SCAG ABM
Long-Term Choice Models

03/25/2015

SCAG Modeling Task Force

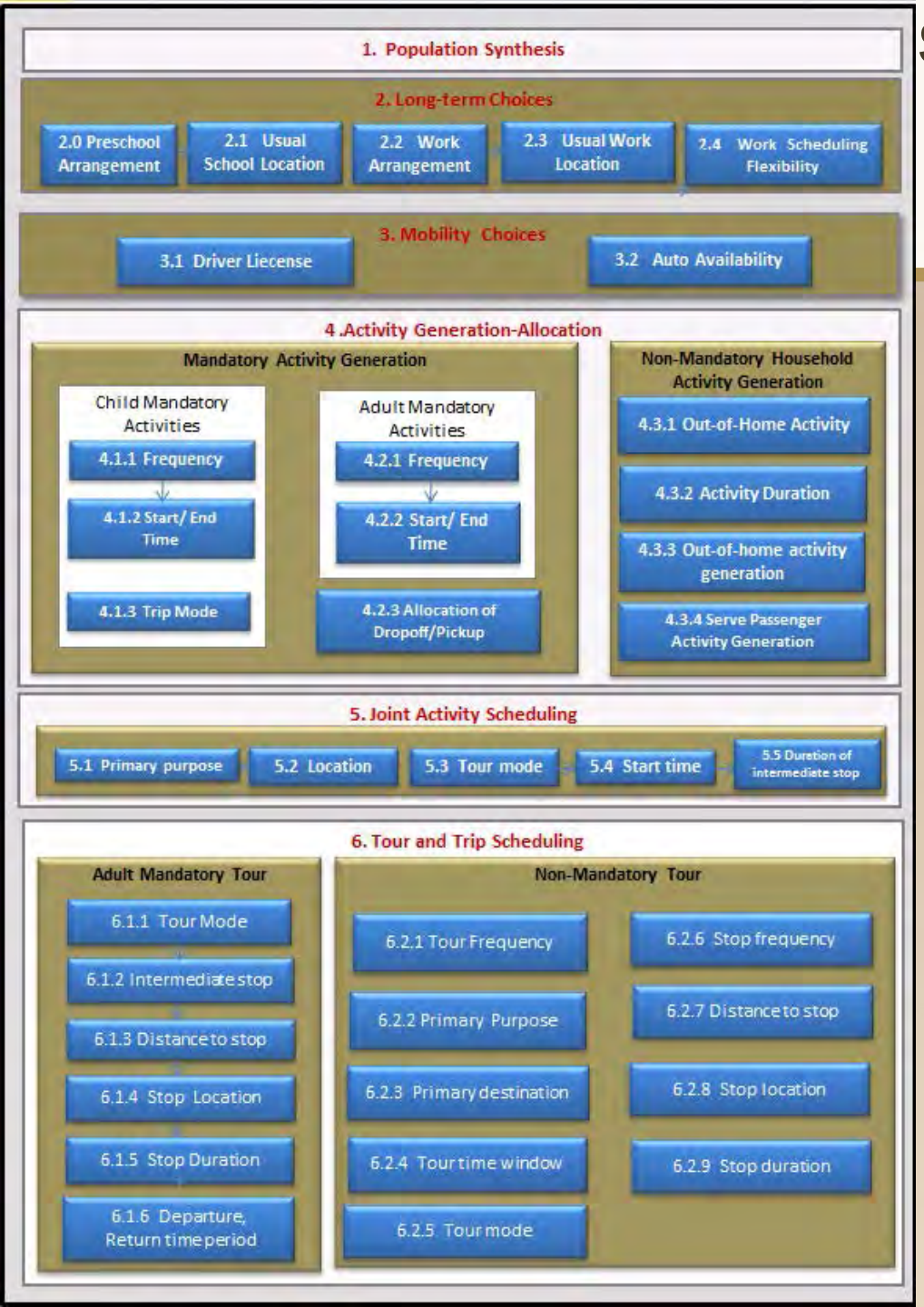
Modeling and Forecasting

Hsi-Hwa Hu

Bayarmaa Aleksandr

Outline

- ABM Overview – Model Structure
- Framework of Long-term Choice Models
- Survey Analysis
- Summary of Model Estimation Results



SCAG Activity Based Model

Person types

Person type	Name
1	Worker
2	Working college student
3	Non-working college student
4	Working HS student
5	Non-working high school student
6	Adult non-worker
7	Children 6-15 years old
8	Children 0-5
9	Non-school kids 6-15

Activity types

- Mandatory
  - Work
  - School
- Non-mandatory
  - Shopping
  - Maintenance
  - Social
  - Entertainment
  - Visit
  - Active Recreation
  - Eat out
  - Other
  - Work-related

ABM Basic Concepts

- Synthetic Population Model (PopSyn) generates socioeconomic input data to SCAG ABM.
- Long-term choice (LTC) model generates additional input variables for workers and students, including school/work location, worker's characteristics on weekly work duration, work schedule flexibility, and number of jobs.
- LTC output are important variables to short-term choice models, particularly on mandatory tour and trip scheduling models.

Long-term Choice: Worker and Student

Workers

- 16 years old or older.
- SCAG region has about 7 million workers in 2012; 39% of total population of SCAG region.

Students

- About 5 million, 28% of total population
- Are categorized by 1) Preschool, 2) Grade K-8, 3) Grade 9-12, and 4) College/University

Long Term Choice Models

Five Sub-Models for Students and Workers

- Preschool Arrangement Model
- Usual School Location
- Work Arrangement
- Usual Work Location
- Work Scheduling Flexibility

Survey Data Analysis

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS
50 YEARS

1. Work Arrangement Model

The work arrangement model predicts workers'

1) weekly work hours, 2) number of jobs, and

3) workplace type.

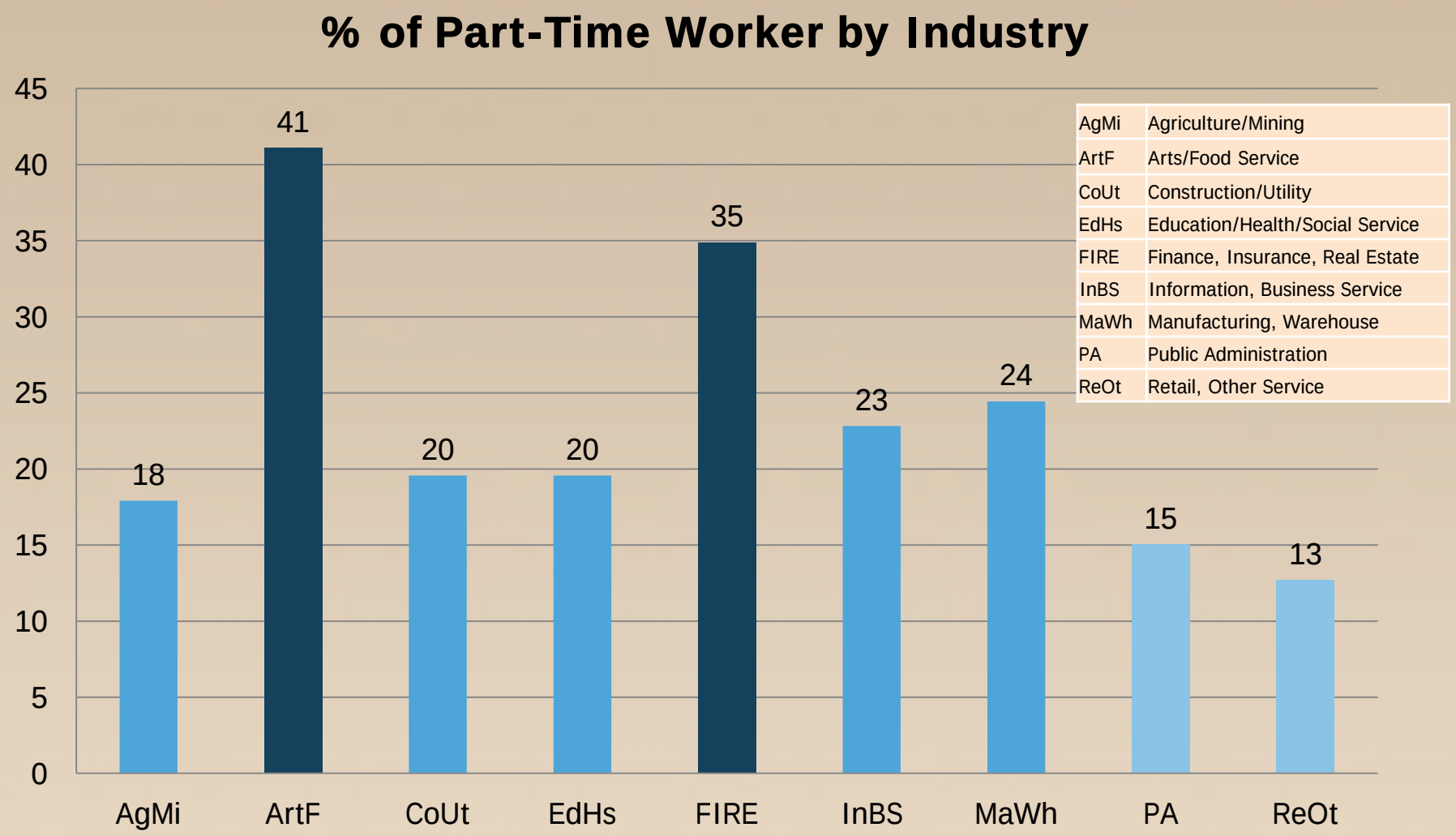
- **Weekly work hours**
  - Hours… 1-20, 21-34, 35+
- **Workers' number of jobs**
  - One job, multiple jobs
- **Primary workplace location type**
  - Fixed work place, work at home, variable work place

Weekly Work Duration

- ACS: Weighted to Regional Workers, used as control.
- HTS: For data/model analysis.

	<=20 hrs.	21-34 hrs.	>=35 hrs.	All
ACS	10	12	78	100
HTS	10	8	82	100

Weekly Work Duration- *By Industry*



Weekly Work Duration
- by Personal Characteristics

- 78% of male workers work for 35 hours or more per week.
- A worker who is female, younger age, and/or student is less likely to work for full-time job.

% of workers

	<=20 hrs.	21-34 hrs.	>=35 hrs.
Gender			
Male	13	9	78
Female	21	15	**64**
Age			
16-29	24	16	**60**
30-44	16	13	71
45-64	15	11	75
>= 65	14	10	76
Student Status			
Not Student	14	11	75
Student	36	22	**42**

Weekly Work Duration
- by Household Characteristics

- Not significant difference between workers with/wo kids
- A worker from low-income household is less likely to work for full-time job.

% of workers

	<=20 hrs.	21-34 hrs.	>=35 hrs.
Household with Kids			
No Kids	17	12	70
With Kids	15	11	73
Household income			
1_ <35K	25	18	**58**
2_ 35-50K	16	14	70
3_ 50-75K	15	12	72
4_ 100-150K	15	11	74
5_ > 150K	13	9	77

Multiple Jobholder

- According to data from Bureau of Labor Statistics (BLS), for multiple jobholders as a percentage of total workers, California is 4.2% in 2012 (+/- 0.3% with 90% CI)
- The assumption for SCAG region is 4.5% (based on special survey from Current Population Survey – 1998).
- Multiple jobholders is about 6.7% from HTS

Number of Jobs - BLS Data

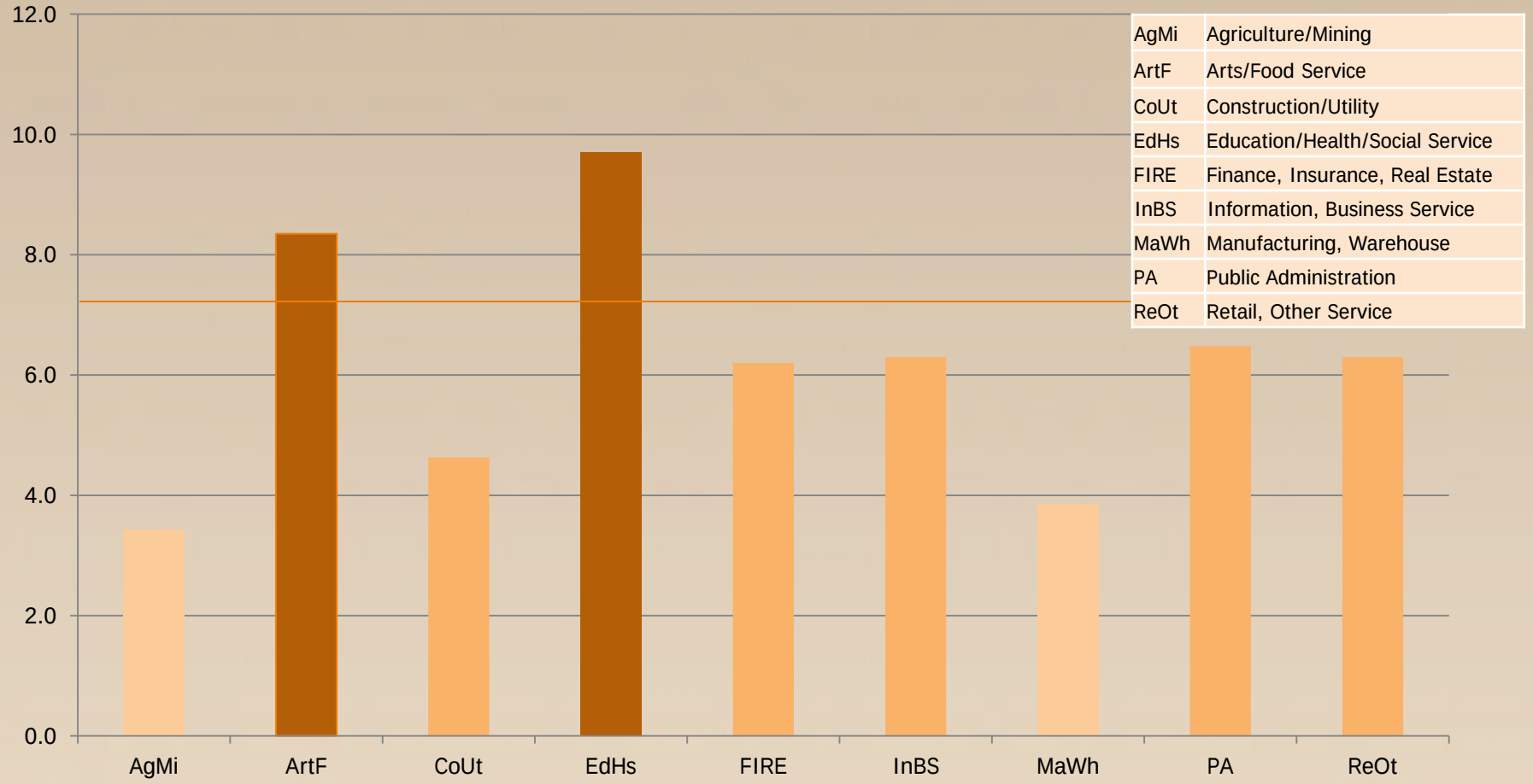
- Younger, single tend to have higher % of multiple jobs

HOUSEHOLD DATA
ANNUAL AVERAGES
36. Multiple jobholders by selected characteristics
[Numbers in thousands]

Characteristic	Total			
	Number		Rate(1)	
	2012	2013	2012	2013
AGE				
Total, 16 years and over(2)	6,943	7,002	4.9	4.9
16 to 19 years	178	198	4.0	4.4
20 years and over	6,765	6,805	4.9	4.9
20 to 24 years	725	789	5.4	5.8
25 years and over	6,040	6,016	4.8	4.8
25 to 54 years	4,639	4,639	4.9	4.9
55 years and over	1,400	1,377	4.6	4.4
55 to 64 years	1,136	1,108	4.9	4.7
65 years and over	264	269	3.6	3.5
RACE AND HISPANIC OR LATINO ETHNICITY				
White	5,756	5,751	5.0	5.0
Black or African American	709	755	4.5	4.7
Asian	249	267	3.2	3.3
Hispanic or Latino ethnicity	668	717	3.1	3.2
MARITAL STATUS				
Married, spouse present	3,683	3,607	4.7	4.6
Widowed, divorced, or separated	1,229	1,198	5.3	5.2
Never married	2,031	2,197	5.0	5.2
FULL- OR PART-TIME STATUS				

Workers' Number of Jobs - *by Industry*

% of Workers with Multiple Jobs



AgMi	Agriculture/Mining
ArtF	Arts/Food Service
CoUt	Construction/Utility
EdHs	Education/Health/Social Service
FIRE	Finance, Insurance, Real Estate
InBS	Information, Business Service
MaWh	Manufacturing, Warehouse
PA	Public Administration
ReOt	Retail, Other Service

Workers' Number of Jobs
- by Personal Characteristics

- A working student is more likely to have multiple jobs
- Other personal characteristics do not show significant relationship with the number of jobs.

% of workers

	Single Job	Multiple Jobs
Gender		
Male	94	6
Female	93	7
Age		
16-29	93	7
30-44	93	7
45-64	93	7
65-99	94	6
Student Status		
Not Student	93	7
Student	90	**10**

Workers' Number of Jobs
- by Household Characteristics

- Household characteristics shown in this table do not show a significant relationship with the number of jobs.

% of workers

	Single	Multiple
Household with Kids		
No Kids	93	7
With Kids	93	7
Household income		
1_ <35K	94	6
2_ 35-50K	92	8
3_ 50-75K	93	7
4_ 100-150K	92	8
5_ > 150K	93	7

Primary Work Location

- Work Location Data from HTS:
  - Fixed work location: 87.1%
  - Variable work location: 11.6%
  - Work at Home: 1.3%
- According to ACS data, % of workers who work at home is about 5% for SCAG region.

% Work Location - *by Industry*

	Industry	Fixed	Variable	Home
AgMi	Agriculture/Mining	77	**22**	1
ArtF	Arts/Food Service	86	12	2
CoUt	Construction/Utility	69	**30**	2
EdHs	Education/Health/Social Service	87	11	1
FIRE	Finance, Insurance, Real Estate	83	11	**6**
InBS	Information, Business Service	84	12	**4**
MaWh	Manufacturing, Warehouse	**92**	6	1
PA	Public Administration	**92**	7	1
ReOt	Retail, Other Service	86	12	2

% Work at Home By Industry - ACS

	% Work at Home (WAH)	
	2000	2010
All	3.6	4.8
Agriculture; Mining	4.7	3.5
Construction	2.3	4.1
Manufacturing	1.7	2.4
Wholesale	3.7	5.5
Retail	2.4	3.0
Transportation; Utility	1.3	2.3
Information and Communications	**4.7**	**6.7**
Finance, Insurance, Real Estate	**6.0**	**7.8**
Business Service	**7.0**	**9.0**
Education/Health	3.8	4.6
Arts/Entertainment/Hospitality	3.2	3.2
Other Service	5.2	5.8
Public Administration	1.4	3.7

Work Location
- by Personal Characteristics

- Male workers are more likely to work at variable location than female workers.
- Other personal characteristics do not show a significant relationship with work location.

% of workers

	Fixed	Home	Variable
Gender			
Male	82	3	**16**
Female	**86**	3	11
Age			
16-29	84	3	13
30-44	84	3	13
45-64	84	3	13
65+	85	2	13
Student Status			
Not Student	84	3	13
Student	85	2	14

Work Location
- by Household Characteristics

- Workers with higher HH income tend to work at fixed location than those with lower HH income.
- Lowest income workers have highest % on variable location

% of workers

	Fixed	Home	Variable
Household with Kids			
No Kids	84	3	13
With Kids	84	2	14
Household income			
1_ <35K	75	4	**21**
2_ 35-50K	83	3	13
3_ 50-75K	84	3	13
4_ 100-150K	85	3	12
5_ > 150K	87	3	11

2. Work Schedule Flexibility Model

The work schedule & flexibility model predicts

1) number of work days per week, 2) work flexibility.

- **Number of Work Days per Week**
  - 1 day, 2 days, 3 days, 4 days, 5+ days

- **Flexible Work Schedule**
  - None, Moderate, High

Number of Work Days per Week
- by Industry

More likely work for 5+ days per week:

- FIRE
- Manufacturing/Warehouse

Less likely work for 5+ days:

- Education/Health
- Retail/ Other Service

4 Days for PA employee

- 9 hours/day – 9/80

% of workers

	1	2	3	4	5+
AgMi	2	2	5	8	83
ArtF	2	5	10	12	70
CoUt	2	3	6	8	81
EdHs	2	5	10	10	**73**
FIRE	2	4	6	7	**81**
InBS	2	4	7	8	79
MaWh	1	1	4	7	**87**
PA	1	2	6	**17**	75
ReOt	2	4	9	13	**72**
Total	2	4	8	10	76

Weekly Work Days vs Work Hours

- Workers working more hours are more likely to work for more days.
- The two variables (weekly work hours and work days) are used to estimate work duration of a weekday, as primary input variables to model work start time/end time.

Work Day Distribution by Weekly Hours

% of workers

	1	2	3	4	5+
<=20 hrs.	9	18	21	14	39
21-34 hrs.		3	21	27	50
>=35 hrs.			4	7	89

Flexible Work Schedule - *By Industry*

Low Flexibility (need to arrival at work on time):

- Public Administration,
- Agriculture/Mining,
- Education/Health/Social Services, and
- Manufacturing and Warehouse.

High Flexibility:

- Financial, insurance, Real Estate
- Information/Business Services

% of workers

	Low	Med	High
AgMi	**46**	36	18
ArtF	35	46	19
CoUt	41	39	20
EdHs	**47**	39	13
FIRE	24	43	**33**
InBS	23	49	**28**
MaWh	**45**	40	15
PA	**48**	41	11
ReOt	34	45	21
Total	38	42	19

Flexible Work Schedule
- by Personal Characteristics

- Personal characteristics do not show significant relationships with Work Schedule.

% of workers

	Low	Med	High
Gender			
Male	37	42	21
Female	39	42	19
Age			
16-29	40	43	17
30-44	38	43	20
45-64	37	42	21
65-99	38	42	21
Student Status			
Not Student	38	42	20
Student	38	45	17

Flexible Work Schedule
- Household Characteristics

- Workers with highest HH income tend to have higher flexible schedule to work.

% of workers

	Low	Med	High
Household with Kids			
No Kids	37	42	21
With Kids	39	43	17
Household income			
1_ <35K	42	39	20
2_ 35-50K	42	39	19
3_ 50-75K	42	40	18
4_ 100-150K	39	43	18
5_ > 150K	32	46	**22**

Flexible Work Schedule

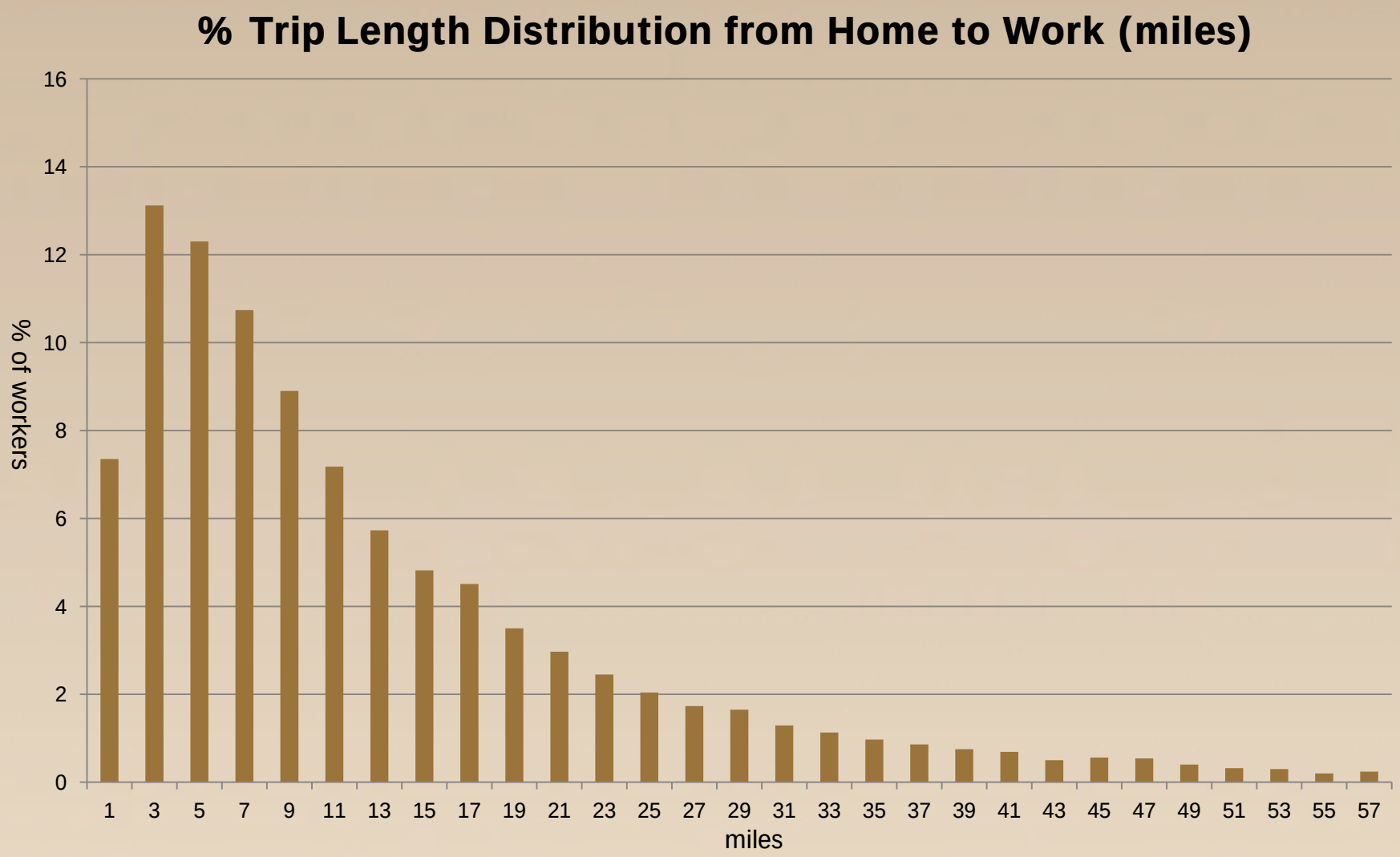
- by Weekly Work Hours

- Workers who work for less hours per week (part time worker) are more likely to have flexible work schedules.

% of workers

	Low	Med	High
<=20 hrs.	31	38	**31**
21-34 hrs.	32	43	25
>=35 hrs.	41	43	16

3. Work Location Model



Home-Work Distance

- Mean = 16 miles
- Median = 10 miles

- 7% of workers are less than 1 mile
- 20% less than 3 miles
- 10% longer than 30 miles

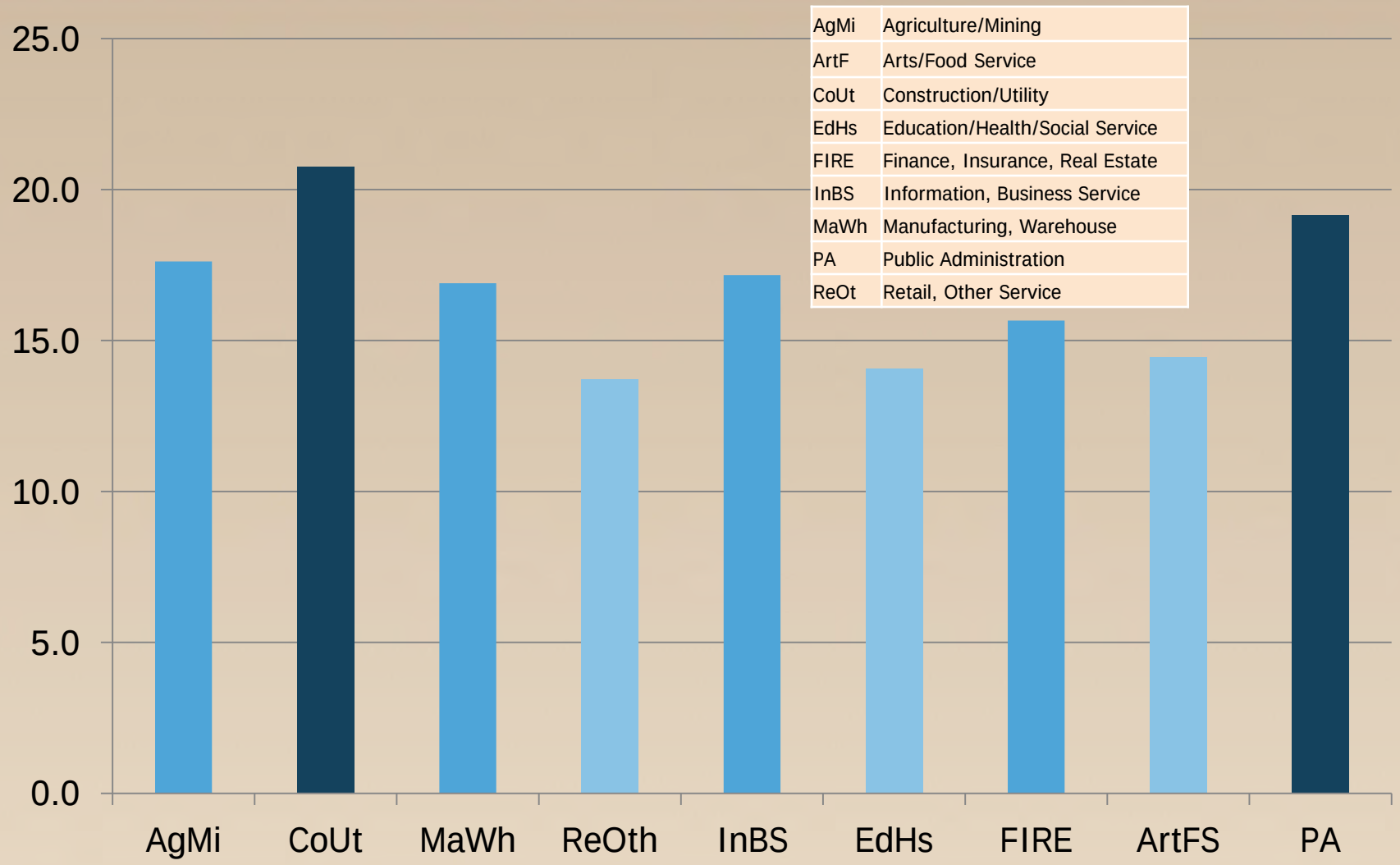
Distance	% Worker
<1	7.4
1-3	13.1
3-5	12.3
5-10	23.5
10-20	23.4
20-30	9.9
30-50	7.2
>50	3.2

Home-Work Distance

- *by Residential County*

HH County	% Workers	Mean Dist.	% Worker (>30 miles)	% Worker (>50 miles)
LA	53%	14	7	2
OR	16%	15	8	2
SBD	11%	**20**	**20**	**7**
RIV	10%	**21**	**21**	**9**
VN	7%	16	12	3
IMP	3%	15	6	3

Home-Work Distance - *by Industry*



AgMi	Agriculture/Mining
ArtF	Arts/Food Service
CoUt	Construction/Utility
EdHs	Education/Health/Social Service
FIRE	Finance, Insurance, Real Estate
InBS	Information, Business Service
MaWh	Manufacturing, Warehouse
PA	Public Administration
ReOt	Retail, Other Service

Home-Work Distance

- by Socioeconomic Characteristics

- Those who are female, with young children, lower household income, or part-time/student workers tend to have shorter work distance.

Gender		Female + Pre-school Kids	
Female	**Male**	**Yes**	**No**
14.1	17.5	13.4	**16.2**
Household Income			
<25K	**25-50K**	**50-100K**	**100K+**
13.1	14.3	16.2	17.1
Worker			
FT	**PT**	**Student**	
16.8	**14.0**	**12.1**	

Home-Work Distance by Residential Density (TAZ)

Higher residential density - > shorter work distance

HH Density	% Workers	Mean Dist. (mile)	% Workers (>30 miles)
>30	0.7	10.0	2.8
18-30	2.4	11.6	4.6
10-18	7.0	12.4	4.8
6-10	13.5	13.2	5.4
3.5-6	29.3	14.5	7.5
2-3.5	23.7	17.2	12.9
1-2	12.3	18.6	15.6
<1	11.2	20.4	18.2

Model Estimation Output

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS
50 YEARS

Preschool Arrangement

- Children <=2 years old are assumed do not go to school.
- Predicts the percentage of home schooling for children 5 years old and younger.
- Model structure: Binary.
- Choice alternative: Schooling Out-of-Home VS from HOME.
- For those attending out of home preschool, the next model will determine school location.

Preschool Arrangement
Model Estimation (Binary)

Variable	Beta - Generic
Intercept	-0.426
If age=4 (base = 3 years old)	1.006
If age=5	2.398
Number of non-workers in the Household	-0.302
HH Income = $75,000 to $99,999	0.335
HH Income =$100,000 to $149,999	0.968
HH Income =$150,000 +	1.282

Preschool Arrangement
Model Summary

- ***Age:***

  5 years old children are more likely to attend preschool out of home than those 3 and 4 years old.

- ***Number of non-working adult in the household***

  Household Preschool children are less likely to go to school out of home if the household has at least 1 non-working adult.

- ***Household income***

  Propensity of attend school out of home is positively associated with household income: children from high income households are more likely to attend school out of home.

Usual School Location

- 2.1a Preschool Location Model – MNL
- 2.1b Usual School Location k-8- Rule based
- 2.1c Usual School Location 9-12 Rule based
- 2.1d University Location- MNL

Preschool Location
Model background

- A *preschool location choice model* assigns a school (day care, kindergarten) location.
- Applied for every preschool child who go to school out of home.
- Total employment was used as size term and constrained to 1.
- A composite distance-decay factor was specified as a combination of linear, logged, squared rooted and cubed distance terms with different estimated coefficients.
- Linear distance was interacted with an income variable: Households with income less than 60K are more sensitive to distance for preschool children.

Preschool Location
Model Estimation (MNL)

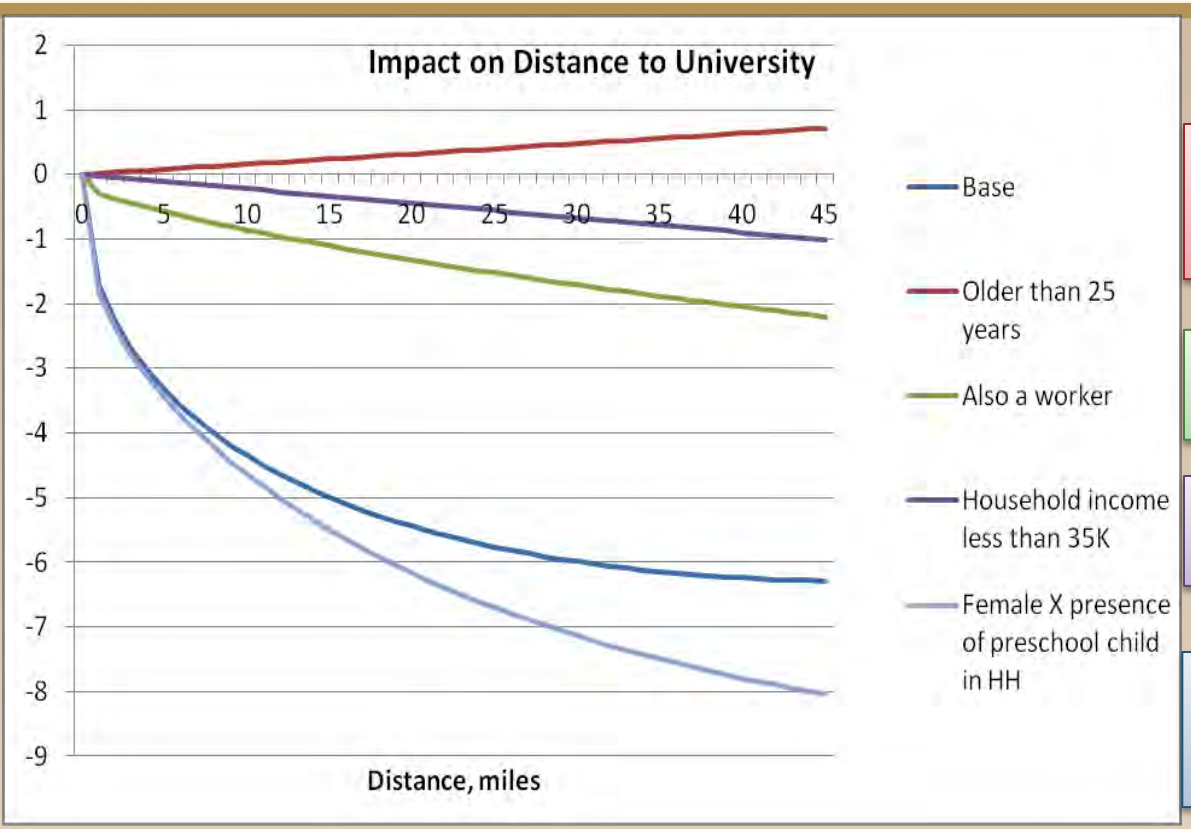
Variable	Beta - Generic
Total employment	1.000
Distance	0.433
Natural log of distance	4.342
Square root of distance	-7.380
Distance squared	0.013
Distance cubed	0.000
Distance - low income (less than $60,000)	-0.096
Person.AGE<=3	-0.007
Mode choice logsum	0.500



University Location
Model Estimation(MNL)

	Beta
LN(University enrollment +0.425* Education emp)	1.00000
Distance	0.16726
Log(1+Distance)	1.50850
Square root distance	-2.89577
Mode choice log-sum	0.50000
Distance*Age >25	0.01467
Log(1+Distance)* Worker	0.79015
SQRT (Distance)* Worker	-0.54774
Distance*Income <=35	-0.01402
Distance*Female with preschool kids	0.14329
Log(1+Distance)*Female with preschool kids	2.90315
SQRT (Distance) *Female with preschool kids	-2.88907

Marginal Effects of Person and Household Characteristics on College Location



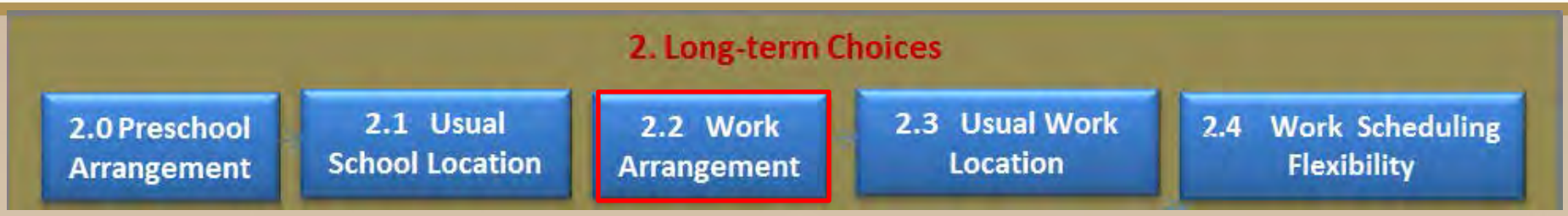
Students older than 25 years have lower friction to go to a university farther from the home location.

Students who are also part-time workers prefer to work closer to home location.

Similar is the effect for students in lower income households.

Female students with preschool children in the household strongly prefer to study close to their home location.

Work Arrangement



The work arrangement model predicts workers':

1) weekly work hours,
2) number of jobs, and
3) workplace type.

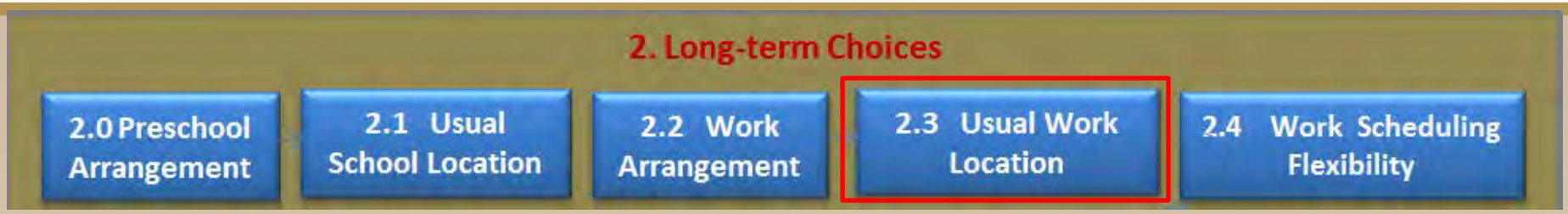
Work Arrangement
Model Estimation (MNL)

Explanatory variables	Hours			Location			Job	
	0-20 hrs	21-34 hrs	35+	Fix	Home	Variable	Single	Multiple
Constants	-2.580	-3.043			-3.337	-2.153		-2.977
Age 16-34	**0.548**	**0.714**			**-0.746**	-0.111		0.000
Age>=60	**0.876**	**0.727**			**0.590**	0.000		-0.289
if student	**1.363**	**0.917**			-0.384	0.000		0.000
If higher educated (educa = 5, 6)	-0.205	-0.263			**0.390**	0.000		**0.373**
Female	**0.563**	**0.624**			**0.000**	**-0.453**		**-0.122**
Presence of school age children at home (<= 5 yr old)	-0.471	-0.688			0	0		0
Female x HpsHome	0.332	0.499			**0.702**	-0.344		0.000
Single person household	0.000	-0.205			0.000	0.000		0.304
HH has 2 or more workers	0.000	0.142			0.236	0.193		0.000
Low (0-35,000)	0.668	0.663			0.483	0.647		0.000
Low (35,001-50,000)	0.000	0.245			0.000	0.155		0.000
High (100,001-150,000)	-0.133	-0.167			-0.381	-0.137		0.000
Very High (>150,000) - 12%	-0.275	-0.226			0.000	0.000		0.000
Agriculture/Mining	-0.445	-0.758			-1.395	**0.499**		-0.784
Transportation/Warehousing and Utility/Construction	-0.458	0.000			-0.856	**0.944**		-0.495
Manufacturing/Wholesale	-0.561	-0.419			-1.427	-0.906		-0.580
Retail/Other services	**0.398**	**0.708**			-1.026	-0.339		-0.257
Information Services/Bussiness Services	0.000	0.196			-0.435	0.000		-0.331
Education and Health Services	0.504	0.476			-1.740	-0.228		0.149
Financial Real Estate	0.000	0.000			0.000	0.000		0.000
Arts/Entertainment and Hospitality/Food Service	**0.536**	**0.774**			-1.088	-0.382		0.000

Work Arrangement
Model Summary

- Female tends to work for part-time, and less likely to work at variable work place and multiple jobs than males.
- A student worker tends to work for part-time, and less likely to work at home.
- Retail, education, and entertainments/food service workers are more likely to work for part time.
- Agriculture and construction workers are more likely to work at variable location; finance/real estate and PA are more likely to work at home than other industries.
- Education/Health/Social services are more likely to work for multiple jobs, and less likely for agriculture and manufacturing.
- Workers who are younger (16-34) or older (>= 60) are more likely to be part-time workers than middle age workers. However, younger workers are less likely to work at fixed work place compared to other age, and older workers are more likely to work at home, but less likely for multiple jobs.

Work Location



- The *Usual Work Location Choice Model* predicts the usual work location for workers who work out of home.
- The Model was estimated in a MNL form using the ALOGIT software.
- The Model includes mode choice logsums, general accessibilities, distance terms, zonal employment, household characteristics, and worker characteristics as explanatory variables.

Work Location
Model Estimation (MNL)

Variable	Beta
LN (zonal emp by industry)	1.00000
TLS*	-0.044350
LN(1+TLS)	-1.226770
Squared TLS	0.000060
TLS* Female	-0.023410
Squared TLS*Female	0.000100
LN(1+TLS)* Income <=35K	-0.302750
TLS*HHINC>100K	0.011300
Squared TLS*HHINC>100K	-0.00007
TLS* PT worker	0.013890
LN(1+TLS)* PT worker	-0.772540
TLS*Female with pre-school children	-0.007420
LN(1+TLS)*Female with pre-school children	0.340060

* TLS-Transformed Log Sum

Work Location
Model Summary:

- Part-time workers are more sensitive to commute distance than full-time workers, and their sensitivity increases with longer distances.
- Females are less likely to travel longer distances compared to males. This could be due to household responsibilities and child care at home.
- Low-income workers are more sensitive to commuting longer distances while higher-income workers are less sensitive.

Work Schedule Flexibility

The Work Schedule & Flexibility Model predicts:

1) Number of work days per week,
2) Work flexibility.

Work Schedule Flexibility
Model Estimation (MNL)

Variable	Beta - Specific to Choice Alternatives							
	Weekly Work Days					Work Flexibility		
	1	2	3	4	5+	No Flex	Moderate	High
Constant	-5.273	-4.988	-3.799	-2.889			-0.542	-2.264
Household Income								
Below 75,000								
Medium High (75,000-100,000)	0.000	0.000	0.207	0.000			0.167	0.000
High household income(>100,000)	0.265	0.280	0.390	0.262			0.427	0.490
Industry								
Agriculture/Mining	0.000	0.000	0.000	0.000			0.000	0.812
Transportation/Warehousing and Utility/Construction	0.000	0.000	-0.300	0.000			0.240	0.841
Manufacturing/Wholesale	**-1.560**	**-1.267**	-0.607	-0.365			0.288	0.637
Retail/Other services	0.000	-0.309	-0.299	0.000			0.530	0.981
Information Services/Business Services	0.000	-0.386	-0.493	0.000			**0.954**	**1.474**
Education and Health Services								
Financial Real Estate	0.000	0.000	-0.579	-0.300			**0.851**	**1.863**
Arts/Entertainment and Hospitality/Food Service	-0.494	0.000	-0.395	0.000			**0.611**	**0.821**
Public Administration	0.000	0.000	0.000	**1.071**			0.000	0.000
Work hours								
<= 20 hours/week	3.300	3.771	2.435	1.352			0.000	0.467
21-34 hours/week	0.853	2.051	2.425	1.978			0.000	0.396
>= 35 hours/week								
Weekly work day 1 X Work Flexibility. Moderate	0.419							
Weekly work day 2 X Work Flexibility. Moderate	0.509							
Weekly work day 3 X Work Flexibility. Moderate	0.642							
Weekly work day 4 X Work Flexibility. Moderate	0.232							
Weekly work day 1 X Work Flexibility. High	1.509							
Weekly work day 2 X Work Flexibility. High	1.270							
Weekly work day 3 X Work Flexibility. High	1.222							
Weekly work day 4 X Work Flexibility. High	0.417							

Work Schedule Flexibility
Model Summary:

- All the decisions are estimated simultaneously in ALOGIT software as a multinomial logit model.
- Part-time workers are less likely to work 5 days a week at primary job. They tend to have high work schedule flexibility.
- Industry:
  - Workers in Public Administration industry are most likely to work less than 5 days a week when compared to workers in other industries.
  - Financial and Real Estate , Information Services/Business Services , Arts/Entertainment and Hospitality/Food Service workers are most likely to have higher work flexibility when compared to other industry types.
  - Workers in Manufacturing/Wholesale are less likely to work 1 or 2 days per week.

Policy implications of alternative / flexible work arrangements:

- Beneficial for reduction of commuting volumes in peak periods
- Demand elasticity to congestion pricing
- Implementation of road pricing schemes

Thank You

Hsi-Hwa Hu
hu@scag.ca.gov

Bayarmaa Aleksandr
aleksandr@scag.ca.gov

SOUTHERN CALIFORNIA ASSOCIATION of GOVERNMENTS
50 YEARS