1,k1}$
	s_2				$n_{s2,k1}$
	s_3				$n_{s3,k1}$
n_1		$n_{s1,k2}$	$n_{s2,k2}$	$n_{s3,k2}$	

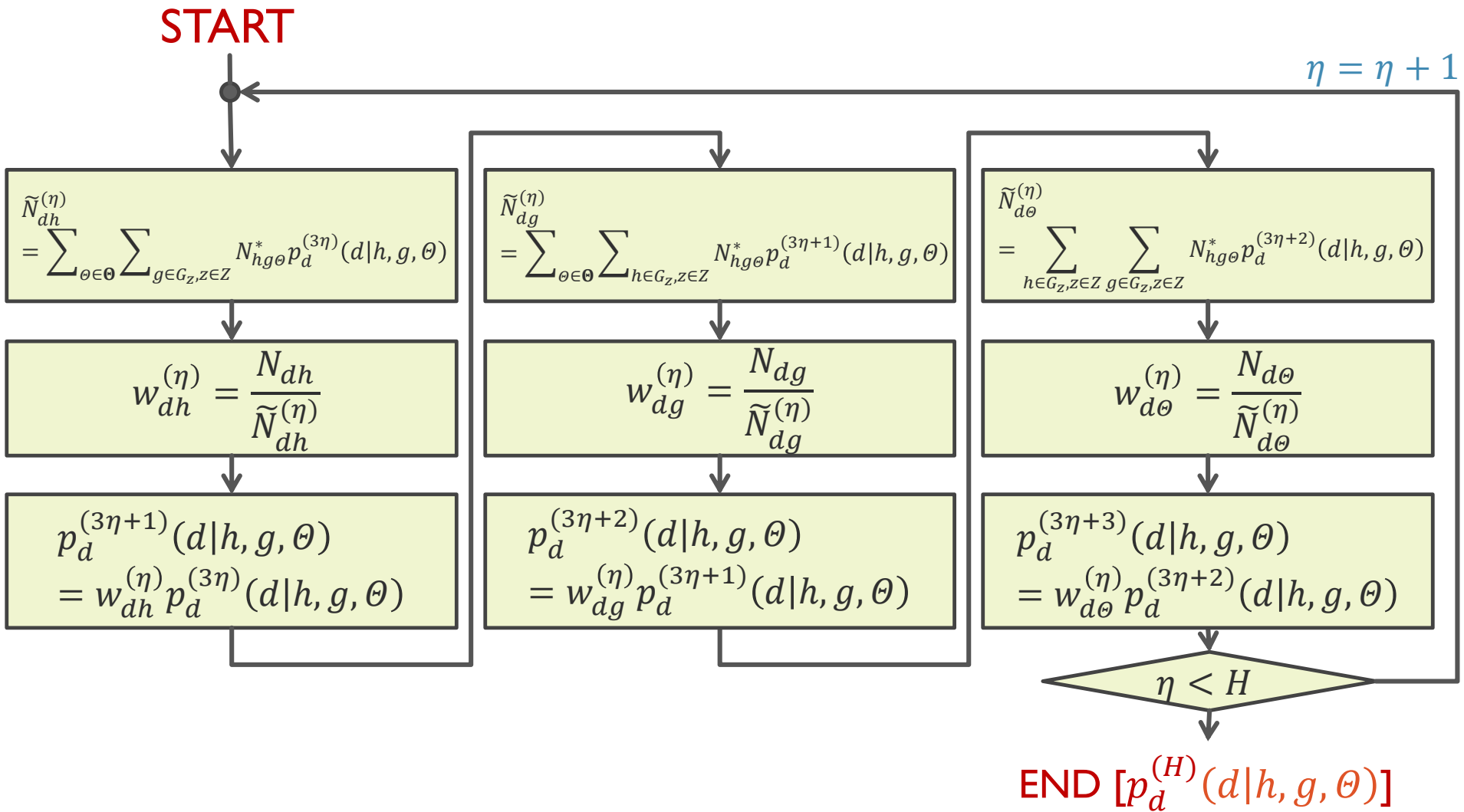
From Census

Estimating attributes k: work place grid

Grouping attributes: residential grid, gender

Outputs: Work place grid: # of work activities in a grid who comes to work at a grid

ESTIMATION OF WORK DURATION



Out of Home Duration:
Divided into
48 intervals every 30 min.

Estimating attributes
- Out of Home duration

Grouping attributes
- Residential Grid
- Work Place Grid
- Personal Attribute

Output
Out of Home duration

CASE STUDY: GREATER TOKYO AREA DATA

SAMPLE DATA

Person Trip Survey Data

Source: Ministry of Land, Infrastructure and Transport

Area: Greater Tokyo Area (238 municipality)

Time: October – November 2008

Number of households: 340,000 (out of 16M)

Number of trips: more than 84,000,000 trips

Trip generation rate: 2.45 trip/day

Activity types (7): Home, Work, Business, School, Leisure, Shopping, Others

COMPLETE CENSUS DATA

National Population Census Data

Source: Statistics Bureau & Statistics Center

Area: Greater Tokyo Area (41,833 Grids)

Number of people: Residential Population in 500m Grids

Time: 10/01/2010

Economic Census Data

Source: MIC and the Ministry of Economy, Trade and Industry

Area: Greater Tokyo Area (41,833 Grids)

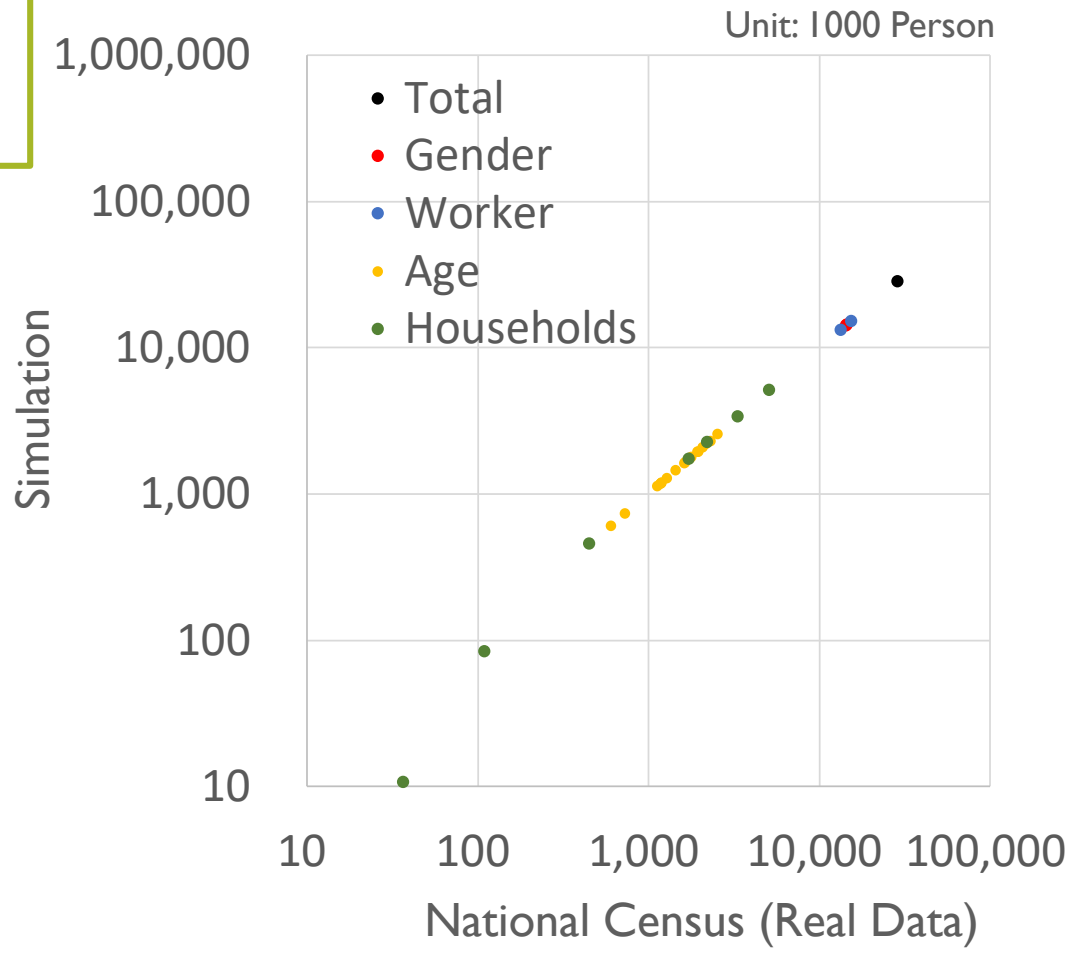
Number of people: Working Population in 500m Grids

Time: February 2012

CASE STUDY: GREATER TOKYO AREA
RESULT I ASSIGNMENT OF HOUSEHOLD COMPOSITION

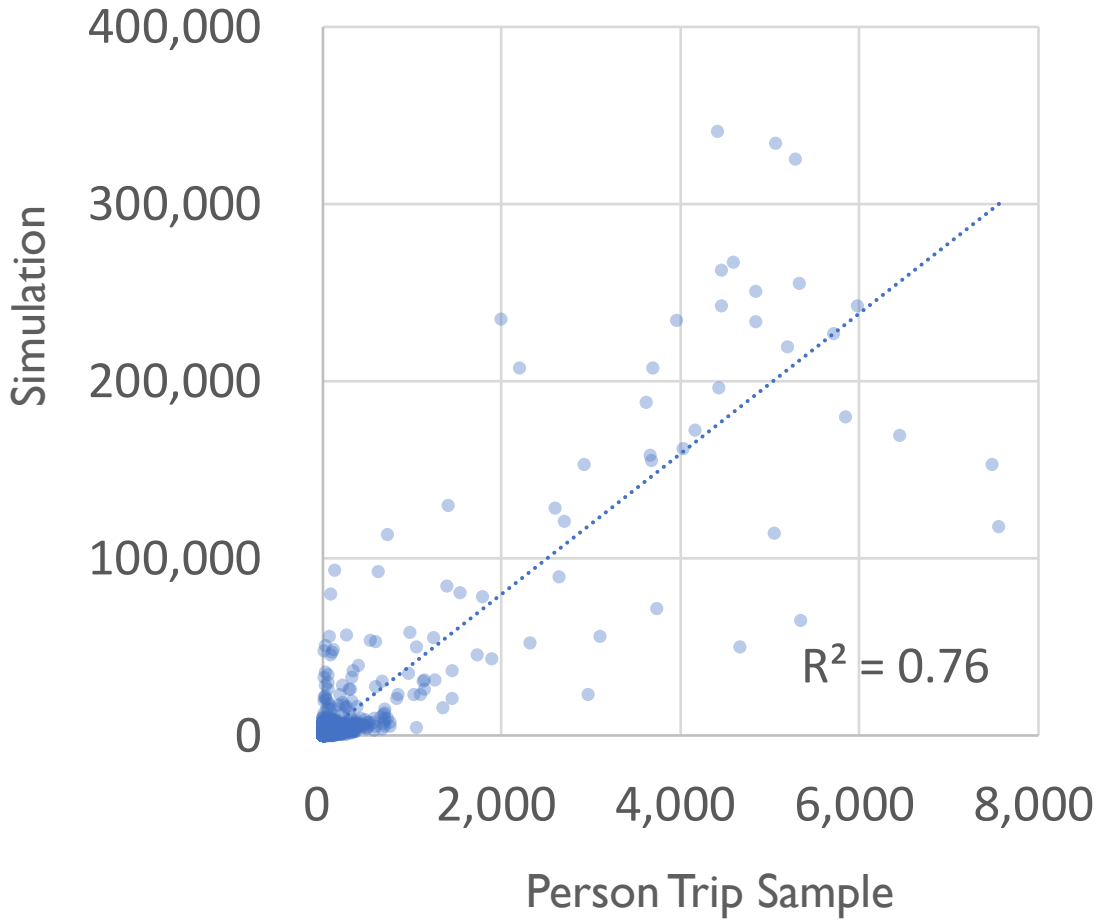
Number of Households: 16,555,354

Number of People: 37,225,544



Attribute	Census	Sim
Total	28674.9	28675.6
Male	14320.8	14321.4
Female	14354.1	14354.2
Worker	13311.3	13314.5
Noneworker	15363.9	15361.1
Age0-4	1175.6	1183.5
Age5	1168.4	1183.2
Age10	1195.0	1205.3
Age15	1275.6	1288.6
Age20	1641.5	1656.7
Age25	1926.1	1944.6
Age30	2172.3	2196.2
Age35	2531.7	2558.3
Age40	2288.7	2307.7
Age45	1939.4	1959.6
Age50	1611.0	1630.3
Age55	1724.7	1745.0
Age60	2072.8	2097.2
Age65	1773.3	1790.1
Age70	1438.4	1457.8
Age75	1114.5	1131.6
Age80	725.6	735.6
Age85-	601.4	604.2
Num of people per household 1	5069.6	5196.4
Num of people per household 2	3310.9	3404.4
Num of people per household 3	2202.7	2263.0
Num of people per household 4	1708.5	1753.8
Num of people per household 5	448.1	456.9
Num of people per household 6	109.1	84.4
Num of people per household 7	36.2	10.8

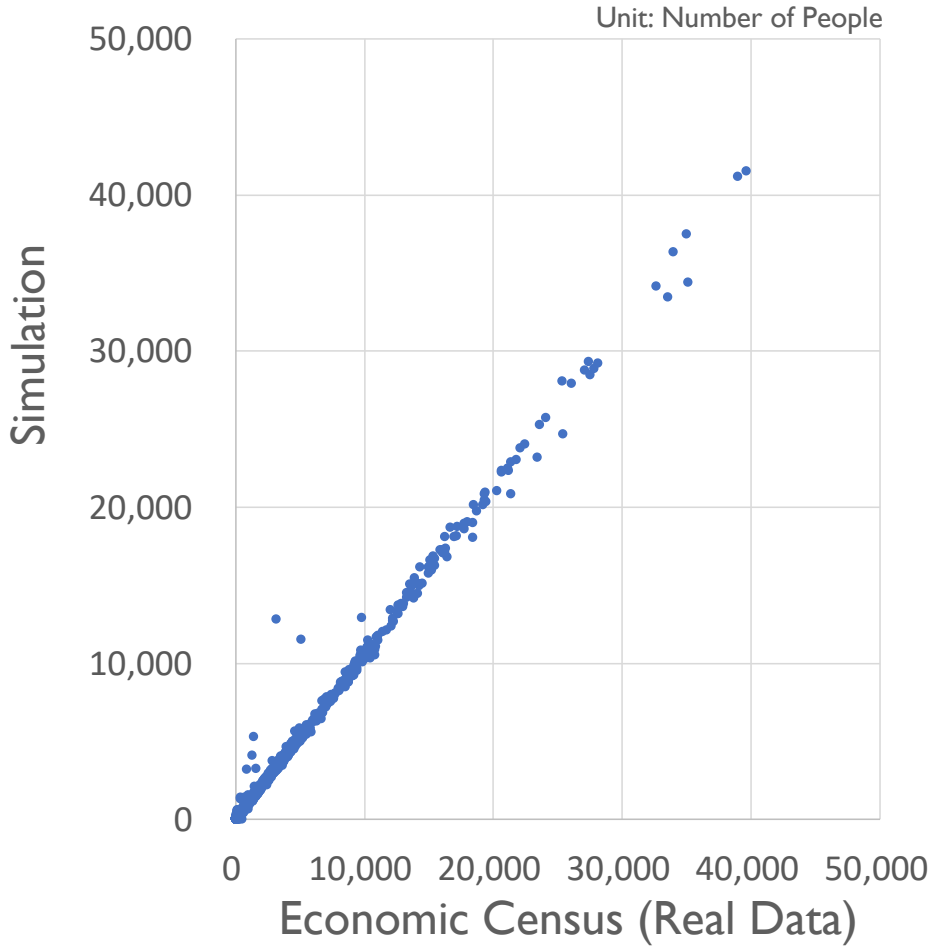
CASE STUDY: GREATER TOKYO AREA
RESULT I ASSIGNMENT OF HOUSEHOLD COMPOSITION



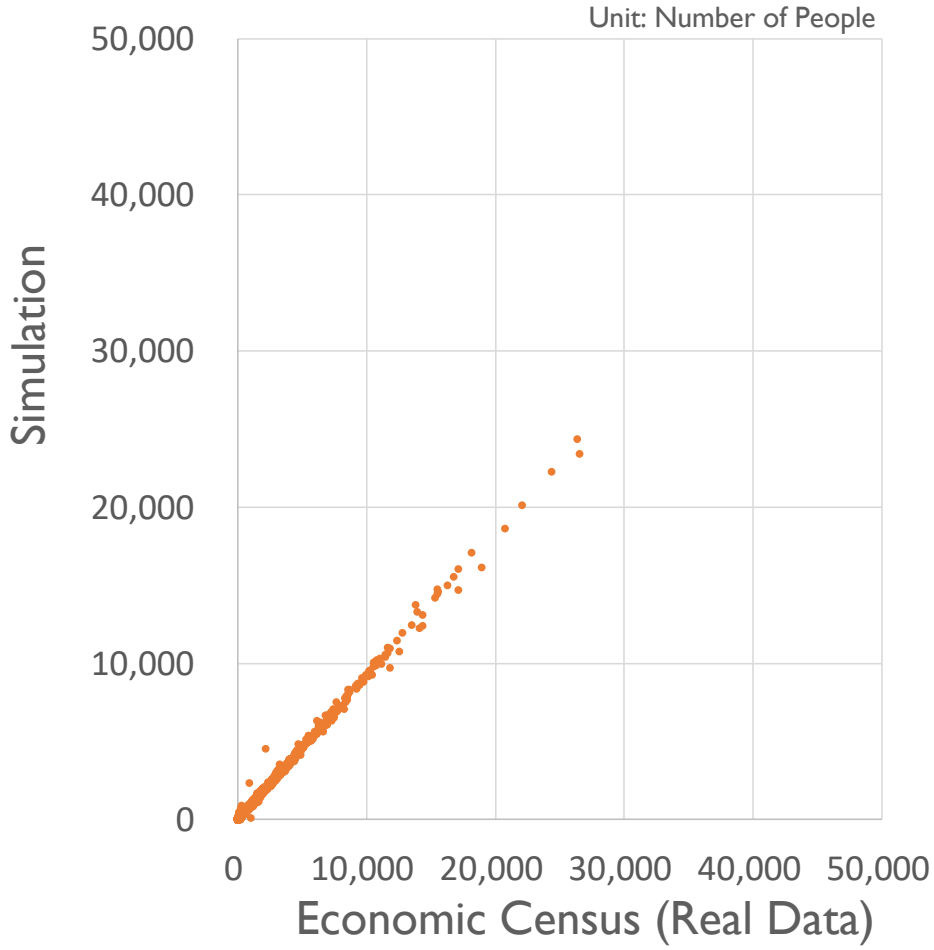
Pm
Gender(2)
Age(4):0-20
:20-40
:40-60
:60-
Num of Member I<=5 Only

CASE STUDY: GREATER TOKYO AREA
RESULT2 ESTIMATION OF NUMBER OF WORK ACTIVITIES

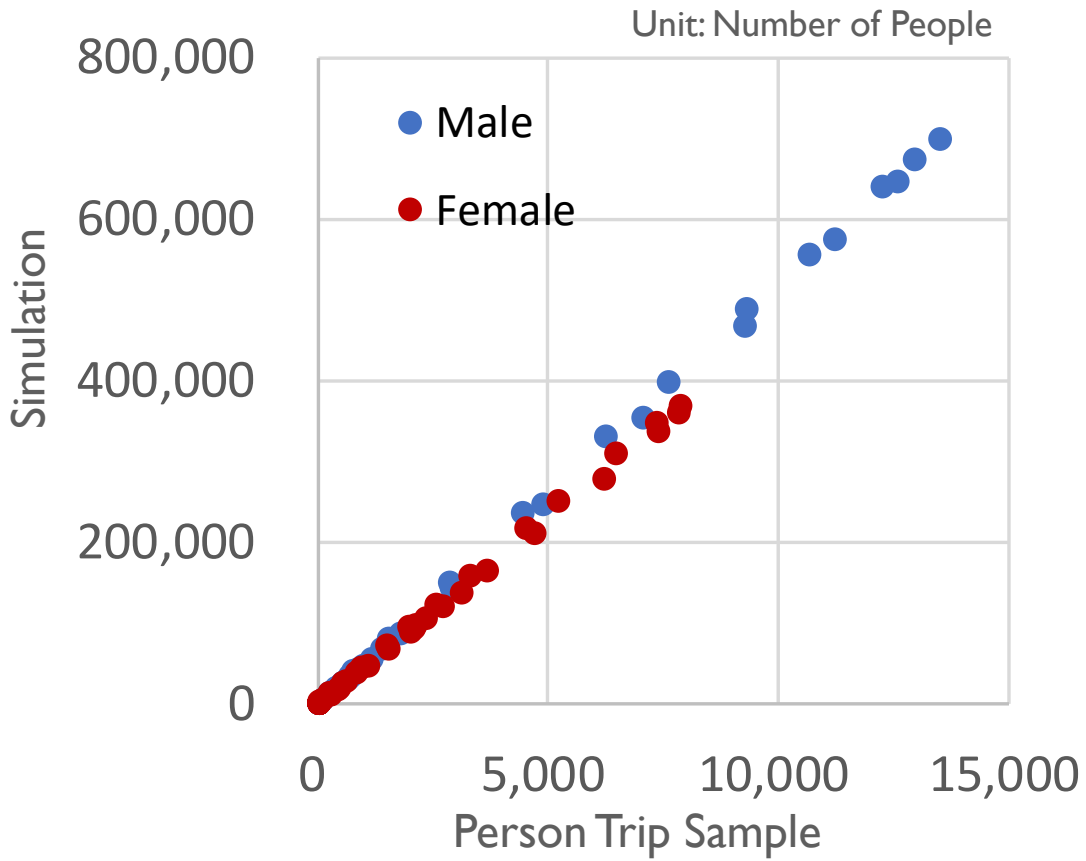
Male

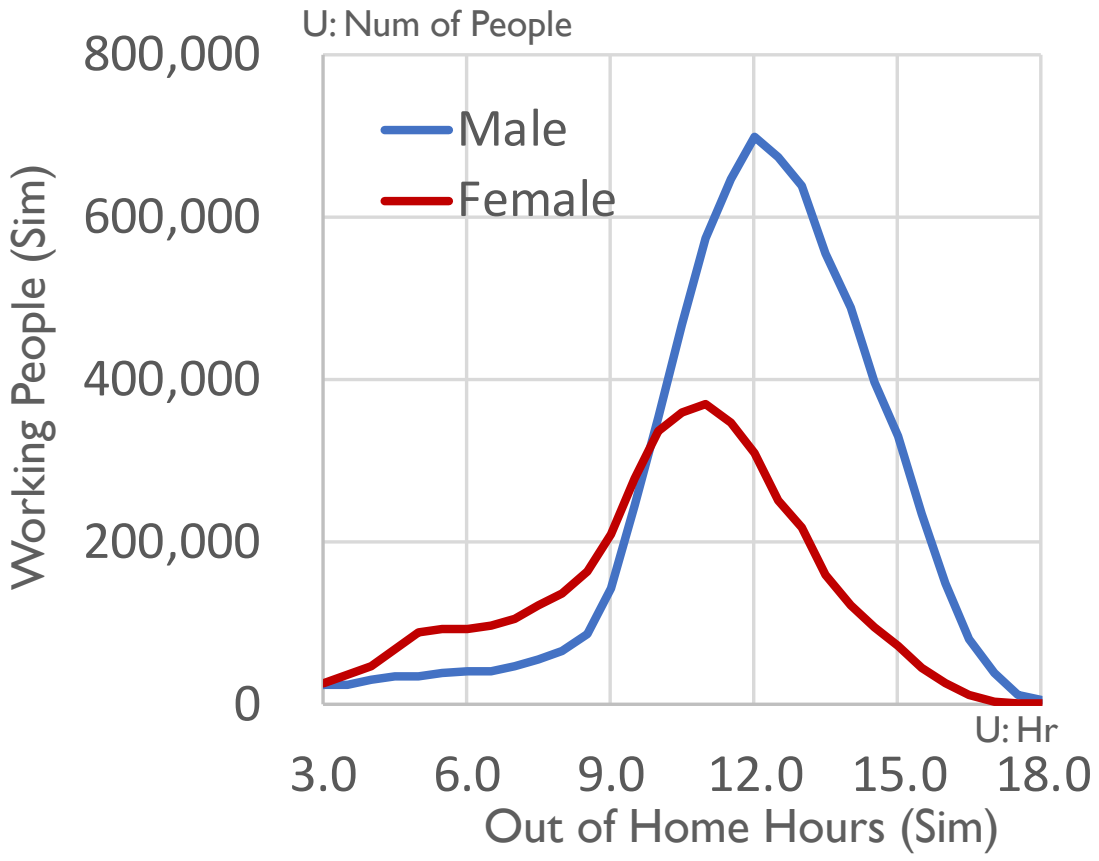


Female



CASE STUDY: GREATER TOKYO AREA
RESULT3 ASSIGNMENT OF OUT OF HOME HOURS





FUTURE WORKS

- Improve Household Composition Model
- Completion of activity model (e.g., including shopping, leisure activities)
- Analyzing autonomous vehicle-sharing and/or ride-sharing systems considering household interaction for Greater Tokyo
- Analyzing the effects of working policies on quality of life (in term of time spending with family)

THANK YOU FOR YOUR ATTENTION
Q&A