

# Challenges in Using PUMS to Generate Small Area Demographic Multipliers

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**Community Data Analytics**

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# Introduction

- Demographic Multipliers
- Local Variations
- New Generation of Multipliers
- Sample Size Issues
- Challenges Ahead
- Q & A and Discussions

# Demographic Multipliers

STRUCTURE TYPE	TENURE	ALL OCCUPIED UNITS		ALL SINGLE-FAMILY	OWNER-OCCUPIED	RENTER-OCCUPIED	ALL SINGLE-FAMILY DETACHED & ATTACHED	DETACHED	ATTACHED					
		OWNER-OCCUPIED	RENTER-OCCUPIED											
MULTI-FAMILY	ALL OCCUPIED UNITS	OWNER-OCCUPIED	All	RENTER-OCCUPIED	ALL SINGLE-FAMILY	OWNER-OCCUPIED	DETACHED	ATTACHED	All					
			1 bedroom or Studio						1 bedroom or Studio	1 bedroom or Studio				
			2 bedrooms						2 bedrooms	2 bedrooms				
			3 bedrooms						3 bedrooms	3 bedrooms				
			4 bedrooms						4 bedrooms	4 bedrooms				
			5+ bedrooms						5+ bedrooms	5+ bedrooms				
	ALL MULTI-FAMILY	OWNER AND RENTER OCCUPIED	All	RENTER-OCCUPIED	ALL SINGLE-FAMILY DETACHED & ATTACHED	RENTER-OCCUPIED	DETACHED	ATTACHED	All					
			1 bedroom or Studio						1 bedroom or Studio	1 bedroom or Studio				
			2 bedrooms						2 bedrooms	2 bedrooms				
		OWNER-OCCUPIED	All	RENTER-OCCUPIED					ALL SINGLE-FAMILY DETACHED & ATTACHED	RENTER-OCCUPIED	DETACHED	ATTACHED	All	
			1 bedroom or Studio										1 bedroom or Studio	1 bedroom or Studio
			2 bedrooms										2 bedrooms	2 bedrooms
RENTER-OCCUPIED	All	RENTER-OCCUPIED	ALL SINGLE-FAMILY DETACHED & ATTACHED	RENTER-OCCUPIED	DETACHED	ATTACHED	All							
	1 bedroom or Studio						1 bedroom or Studio	1 bedroom or Studio						
	2 bedrooms						2 bedrooms	2 bedrooms						

Definition, Examples, Housing and Household Specificity, and Estimation Steps

# What is a Demographic Multiplier?

- An average ratio of various populations or demographic measures per household
- Cohort – age or grade groups
- Further differentiation – rent or value
- Common Examples:
  - Number of school-age children per household (SAC)
  - Average household size (AVHH)

# Traditional Demographic Multipliers

## Fannie Mae Foundation Residential Demographic Multipliers

Projections of the Occupants of New Housing

(Residents, School-Age Children, Public School-Age Children)  
by State, Housing Type, Housing Size, and Housing Price

Prepared for:

Patrick Simmons, Director  
Department of Housing Demography  
Fannie Mae Foundation  
Washington, D.C.

Prepared by:

Robert W. Burchell, Ph.D.  
David Listokin, Ph.D.  
William Dolphin, M.A.  
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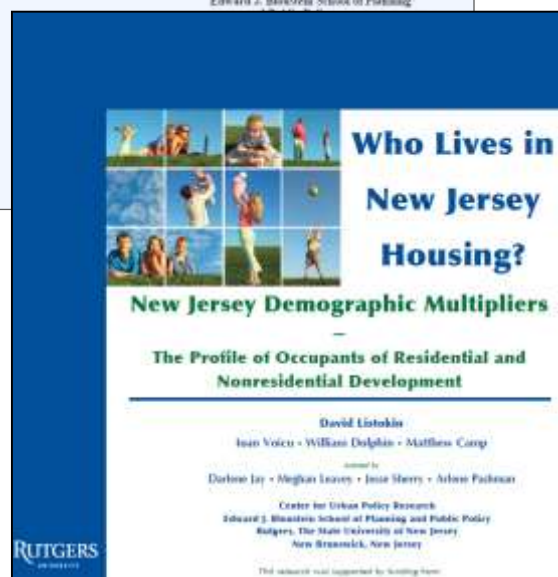
## Before 2006

- 1978 *The Fiscal Impact Handbook*
- 1985 *The New Practitioner's Guide to Fiscal Impact Analysis*
- 1994 *Development Impact: Assessment Handbook*

## 2006

Both use 2000 Census- PUMS records

- *Fannie Mae Series*
  - 50 States & DC
  - AVHH, SAC, Public School-Age Children
- *Who Lives in NJ Housing?*
  - 3 sub-state regions & NJ
  - AVHH, SAC, Public School Children
  - More elaborate





# Household Attributes & Housing Configurations

**Household Attributes:** Multipliers are specific to the sample drawn from PUMS:

- Households in recently built housing units
- Households living in specialized housing

**Housing Configurations** from *Fannie Mae Series*, derived from 2000 PUMS

Bedroom	Single-Family Detached	Single-Family Attached	5+ Units Own	5+ Units Rent	2-4 Unit	Mobile
1			✓	✓	✓	
2	✓	✓	✓	✓	✓	✓
3	✓	✓	✓	✓	✓	✓
4	✓	✓				✓
5	✓					

Each is subdivided into four housing value groups.

76 configurations, only large states have full coverage.

# Multipliers and Impact Studies

- Critical to forecast added populations and school enrollment.
- Public finance: assess impact fees and costs to support public services and staffing.
- Proposed development projects, comprehensive planning, rezoning, annexation, etc. required impact studies.
- Various types of impact studies:
  - School
  - Fiscal
  - Economic
  - Traffic
  - Environmental
  - Political
  - Social
  - Cumulative

# Steps to Generate Multipliers

1. Specifying Geography by PUMA
2. Merging PUMS Person and Housing Record
3. Selecting Relevant Variables
4. Eliminating non-Household Records
5. Selecting Records by Sample Characteristics
6. Creating Housing Configurations



# Steps to Generate Multipliers

7. Applying Various Weights
8. Grouping Variables by Age or Grade Cohorts
9. Calculating Weighted Number of Households by Housing Configuration
10. Calculating the Weighted Sums of Each Variable
11. Computing per Household Figures
12. Listing Results by Housing Configurations

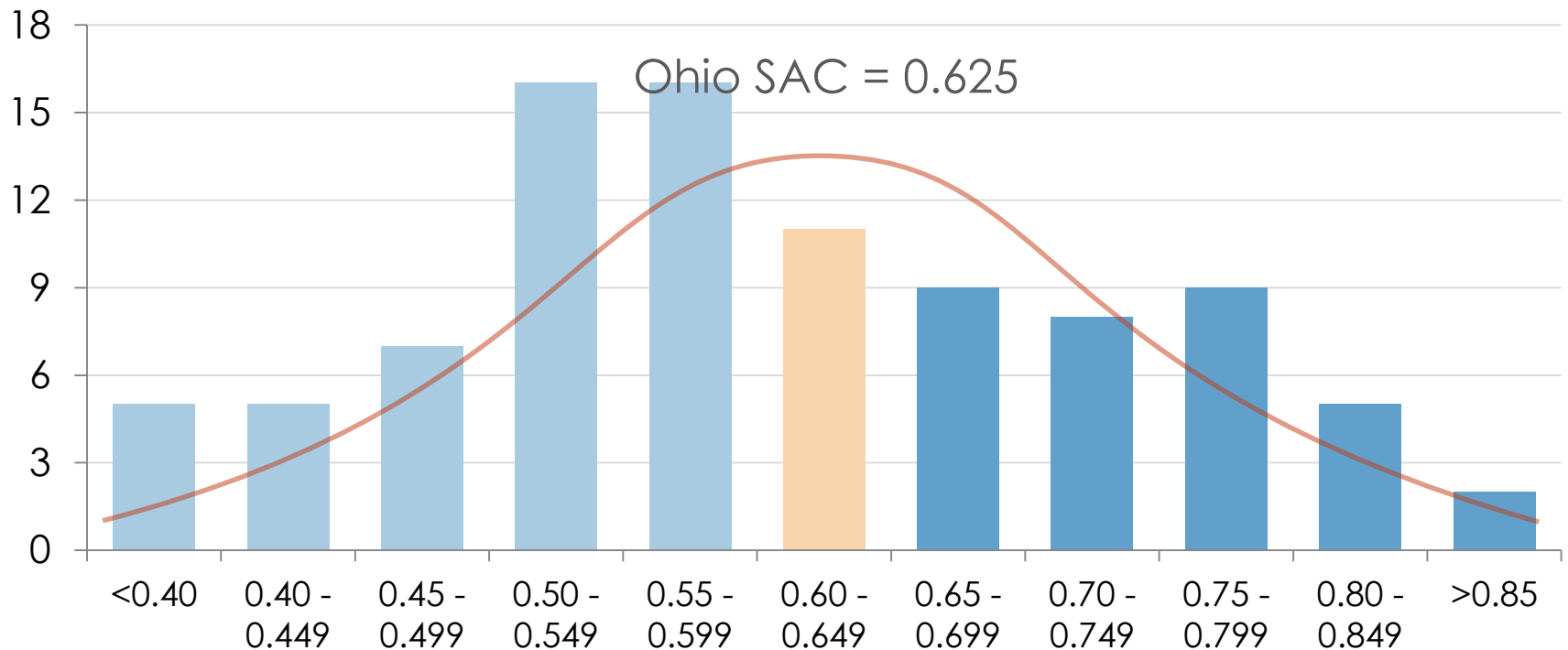
# Variations across Geographies

Compare PUMA and State-level Multipliers

<http://cmsny.org/wp-content/uploads/WongFigure1.png>

# SAC Variations in Ohio PUMAs

3-Bedroom Single-Family Units, Owned and Rented  
Distribution of 93 PUMAs by SAC Value Groups



2015 Newly Moved-In Household Sample

Source: Community Data Analytics, 2017

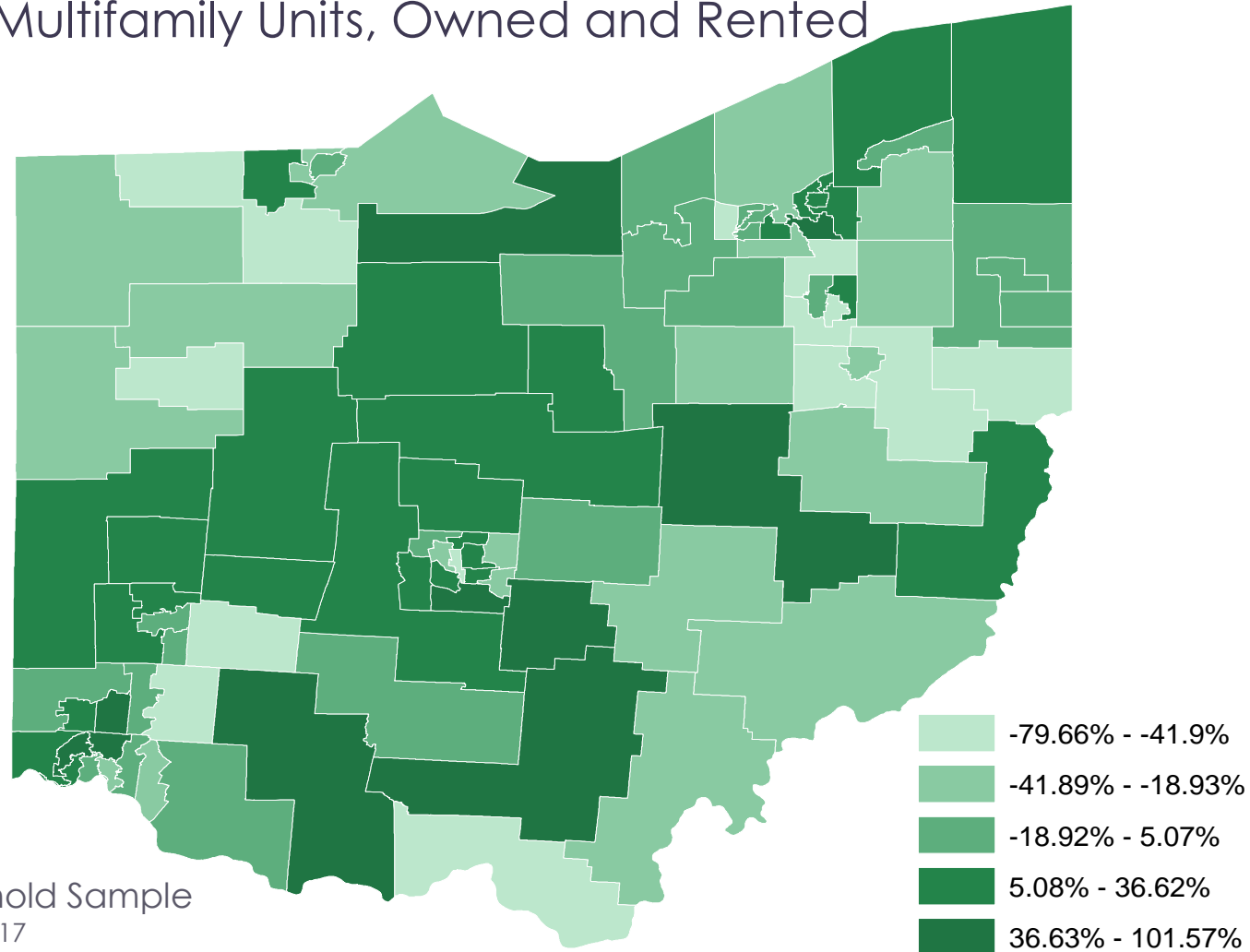
Challenges in Using PUMS to  
Generate Small Area Demographic Multipliers  
2017 ACS Data Users Conference, #ACSCConf17



# Large Variations in Ohio SAC

## 2-Bedroom Multifamily Units, Owned and Rented

- 93 PUMAs in OH
- OH SAC: 0.276
- Highest SAC: 0.556
- Lowest SAC: 0.056
- Wide range of variations
- Variance ranges from -80% to 102%
- Median Variance: -6%



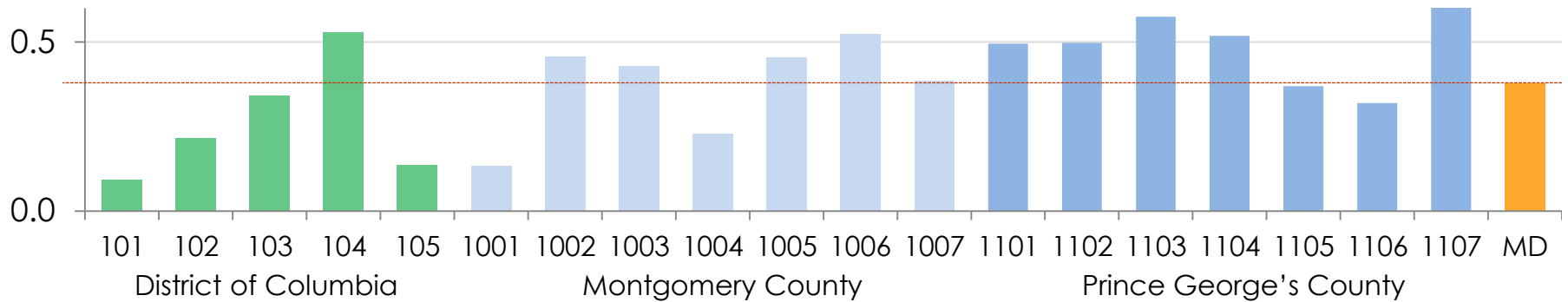
2015 Newly Moved-In Household Sample

Source: Community Data Analytics, 2017

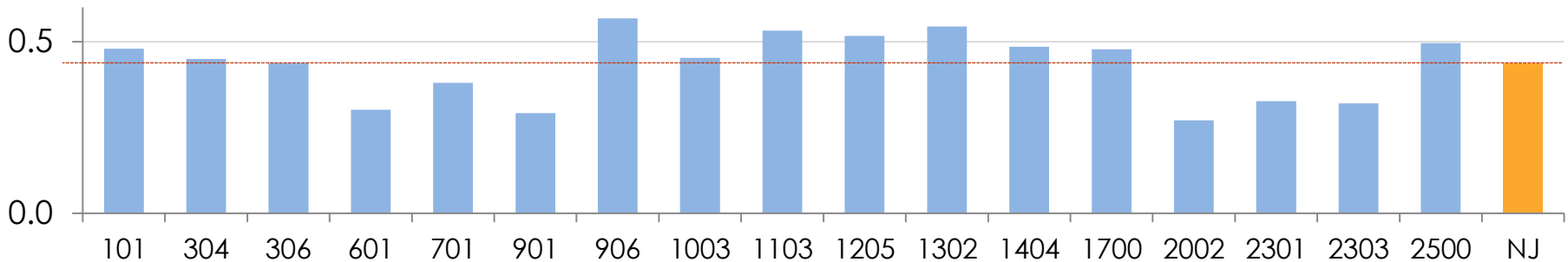
# SAC Variations in Other States

2-Bedroom Multifamily Units, Owned and Rented

District of Columbia and Maryland, 2014



New Jersey, 2015



Map for PUMAs available during Q & A.

Newly Moved-In Household Sample  
Source: Community Data Analytics, 2016 & 2017

# New Generation Demographic Multipliers

Improvements and Specialized Samples

TENURE	ALL OCCUPIED UNITS		OWNER-OCCUPIED		RENTER-OCCUPIED	
STRUCUTRE TYPE	LY	ALL MULTI-FAMILY	OWNER AND RENTER OCCUPIED	All	All	All
				1 bedroom or Studio	1 bedroom or Studio	1 bedroom or Studio
				2 bedrooms	2 bedrooms	2 bedrooms
				3 bedrooms	3 bedrooms	3 bedrooms
				4 bedrooms	4 bedrooms	4 bedrooms
		5+ bedrooms	5+ bedrooms	5+ bedrooms		
		ALL MULTI-FAMILY	OWNER-OCCUPIED	All	All	All
				1 bedroom or Studio	1 bedroom or Studio	1 bedroom or Studio
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				3 bedrooms	3 bedrooms	3 bedrooms
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		ALL MULTI-FAMILY	RENTER-OCCUPIED	All	All	All
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3 bedrooms	3 bedrooms			3 bedrooms		
4 bedrooms	4 bedrooms			4 bedrooms		
5+ bedrooms	5+ bedrooms	5+ bedrooms				
SINGLE-FAMILY	LY	ALL SINGLE-FAMILY	OWNER-OCCUPIED	All	All	All
				1 bedroom or Studio	1 bedroom or Studio	1 bedroom or Studio
				2 bedrooms	2 bedrooms	2 bedrooms
				3 bedrooms	3 bedrooms	3 bedrooms
				4 bedrooms	4 bedrooms	4 bedrooms
		5+ bedrooms	5+ bedrooms	5+ bedrooms		
		ALL SINGLE-FAMILY	RENTER-OCCUPIED	All	All	All
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ATTACHED	RENTER-OCCUPIED	All	All	All		
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		3 bedrooms	3 bedrooms	3 bedrooms		
		4 bedrooms	4 bedrooms	4 bedrooms		
5+ bedrooms	5+ bedrooms	5+ bedrooms				



# New Generation of CDA Multipliers

- Using current 5 percent 5-year PUMS
- Local multipliers to minimize state average effects
- Alternative sample to ensure sample size
- Appropriate housing configurations
- Proxy sample for specialized housing or households

# Specialized Samples

- Households living in condominiums
- Households who have retirees and no teenagers
- Low and moderate income households
- Households with transit commuters
- Double income without kid households
- Millennial households
- Other custom households or development types

# Other Differentiations

- SAC is usually divided into age cohorts or proxy grade groups
- Public School Attendees by grade groups
- Multipliers can be specific to housing value or rent groups
- Significant sample size problem
- Unreliable confidence interval

# Sample Size Issues

## Supplementary Sample

STRUCTURE TYPE	TENURE	ALL OCCUPIED UNITS		ALL SINGLE-FAMILY	OWNER-OCCUPIED	RENTER-OCCUPIED
		OWNER-OCCUPIED	RENTER-OCCUPIED			
MULTI-FAMILY	ALL OCCUPIED UNITS	All		SINGLE-FAMILY	OWNER-OCCUPIED	RENTER-OCCUPIED
		1 bedroom or Studio				
		2 bedrooms				
		3 bedrooms				
		4 bedrooms				
		5+ bedrooms				
	OWNER-OCCUPIED	All			OWNER-OCCUPIED	RENTER-OCCUPIED
		1 bedroom or Studio				
		2 bedrooms				
		3 bedrooms				
		4 bedrooms				
		5+ bedrooms				
	RENTER-OCCUPIED	All			ALL SINGLE-FAMILY DETACHED & ATTACHED	RENTER-OCCUPIED
		1 bedroom or Studio				
		2 bedrooms				
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		4 bedrooms				
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SINGLE-FAMILY	ALL MULTI-FAMILY	All		DETACHED	RENTER-OCCUPIED	
		1 bedroom or Studio				
		2 bedrooms				
		3 bedrooms				
		4 bedrooms				
		5+ bedrooms				
	OWNER AND RENTER OCCUPIED	All		ATTACHED	RENTER-OCCUPIED	
		1 bedroom or Studio				
		2 bedrooms				
		3 bedrooms				
		4 bedrooms				
		5+ bedrooms				
	OWNER-OCCUPIED	All		ATTACHED	RENTER-OCCUPIED	
		1 bedroom or Studio				
		2 bedrooms				
		3 bedrooms				
		4 bedrooms				
		5+ bedrooms				
RENTER-OCCUPIED	All		ATTACHED	RENTER-OCCUPIED		
	1 bedroom or Studio					
	2 bedrooms					
	3 bedrooms					
	4 bedrooms					
	5+ bedrooms					

# Sample Size Issues

- The sample size of the traditional recently built unit sample is a function of recent housing construction.
- Highly differentiated housing configurations lacks sufficient sample size even at the state level.
- Same problem for specialized samples.

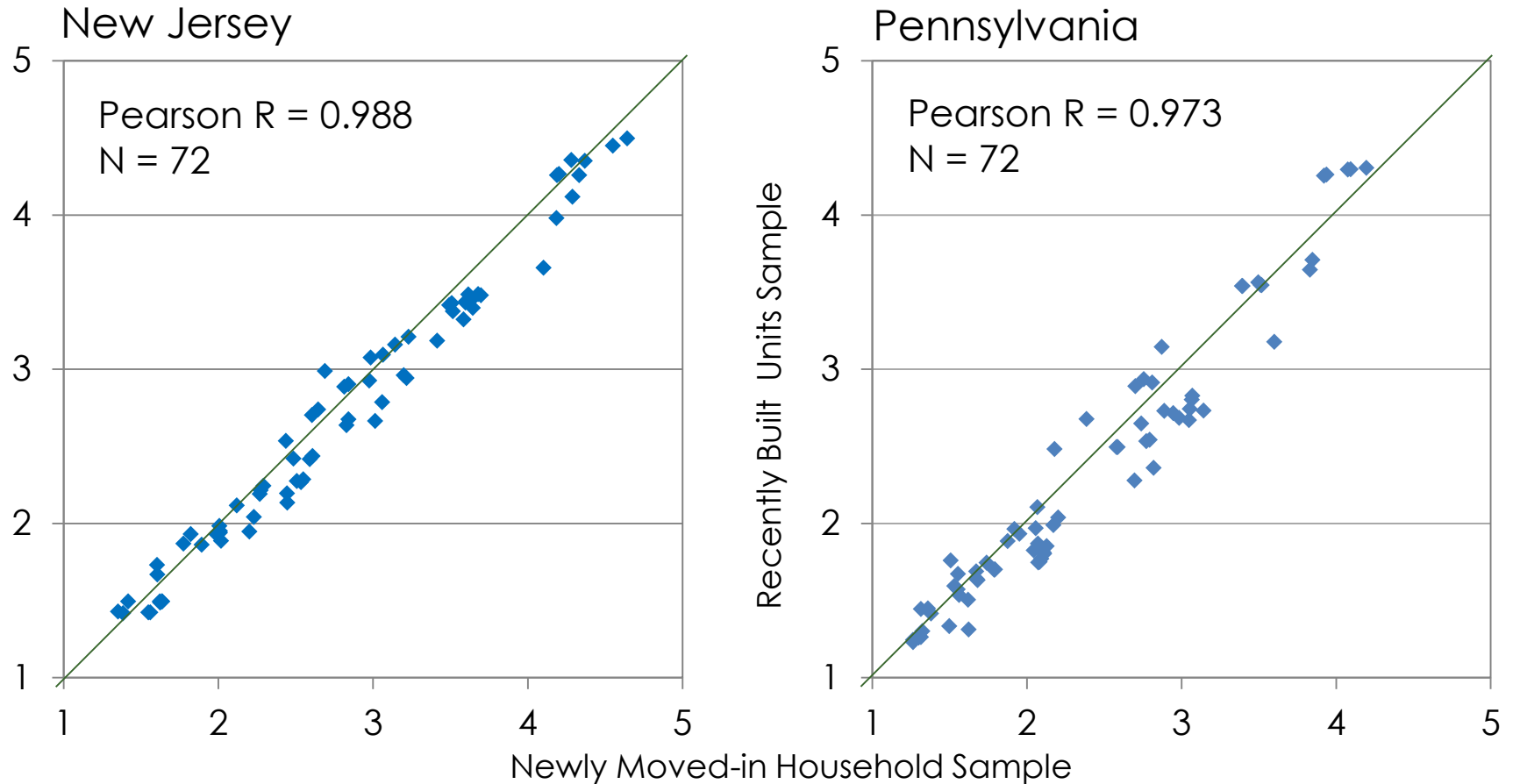
# Newly Moved-in Households

- Households recently moved in a unit, regardless of whether it is recently built.
- Likely occupants of the development – potential movers.
- Sample size 3 to 7 times larger than the traditional recently built unit sample.
- Sample size less affected by housing activities.
- It provides reliable multipliers for most common housing configurations at the aggregate PUMA level.
- It reflects long term effects.



# Comparing 2 Samples

AVHH Scatterplot, 0 to 4 Bedroom Units



Source: Community Data Analytics, 2017 based on 2010-2014 5-Year ACS-PUMS

# Not 100 Percent Match

- High degree of correlation at the state level, but ....
- T-test results comparing AVHH and SAC vary.
- Is the Newly Moved-In Household sample a reasonable alternative or just a complement?

# Weighted and Unweighted Observations

Should **600** weighted households be the cut-off?

Selected Samples		Unweighted Households	Weighted / Unweighted Ratio Minimum	Maximum
<b>Recently Built Unit Sample</b>				
Maryland, 4-B or less Configurations	2000	4 up	17.6	32.3
	2014	6 up	14.9	27.0
<b>Newly Moved-In Household Sample</b>				
Maryland, 4-B or less Configurations	2000	36 up	17.8	27.2
	2014	44 up	15.7	27.1
Ohio 4-B or less	2015	120 up	16.0	28.4
2015 Ohio 93 PUMAs	3-B Single Family	88 to 359	13.6	31.6
	2-B all Multifamily	37 to 313	16.7	43.4
	2-B Townhome	4 to 78	8.2	37.0
	2-B MF 5+ unit, rented	11 to 168	18.4	47.5

# Housing Configurations

- Should 30 or 50 unweighted observation as a cut off?
- Insufficient sample size for highly differentiated configuration cannot be resolved?
- The affinity principle
  - Same configuration but from respective region
  - Same geography but broader or blended configuration

# Challenges Ahead

## Approximation of Missing Data, Statistical Constructs

STRUCTURE TYPE	TENURE	ALL OCCUPIED UNITS		OWNER- OCCUPIED	RENTER- OCCUPIED	ALL SINGLE-FAMILY	OWNER- OCCUPIED	RENTER- OCCUPIED					
		OWNER- OCCUPIED	RENTER- OCCUPIED										
MULTI-FAMILY	ALL OCCUPIED UNITS	OWNER- OCCUPIED	All	1 bedroom or Studio	1 bedroom or Studio	ALL SINGLE-FAMILY	OWNER- OCCUPIED	All	1 bedroom or Studio				
			2 bedrooms	2 bedrooms	2 bedrooms			2 bedrooms					
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			4 bedrooms	4 bedrooms	4 bedrooms			4 bedrooms					
			5+ bedrooms	5+ bedrooms	5+ bedrooms			5+ bedrooms					
	OWNER- OCCUPIED	RENTER- OCCUPIED	All	1 bedroom or Studio	1 bedroom or Studio	ALL SINGLE-FAMILY DETACHED & ATTACHED	RENTER- OCCUPIED	All	1 bedroom or Studio				
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			4 bedrooms	4 bedrooms	4 bedrooms			4 bedrooms					
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			ALL MULTI-FAMILY	OWNER AND RENTER OCCUPIED	All			1 bedroom or Studio	1 bedroom or Studio	DETACHED	RENTER- OCCUPIED	All	1 bedroom or Studio
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3 bedrooms	3 bedrooms	3 bedrooms			3 bedrooms								
4 bedrooms	4 bedrooms	4 bedrooms			4 bedrooms								
5+ bedrooms	5+ bedrooms	5+ bedrooms			5+ bedrooms								
OWNER- OCCUPIED	RENTER- OCCUPIED	All	1 bedroom or Studio	1 bedroom or Studio	ATTACHED	RENTER- OCCUPIED	All	1 bedroom or Studio					
		2 bedrooms	2 bedrooms	2 bedrooms			2 bedrooms						
		3 bedrooms	3 bedrooms	3 bedrooms			3 bedrooms						
		4 bedrooms	4 bedrooms	4 bedrooms			4 bedrooms						
		5+ bedrooms	5+ bedrooms	5+ bedrooms			5+ bedrooms						

# Information from the Region for Approximation?

Applying a ratio from the reference region.

## School-Age Children

	Region	Region Ratio	PUMA Original	PUMA Adjusted
3-Bedroom Multifamily	0.98	100.00%	0.87	0.87
3-B Multifamily 2-4 Unit	1.02	104.08%	-	0.906
3-B Multifamily 2-4 Unit Rented	1.16	118.36%	-	1.030



# Statistical Construct for Municipality

- Municipal boundaries vs PUMA geography
- Can we pull PUMS records to create a statistical construct that carries selected attributes of a target municipality?
- Feasibility of developing a multivariate model with a series of dummies?

# Previous Work

## Demographic Multipliers: Data Mining & Measuring Development Impacts

Sidney Wong, Ph.D., Community Data Analytics & Econsult Solutions, Inc.

**F**iscal impact analysis is an important tool for assessing how new development will impact municipal costs and revenues, helping leaders make better decisions for their communities. Thirty-eight years ago, Robert Burchell and David Listokin formalized a set of demographic multipliers critical to measuring development impacts, such as added populations, added school students, and consequent costs necessary to support public services.

**The implication is clear:** Using old multipliers overestimates development impacts on many occasions, a point repeatedly confirmed by our research findings at Community Data Analytics (cda-esi.com). For example, the 2000 PUMS-based School-Age Children (SAC) in New Jersey are generally higher than the current amount of SAC in 2014. Figure 1 demonstrates that the old multipliers overestimate SAC in single-family detached units by 70 percent, while underestimating one-quarter of the SAC.

### CDA Glossary

**2-4 Unit.** A housing unit in a structure containing 2, 3, or 4 units.

**5+ Units.** A housing unit in a structure containing 5 or more units.

**55+ Household Sample.** Part of the Newly Moved-in Household Sample limited to households with at least one member aged 55 and over and the absence of persons below 19 and K to 12<sup>th</sup> grade students.

**American Community Survey (ACS).** An ongoing survey taken each year by the Census Bureau. It provides 1-year, 3-year, and 5-year estimates of demographic, housing, social, and economic information.

**Bedroom.** The room in a housing unit designed to be used as bedroom; a one-room unit such as studio, efficiency, or in-law apartment is considered as having no bedroom.

**Condominium Sample.** A sample

## What is a Demographic Multiplier and Why Does it Matter?

Sidney Wong, Ph.D.  
Senior Advisor, Econsult Solutions Inc.  
Updated March 2017, original in November 2016

Recently, the CDA team got the opportunity to present at two American Planning Association (APA) Chapter conferences on fiscal impact analysis and data needs in forecasting development impacts. During and after our sessions we received a lot of questions focused on the technical nature regarding demographic multipliers, data sources, applications, and statistical issues. While I have touched on this subject in a previous [post](#) and in a recent [APA article](#), I am happy to further expand on CDA's research in demographic multipliers and efforts in updating and expanding the old series based on the 2000 Census records.

### WHAT IS A RESIDENTIAL DEMOGRAPHIC MULTIPLIER?



A residential demographic multiplier in a general sense is an average ratio of different populations or other measures of an occupied housing unit. The population being composed of different groups such as school-age children (SAC), public school attendees, commuters, etc. Other measures also include number of cars, average income, etc.

The most well-known example is the average household size: data that the Census Bureau routinely reports on. This is calculated by dividing the household population by the number

## RECAP: ESI PRESENTS AT NCAC-APA CONFERENCE



On June 4, our Community Data Analytics (CDA) team consisted of ESI Director, Dr. Daniel Miles, Research Analyst, Ms. Rina Guo, and Senior Advisor, Dr. Sidney Wong made the trip down to our nation's capital to speak at the American Planning Association National Capital Area Chapter Conference. They delivered a CPE session to an engaged crowd of over 60 people. The session, "Projecting Development Impacts for Sustainable and Fiscally Responsible Growth," focused on the importance of recent and geographic specific data in reference to community planning and the procedure of fiscal impact studies.

Dr. Wong began the session with an overview of development impacts, showing that household sizes have either fallen or remained stable in 35 states

## A NEW TECHNIQUE FOR MORE ACCURATE IMPACT ASSESSMENT

States, municipalities, and school districts make land use decisions that influence their fiscal and economic conditions. Understanding the effects of those decisions on schools, traffic and municipal services can help to prevent school overcrowding, gridlock, gaps in services and fiscal distress. A fiscal impact analysis (FIA) is an important tool for assessing how new development will impact costs and revenues, helping leaders make better decisions for their respective communities. Unfortunately, many FIAs are based on data that is out-of-date and lacks sufficient geographic granularity to support sound planning decisions.

At ESI, we have conducted numerous FIAs. For years, like other practitioners, we have been relying on the multipliers compiled by Professors Burchell and Listokin from Rutgers University. The main two multipliers used to estimate occupant characteristics are the average household size (AVHS) and school-aged children (SAC). Each is reported at the state level or multi-state region by housing configurations (categories combining number of bedrooms, building structure, and whether

### ABOUT THE BLOG

At least once a week, we turn over this space to an expert from our staff or network of senior advisors, partners and friends, with the aim of delivering useful insights and commentary on topics we tend to observe over: economics, policy, real estate, transportation and urban development.

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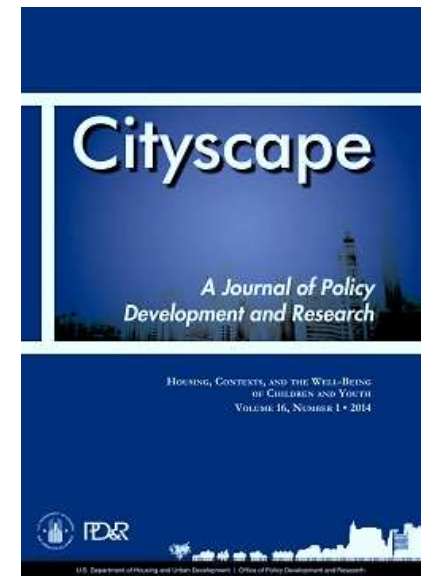


economics | policy | strategy

# Research of Community Data Analytics Team

A methodological paper, “Residential Demographic Multipliers: Using PUMS Records to Estimate Housing Development Impacts,” will appear in HUD Office of PD&R’s **Cityscape** later this year.

If you are interested, please leave your contact information.





# Questions Advice Sought

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