Price inputs for U.S. sub-national comparisons (RPPs)

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OUTLINE

Two microdata sources: Bureau of Census and Bureau of Labor Statistics

1. *ACS for Housing (Census)*
   - *Rent price levels: hedonic estimation*
   - *Imputing owner-occupied expenditures*

2. *CPI for all other goods and services (BLS)*
   - *CPDs and hedonic regressions*
   - *Patterns between 2010-2016*

To what extent do more detailed hedonic regression estimates make a difference to the price levels across regions in the U.S.?

1. ACS Housing

1. ACS for Housing

Overview of rent price level estimation and owner-occupied expenditure imputation

- US Bureau of the Census
- 500,000 rent price observations per year

- Numerous characteristics of the observed dwelling
  - Geography : states (50 + 1)
  - Type of structure, number of bedrooms, age, location

For any given year, compare the relative area price levels using a simple area mean (a) versus a more d*etailed hedonic class mean (b) :*

a) $\log_e(\text{rent}) = f(\text{geography})$

b) $\log_e(\text{rent}) = f(\text{geography, type, bedrooms, rooms, age, urban})$

Simple area vs detailed hedonic means: Example one area

Balanced: no missing data, no difference

beds/type	M	A	D	
1	1	6	10	
2	2	8	15	
3	4	10	20	
Simple Mean				**8.4**
Class Means	**2.3**	**8.0**	15.0	**8.4**

Unbalanced: missing data

beds/type	M	A	D	
1	1	6	10	
2	2	8	15	
3	4	10	-	
Simple Mean				**7.0**
Class Mean	**2.3**	**8.0**	12.5	7.6

Optional - ACS Regressions: example

$$lnP_{ijn} = \sum_{i=1}^{M} \alpha_i A_i + \sum_{j=1}^{J} \sum_{n=1}^{N} \beta_{jn} Z_{jn} + \varepsilon_{ijn}$$

Area (State): $\alpha_1 Alabama + \alpha_2 Alaska + \cdots + \alpha_{51} Wyoming$

Classification:

Structure/BR $+ \beta_{1,1} Mobile\ 1\ bed + \beta_{1,2} Short\ Apt\ 1\ bed + \cdots + \beta_{1,17} Detached$ 4beds

Rooms $+ \beta_{3,1}\ 1 + \cdots + \beta_{3,9}\ 9\ or\ more$

Year Built $+ \beta_{4,1}\ Before\ 1939 + \cdots + \beta_{4,4}\ After\ 2000$

Urban/Rural $+ \beta_{5,1}\ Urban + \beta_{5,2}\ Rural$

SAS GLM to obtain Class Means

```
***Simple means by State ***;
proc glm data = input_file;
        class st;
        weight hwgt;
        model ln_rnt = st / solution;
        lsmeans st / stderr out = output_file;
        run;


 ***Hedonic class means by State ***;
 proc glm data = input_file;
         class st ur typeb beds rms yblt;
         weight hwgt;
         model ln_rnt = st ur typeb*beds rms yblt / solution;
         lsmeans st / stderr out = output_file;
         run;
```

ACS Area vs Hedonic results: example

	Simple Area		Hedonic Class	
	Mean	Price level	Mean	Price Level
U.S.A.	**714**	**1.00**	**625**	**1.00**
1 AL	510	**0.71**	430	**0.69**
2 AK	1,033	**1.45**	936	**1.50**
3 AZ	771	**1.08**	625	**1.00**
4 AR	488	**0.68**	434	**0.69**
…				
47 VA	897	**1.26**	747	**1.19**
48 WA	943	**1.32**	790	**1.26**
49 WV	461	**0.65**	430	**0.69**
50 WI	652	**0.91**	577	**0.92**
51 WY	710	**0.99**	633	**1.01**
Range*		**1.11**		**1.03**

HI has the highest price level: 1.75 (simple) and 1.71 (hedonic) and WV lowest

Stability: Area Parameters 2008-2016

State	2008	2009	2010	2011	2012	2013	2014	2015	2016
INTERCEPT									7.073
Alabama									-0.386
Alaska									0.392
Arizona									-0.012
Arkansas									-0.376
California									0.468
Colorado									0.236
Connecticut									0.216
Delaware									0.044
District of Columbia									0.447
Florida									0.133
Georgia									-0.135
Hawaii									0.527
Idaho									-0.180
Illinois									0.058
Indiana									-0.230
Iowa									-0.212
Kansas									-0.220
Kentucky									-0.325
Louisiana									-0.198
Maine									0.016
Maryland									0.272
Massachusetts									0.280
Michigan									-0.137
Minnesota									0.026
Mississippi									-0.358
Missouri									-0.240
Montana									-0.138
Nebraska									-0.199
Nevada									0.019
New Hampshire									0.241
New Jersey									0.355
New Mexico									-0.148
New York									0.360
North Carolina									-0.168
North Dakota									-0.116
Ohio									-0.244
Oklahoma									-0.281
Oregon									0.132
Pennsylvania									-0.045
Rhode Island									0.079
South Carolina									-0.186
South Dakota									-0.293
Tennessee									-0.204
Texas									0.009
Utah									0.015
Vermont									0.197
Virginia									0.166
Washington									0.223
West Virginia									-0.386
Wisconsin									-0.091
Wyoming									0

Hawaii = 0.527

West Virginia = -0.386

Optional - ACS hedonic regression mechanics

PARAMETER	ESTIMATE (ln)	EXP (estimate)	Price level (US=1)
Intercept	7.073	$1,179*	
STATE			
1 AL	-0.386	0.68	0.69
2	0.392	1.48	1.50
3	-0.012	0.99	1.00
4	-0.376	0.69	0.69
…			
47	0.166	1.18	1.19
48	0.223	1.25	1.26
49 WV	-0.386	0.68	0.69
50	-0.091	0.91	0.92
51	0.000	1.00	1.01
State Means	**-0.0117**	**0.988**	1.00

* Hedonic mean for units with the base characteristics (state 51, Detached 4+ bedrooms, utilities included, 9 rooms, built after 2000, urban)

Stability: Area Parameters 2008-2016

State	2008	2009	2010	2011	2012	2013	2014	2015	2016
INTERCEPT	6.957	6.969	7.094	7.179	6.997	7.009	7.054	7.057	7.073
Alabama	-0.287	-0.319	-0.319	-0.400	-0.343	-0.346	-0.382	-0.377	-0.386
Alaska	0.452	0.463	0.416	0.373	0.448	0.435	0.435	0.421	0.392
Arizona	0.187	0.134	0.080	0.000	0.034	0.021	-0.022	-0.001	-0.012
Arkansas	-0.310	-0.353	-0.328	-0.401	-0.361	-0.353	-0.396	-0.359	-0.376
California	0.597	0.562	0.542	0.459	0.487	0.484	0.456	0.476	0.468
Colorado	0.230	0.198	0.173	0.123	0.160	0.198	0.174	0.226	0.236
Connecticut	0.348	0.328	0.299	0.225	0.271	0.252	0.219	0.244	0.216
Delaware	0.130	0.149	0.137	0.046	0.086	0.086	0.085	0.064	0.044
District of Columbia	0.504	0.468	0.570	0.486	0.550	0.554	0.547	0.523	0.447
Florida	0.288	0.227	0.191	0.126	0.145	0.151	0.116	0.141	0.133
Georgia	-0.024	-0.058	-0.076	-0.158	-0.126	-0.122	-0.168	-0.120	-0.135
Hawaii	0.677	0.630	0.596	0.513	0.563	0.572	0.531	0.580	0.527
Idaho	-0.023	-0.061	-0.124	-0.201	-0.140	-0.156	-0.160	-0.151	-0.180
Illinois	0.155	0.147	0.144	0.073	0.102	0.114	0.063	0.083	0.058
Indiana	-0.094	-0.123	-0.136	-0.203	-0.180	-0.166	-0.212	-0.201	-0.230
Iowa	-0.156	-0.171	-0.180	-0.235	-0.195	-0.166	-0.219	-0.195	-0.212
Kansas	-0.121	-0.149	-0.158	-0.224	-0.191	-0.159	-0.212	-0.205	-0.220
Kentucky	-0.237	-0.266	-0.272	-0.340	-0.285	-0.255	-0.318	-0.284	-0.325
Louisiana	-0.143	-0.134	-0.133	-0.212	-0.156	-0.156	-0.185	-0.183	-0.198
Maine	0.102	0.091	0.041	0.012	0.092	0.080	-0.008	0.045	0.016
Maryland	0.380	0.361	0.341	0.288	0.321	0.337	0.303	0.303	0.272
Massachusetts	0.382	0.350	0.345	0.278	0.290	0.316	0.276	0.298	0.280
Michigan	0.014	-0.037	-0.054	-0.136	-0.096	-0.091	-0.131	-0.121	-0.137
Minnesota	0.100	0.091	0.070	-0.006	0.053	0.060	0.023	0.038	0.026
Mississippi	-0.298	-0.348	-0.333	-0.393	-0.374	-0.338	-0.388	-0.372	-0.358
Missouri	-0.121	-0.160	-0.175	-0.239	-0.201	-0.175	-0.227	-0.218	-0.240
Montana	-0.048	-0.093	-0.115	-0.173	-0.121	-0.073	-0.109	-0.067	-0.138
Nebraska	-0.120	-0.159	-0.137	-0.234	-0.176	-0.166	-0.209	-0.181	-0.199
Nevada	0.335	0.257	0.197	0.103	0.088	0.081	0.019	0.040	0.019
New Hampshire	0.390	0.336	0.344	0.234	0.306	0.306	0.245	0.255	0.241
New Jersey	0.501	0.475	0.451	0.382	0.412	0.406	0.377	0.373	0.355
New Mexico	-0.033	-0.077	-0.076	-0.122	-0.082	-0.073	-0.109	-0.120	-0.148
New York	0.438	0.421	0.417	0.358	0.399	0.408	0.373	0.381	0.360
North Carolina	-0.074	-0.096	-0.118	-0.180	-0.133	-0.118	-0.158	-0.151	-0.168
North Dakota	-0.188	-0.189	-0.182	-0.246	-0.135	-0.079	-0.126	-0.058	-0.116
Ohio	-0.118	-0.168	-0.158	-0.243	-0.207	-0.197	-0.248	-0.227	-0.244
Oklahoma	-0.239	-0.236	-0.237	-0.308	-0.253	-0.240	-0.271	-0.239	-0.281
Oregon	0.136	0.142	0.110	0.047	0.089	0.106	0.079	0.104	0.132
Pennsylvania	0.039	0.002	0.010	-0.057	-0.012	0.006	-0.052	-0.031	-0.045
Rhode Island	0.220	0.192	0.165	0.112	0.114	0.105	0.085	0.091	0.079
South Carolina	-0.114	-0.124	-0.153	-0.208	-0.168	-0.170	-0.211	-0.181	-0.186
South Dakota	-0.234	-0.334	-0.292	-0.373	-0.246	-0.298	-0.328	-0.290	-0.293
Tennessee	-0.147	-0.173	-0.175	-0.241	-0.182	-0.178	-0.237	-0.216	-0.204
Texas	0.035	0.006	0.007	-0.058	-0.013	0.006	-0.022	0.015	0.009
Utah	0.109	0.103	0.045	-0.023	0.016	0.037	-0.016	-0.004	0.015
Vermont	0.264	0.260	0.219	0.189	0.247	0.232	0.236	0.246	0.197
Virginia	0.264	0.260	0.258	0.187	0.234	0.236	0.184	0.200	0.166
Washington	0.259	0.261	0.231	0.155	0.201	0.214	0.188	0.213	0.223
West Virginia	-0.347	-0.351	-0.339	-0.402	-0.360	-0.357	-0.372	-0.327	-0.386
Wisconsin	0.044	0.003	-0.007	-0.068	-0.034	-0.042	-0.076	-0.064	-0.091
Wyoming	0	0	0	0	0	0	0	0	0

Optional –
ACS Classification & Characteristic Values (States)

PARAMETER		ESTIMATE
STRUCTURE TYPE and # BEDROOMS		
Mobile and other	0+	-0.540
Short apartment (no elevator)	0	-0.402
	1	-0.406
	2	-0.248
	3+	-0.237
Tall apartment (elevator)	0	-0.304
	1	-0.305
	2	-0.065
	3+	-0.146
Attached	1	-0.409
	2	-0.141
	3	-0.043
	4+	-0.040
Detached	1	-0.418
	2	-0.263
	3	-0.104
	4+	0

PARAMETER	ESTIMATE
ROOMS	
1	-0.275
2	-0.181
3	-0.229
4	-0.233
5	-0.186
6	-0.136
7	-0.081
8	-0.035
9	0
YEAR BUILT	
1939 or before	-0.265
1940-1979	-0.284
1980-199	-0.162
2000 or after	0
URBAN vs RURAL	
Rural	-0.285
Urban	0

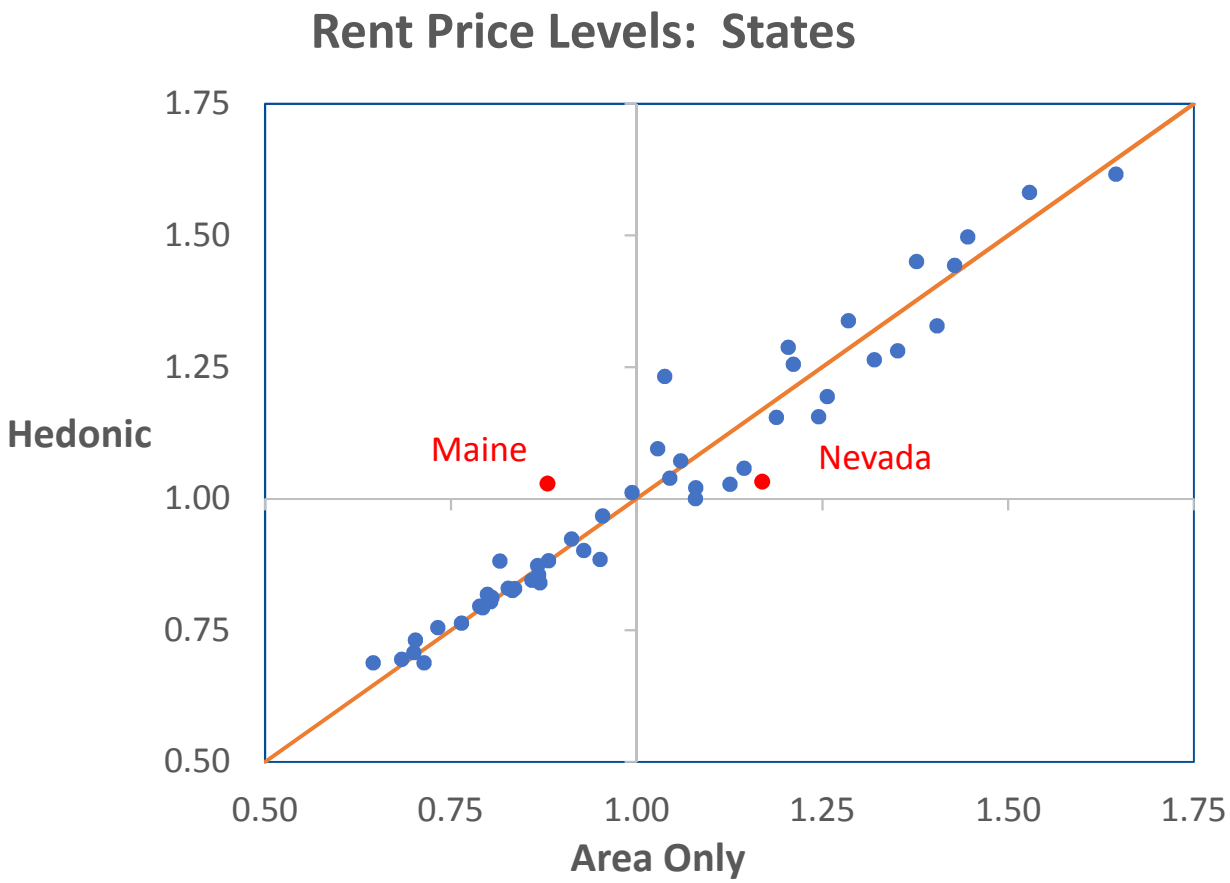
Stability: Characteristics Parameters 2008-2016

PARAMETER		2008	2009	2010	2011	2012	2013	2014	2015	2016
STRUCTURE TYPE and # BEDROOMS										
Mobile and other	0+									-0.540
Short apartment (no elevator)	0									-0.402
	1									-0.406
	2									-0.248
	3+									-0.237
Tall apartment (elevator)	0									-0.304
	1									-0.305
	2									-0.065
	3+									-0.146
Attached	1									-0.409
	2									-0.141
	3									-0.043
	4+									-0.040
Detached	1									-0.418
	2									-0.263
	3									-0.104
	4+									0
UTILITIES INCLUDED										
No										0.176
Yes										0
ROOMS										
1										-0.275
2										-0.181
3										-0.229
4										-0.233
5										-0.186
6										-0.136
7										-0.081
8										-0.035
9										0
YEAR BUILT										
1939 or before										-0.265
1940-1979										-0.284
1980-199										-0.162
2000 or after										0
URBAN vs RURAL										
Rural										-0.285
Urban										0

Stability: Characteristic Parameters 2008-2016

PARAMETER		2008	2009	2010	2011	2012	2013	2014	2015	2016
STRUCTURE TYPE and # BEDROOMS										
Mobile and other	0+	-0.534	-0.533	-0.540	-0.566	-0.521	-0.511	-0.520	-0.507	-0.540
Short apartment (no elevator)	0	-0.367	-0.362	-0.391	-0.437	-0.440	-0.426	-0.406	-0.382	-0.402
	1	-0.384	-0.384	-0.405	-0.433	-0.423	-0.405	-0.404	-0.397	-0.406
	2	-0.252	-0.244	-0.254	-0.282	-0.267	-0.251	-0.256	-0.244	-0.248
	3+	-0.246	-0.259	-0.242	-0.277	-0.258	-0.241	-0.251	-0.243	-0.237
Tall apartment (elevator)	0	-0.321	-0.300	-0.340	-0.397	-0.351	-0.304	-0.293	-0.261	-0.304
	1	-0.301	-0.301	-0.328	-0.358	-0.341	-0.310	-0.316	-0.299	-0.305
	2	-0.101	-0.091	-0.103	-0.124	-0.112	-0.086	-0.082	-0.069	-0.065
	3+	-0.192	-0.182	-0.175	-0.191	-0.162	-0.163	-0.152	-0.137	-0.146
Attached	1	-0.418	-0.406	-0.445	-0.464	-0.425	-0.421	-0.414	-0.399	-0.409
	2	-0.155	-0.145	-0.147	-0.165	-0.162	-0.134	-0.141	-0.129	-0.141
	3	-0.069	-0.066	-0.074	-0.080	-0.070	-0.061	-0.053	-0.041	-0.043
	4+	-0.076	-0.092	-0.068	-0.063	-0.068	-0.028	-0.044	-0.019	-0.040
Detached	1	-0.418	-0.412	-0.430	-0.460	-0.438	-0.423	-0.425	-0.409	-0.418
	2	-0.259	-0.245	-0.258	-0.283	-0.254	-0.246	-0.255	-0.247	-0.263
	3	-0.094	-0.095	-0.097	-0.113	-0.093	-0.090	-0.099	-0.093	-0.104
	4+	0	0	0	0	0	0	0	0	0
UTILITIES INCLUDED										
No		0.110	0.115	0.097	0.110	0.111	0.140	0.151	0.156	0.176
Yes		0	0	0	0	0	0	0	0	0
ROOMS										
1		-0.306	-0.345	-0.308	-0.270	-0.300	-0.332	-0.326	-0.313	-0.275
2		-0.255	-0.282	-0.267	-0.239	-0.234	-0.253	-0.225	-0.213	-0.181
3		-0.256	-0.279	-0.273	-0.247	-0.248	-0.269	-0.258	-0.257	-0.229
4		-0.228	-0.260	-0.259	-0.243	-0.243	-0.266	-0.257	-0.259	-0.233
5		-0.165	-0.203	-0.201	-0.192	-0.199	-0.212	-0.203	-0.207	-0.186
6		-0.124	-0.141	-0.150	-0.146	-0.142	-0.159	-0.151	-0.153	-0.136
7		-0.066	-0.088	-0.096	-0.084	-0.089	-0.100	-0.091	-0.093	-0.081
8		-0.025	-0.043	-0.055	-0.046	-0.034	-0.041	-0.033	-0.047	-0.035
9		0	0	0	0	0	0	0	0	0
YEAR BUILT										
1939 or before							-0.265	-0.260	-0.264	-0.265
1940-1979							-0.275	-0.272	-0.280	-0.284
1980-199							-0.151	-0.150	-0.156	-0.162
2000 or after							0	0	0	0
URBAN vs RURAL										
Rural		-0.21951	-0.2134	-0.18585	-0.17961	-0.2841	-0.28576	-0.27636	-0.28742	-0.285
Urban		0	0	0	0	0	0	0	0	0

Rents: Hedonic Results vs Geomean, States



Imputing Owner-occupied expenditures

- The hedonic mean rent for each type of dwelling is imputed to the owner-occupied units with similar characteristics
  - 17 structure types * 9 rooms * 4 year built
  - For each of the 51 geographic areas
    - Utilities calculated separately and removed
- Sum across all units equals the imputed expenditures
- Alternatives:
  - With a premium added to the rent based on the house value
  - Using an arithmetic mean instead of geomeans

2. CPI for other goods and services

2. CPI for other goods and services

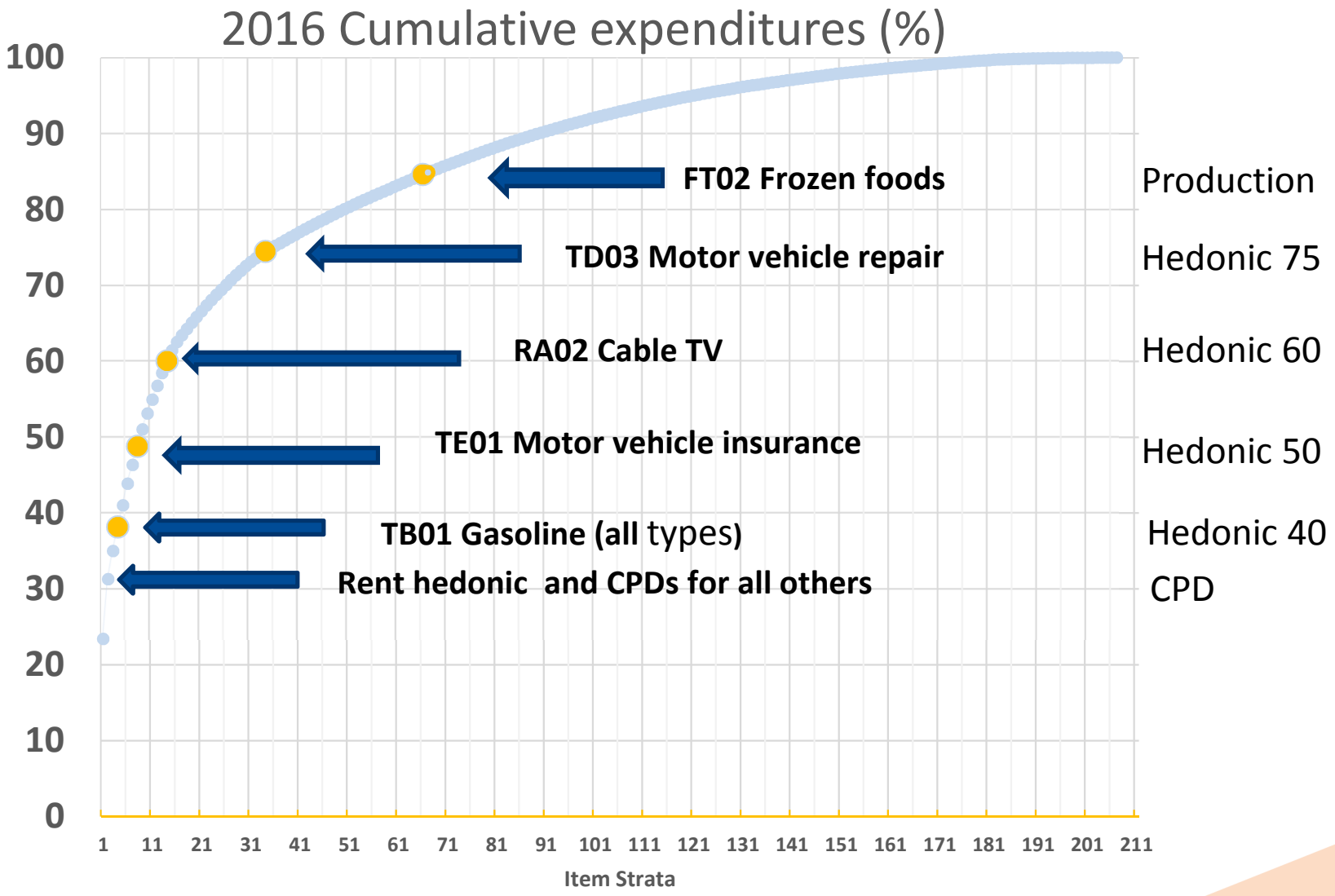
Overview of how the CPI is used for RPP estimates

- US Bureau of Labor Statistics
- 200,000 annual average prices for 200+ item strata

Is there a need for detailed hedonics instead of simple CPD means?

1. For any given year, how sensitive are the results to using hedonics?
2. Are there patterns over time?

Distribution of expenditures for 2016 by Item Strata



A Note on Nomenclature

ICP (International)

i. Summary headings
ii. Basic Headings (110+)
iii. SPD (structured product description)

CPI (United States)

i. Expenditure Classes
ii. Item Strata (200+)
iii. ELI (entry-level item) & Clusters

Product Classification: ICP vs CPI (US)

ICP (individual consumption)

i.	Basic heading (110)	110111.1	Rice
ii.	Structured product description (≈800)	110111.1.02	Long-grain rice / not parboiled
		.03	" / family pack
		.04	" / jasmine rice

TIGHT SPECIFICATION:

Type:	Long grain, milled white rice
Preparation:	Non-parboiled (uncooked)
Packaging:	Pre-packed: paper or plastic bag

CPI (United States)

i.	Item strata (185 priced)	FA03	Rice, pasta, cornmeal
ii.	ELI-Clusters (≈700)	FA031-01B	Rice

CHECKLIST:

Type:	1-Long grain, 2-Medium grain, 3-Short grain, 4-Not specified, 5-Comb.
Preparation:	1-Pre-cooked/instant, 2-Uncooked
Packaging:	1-Box, 2-Bag, 3-Other

Example: Item strata FA03-01B: Rice

1	2	3	4	5*			
Area	ELI	Cluster	Outlet	A (type)	…	C (packaging)	Price ($)
NY	FA031	01B	410	A1	…	C2	14.50
NY	FA031	01B	435	A5	…	C2	7.99
KC	FA031	01B	200	A5	…	C2	4.50
SF	FA031	01B	313	A1	…	C1	9.99

* An SPD would correspond to a combination of characteristics within column 5, such as A5 (long grain), C2 (uncooked)

Simple CPDs for each Item Stratum

CPD:

$$lnP_{ij} = \sum_{i=1}^{M} \alpha_i A_i + \sum^{J} \beta_j Z_j + \varepsilon_{ij}$$

Where P_{ij} include all observations in the Item Stratum (FA03 Rice, Pasta, Cornmeal)

Area: $\alpha_1 New\ York + \alpha_2 Kansas\ City + \cdots + \alpha_{51} San\ Francisco$

Plus ELI-clusters $+ \beta_1 Rice + \beta_2 Pasta + \beta_3 Cornmeal$

Detailed hedonic for each ELI-Cluster: FA03 01B (Rice)

Hedonic

$$lnP_{ijn} = \sum_{i=1}^{M} \alpha_i A_i + \sum_{j=1}^{J} \sum_{n=1}^{N} \beta_{jn} Z_{jn} + \varepsilon_{ijn}$$

*Where P_{ijn} include **only** observations in the ELI-Cluster for Rice (FA0301B Rice)*

Area: $\alpha_1 New\ York + \alpha_2 Kansas\ City + \cdots + \alpha_{51} San\ Francisco$

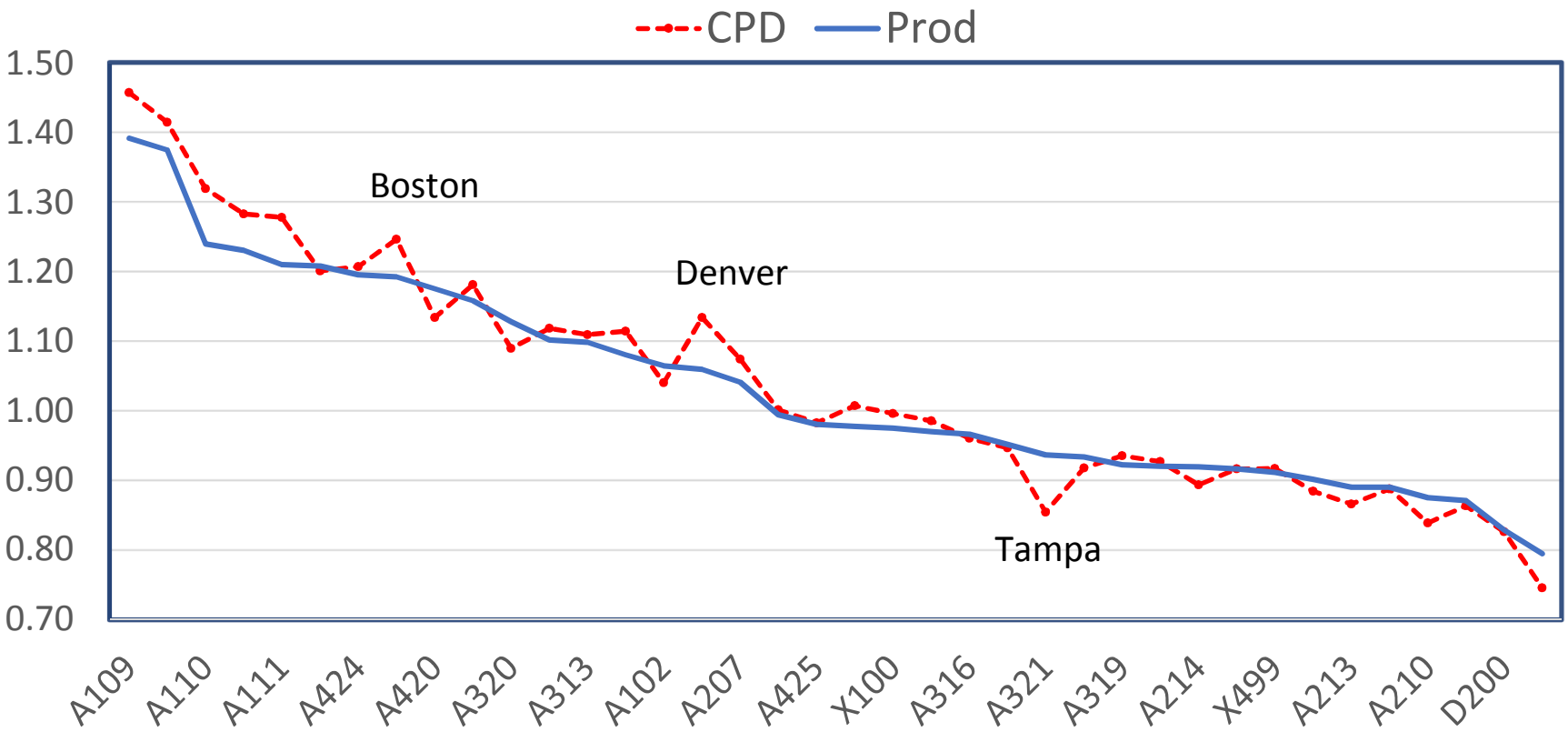
Plus Characteristics:

Type $+ \beta_{1,1}\ long\ grain + \beta_{1,2}\ medium + \cdots + \beta_{1,5}\ other$

Preparation $+ \beta_{2,1}\ precooked + \beta_{2,2}\ uncooked$

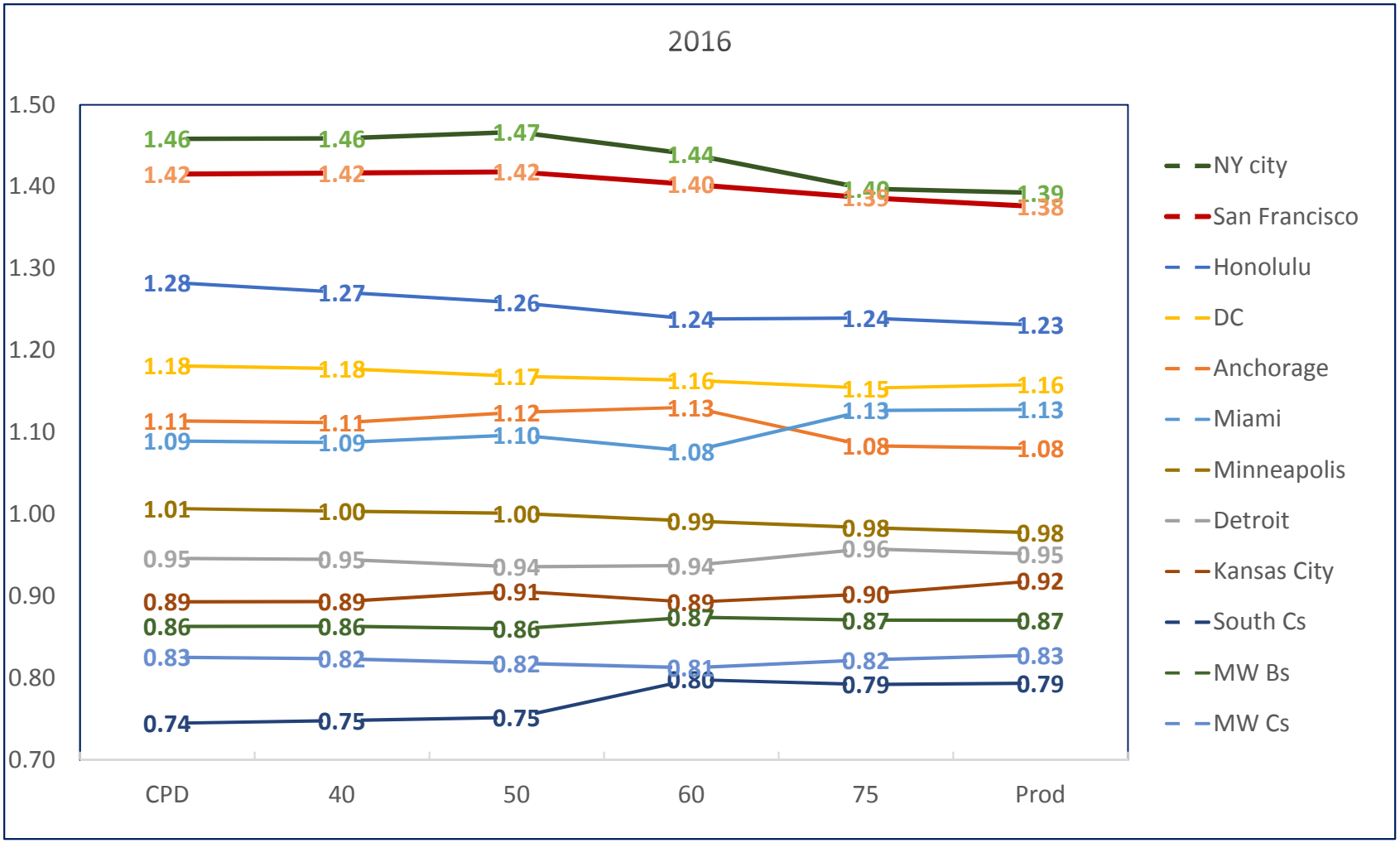
Packaging $+ \beta_{3,1}\ box + \cdots + \beta_{3,3}\ \ other$

Largest difference between CPD and Production (2016)

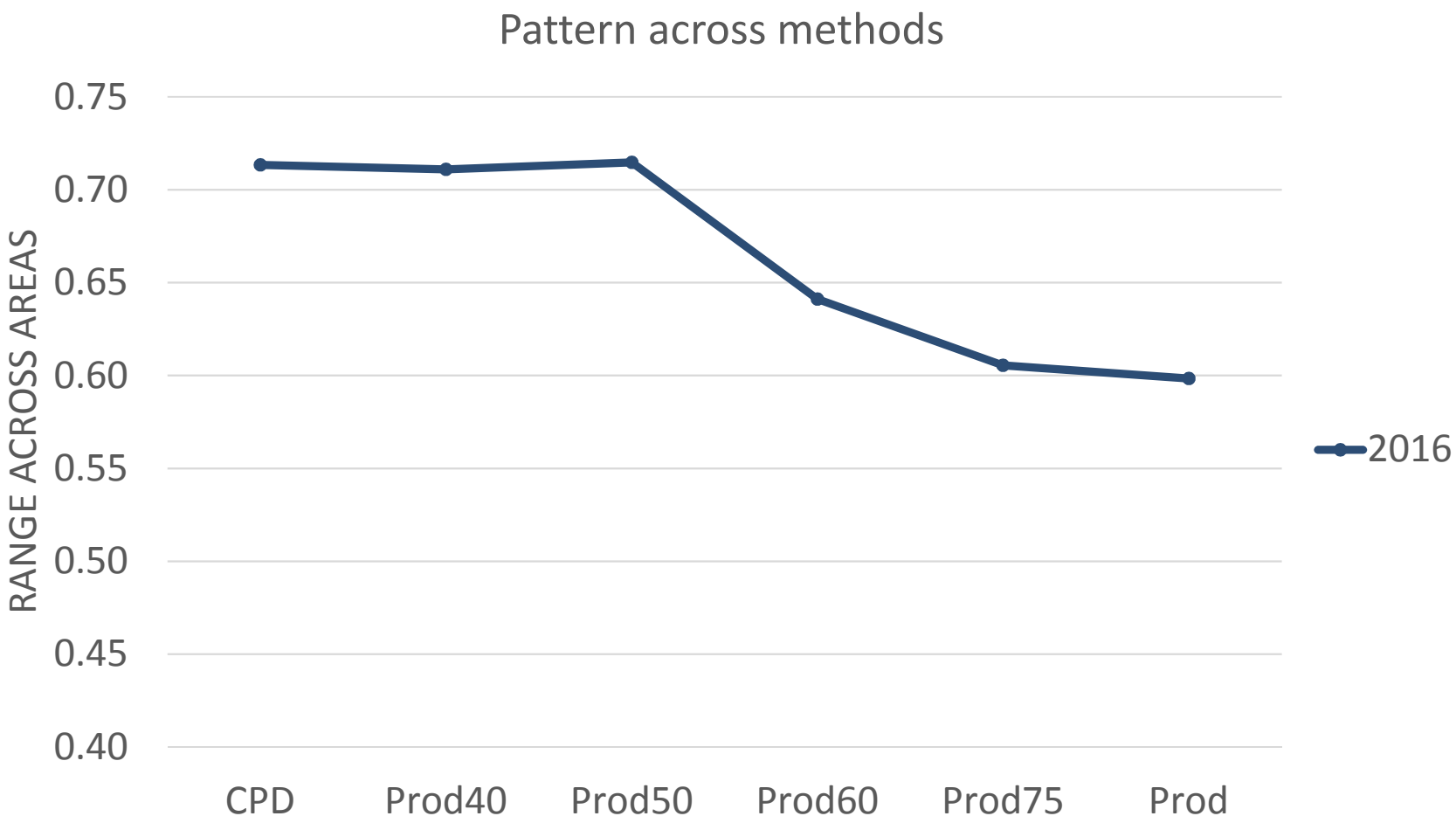


Detailed hedonics tend to lower the high-price level areas and increase the low-price level areas, reducing the range

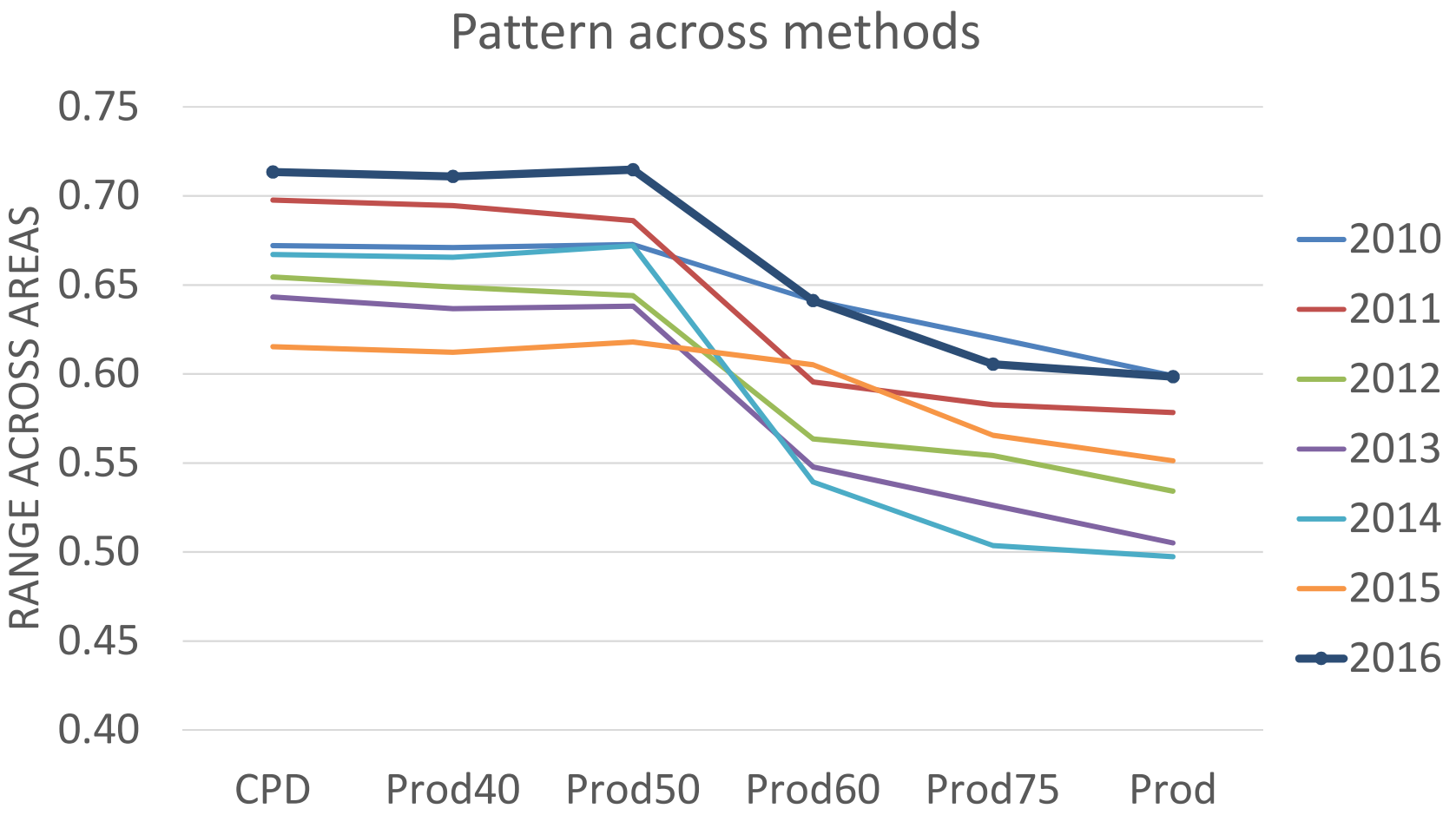
For any given year, does the method matter?



Is the pattern similar for different years? (1)



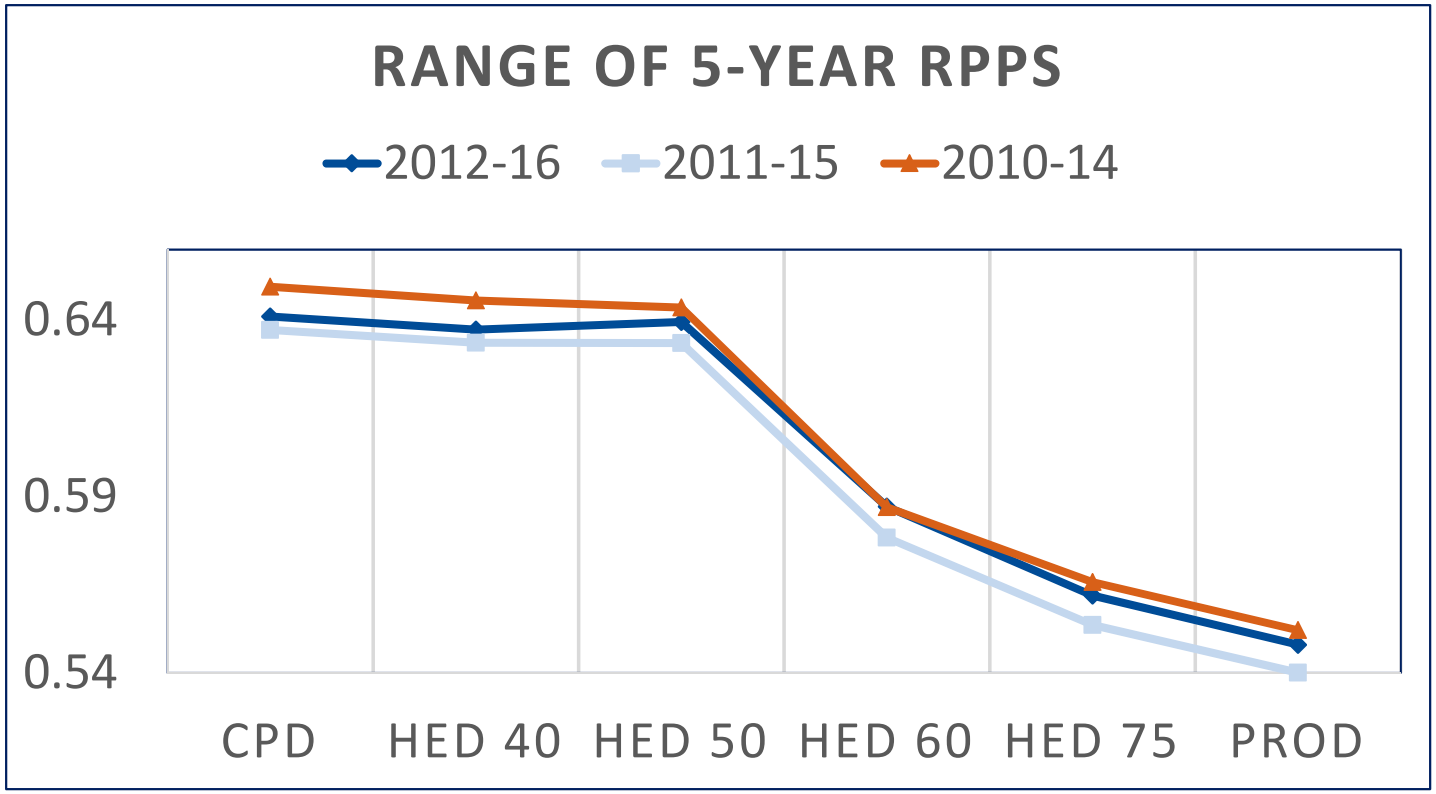
Is the pattern similar for different years? (1)



Production vs other methods – final differences for each area and across all areas 2012-2016

	Ratio of RPPs (5-year average)				
	Production (85%) /				
	CPD	Hed 40%	Hed 50%	Hed 60%	Hed 75%
NY City	0.97	0.97	0.97	0.98	0.99
Baltimore	0.98	0.98	0.99	0.99	1.00
Tampa	1.03	1.03	1.01	1.00	1.00
Portland	1.02	1.03	1.02	1.01	1.00
South C	1.07	1.07	1.07	1.02	1.01
Max	1.07	1.07	1.07	1.02	1.01
Min	0.96	0.96	0.97	0.97	0.99
Range ▲	0.12 ▲	0.11 ▲	0.10 ▼	0.05 ▼	0.02

Smoothing over 5 years, does it still make a difference?



Optional

Optional - ACS area only mechanics

PARAMETER	ESTIMATE (ln)	EXP (estimate)	Price level (US=1)
Intercept	6.565	**$710 ***	
STATE			
1	-0.331	0.72	0.71
2	0.375	1.45	1.45
3	0.082	1.09	1.08
4	-0.374	0.69	0.68
…			
47	0.234	1.26	1.26
48	0.284	1.33	1.32
49	-0.432	0.65	0.65
50	-0.085	0.92	0.91
51	0.000	1.00	0.99
	0.0061	**1.006**	1.00

* Hedonic mean for units with the base characteristics (state 51)