Developing the Sample Design for the New Annual Integrated Economic Survey

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Acknowledgements

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Definitions

- Sector: an area of the economy in which businesses share the same or related business activity, product, or service (www.investopedia.com)
- Industry: a group of companies that are related based on their primary business activities or service (www.investopedia.com)
- Industrial classification: industry code assigned to an individual business, usually based on the business' largest source(s) of revenue
- NAICS: North American Industry Classification System
  - Digits indicate level of detail used for classification (more digits = more criteria)

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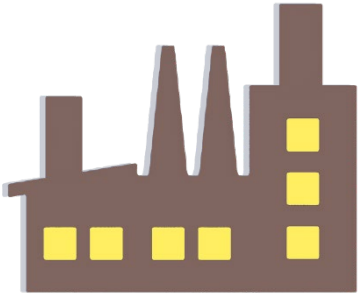
More Definitions



- Establishment – a <u>single</u> business location

- Company – any formal business entity for profit, which may be [illegible]orati[illegible] partnership, association or individual proprietorship (https://[illegible]y.l[illegible]
  - Multi-unit company
  - [illegible]pany

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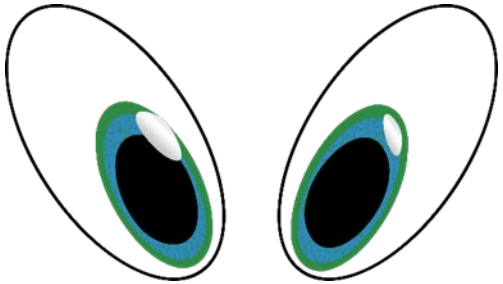
The Project

- Replace six annual surveys with one annual survey
  - Recommended by National Academy of Science Panel (2018)
  - Annual Integrated Economic Survey (AIES)



- Requirements for new survey
  - National Industry estimates
    - At least 5 key items (multipurpose)
    - C.V. target ≈ 2%
    - Disaggregated NAICS levels: 4-digit NAICS (NAICS4), 5-digit NAICS (NAICS5), **6-digit NAICS (NAICS6)**
  - Geographic Industry estimates
    - 4 key items
    - C.V. target ≈ 15%
    - Aggregated NAICS levels: **3-digit NAICS (NAICS3)**
      - 23 “Direct use” states
      - 4 “Balance of region” categories

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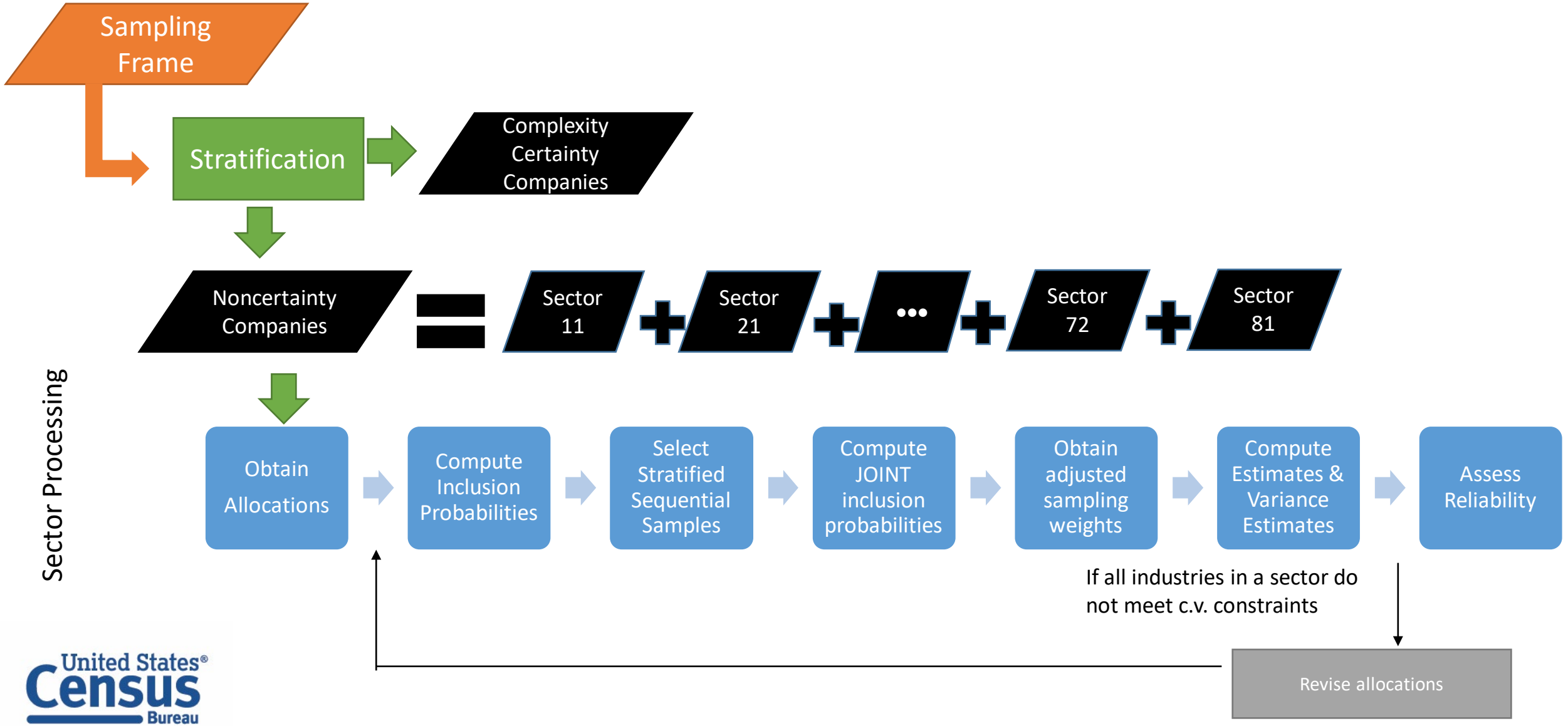
Overview of AIES Sample Design Process



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Sampling Frame…

Sampling Unit

Components

Classification Information

Geo Infor

Measure of Size (MOS)

Quantitative oles

Company	Establishment	ector	Industry					
Global Dynamics, Inc.	Mom & Pop Hardware 1	Retail Trade	Hardware Stores	444130	MO	600	20	1,380
	Mom & Pop Hardware 2			444130	MO	800		
	Mom & Po Hardware		Hardware Stores	444130	MO	762	25	1,753
	GD Plant		Ma	332722	TN	9,452		
	Dad's Warehouse	Wholesale Trade	Hardware Merchant Wholesalers	423710	TN	475	16	489
The Shop								

Multi-unit
Multi-sector
Multi-state

Single-units
Single-sector
Single-state

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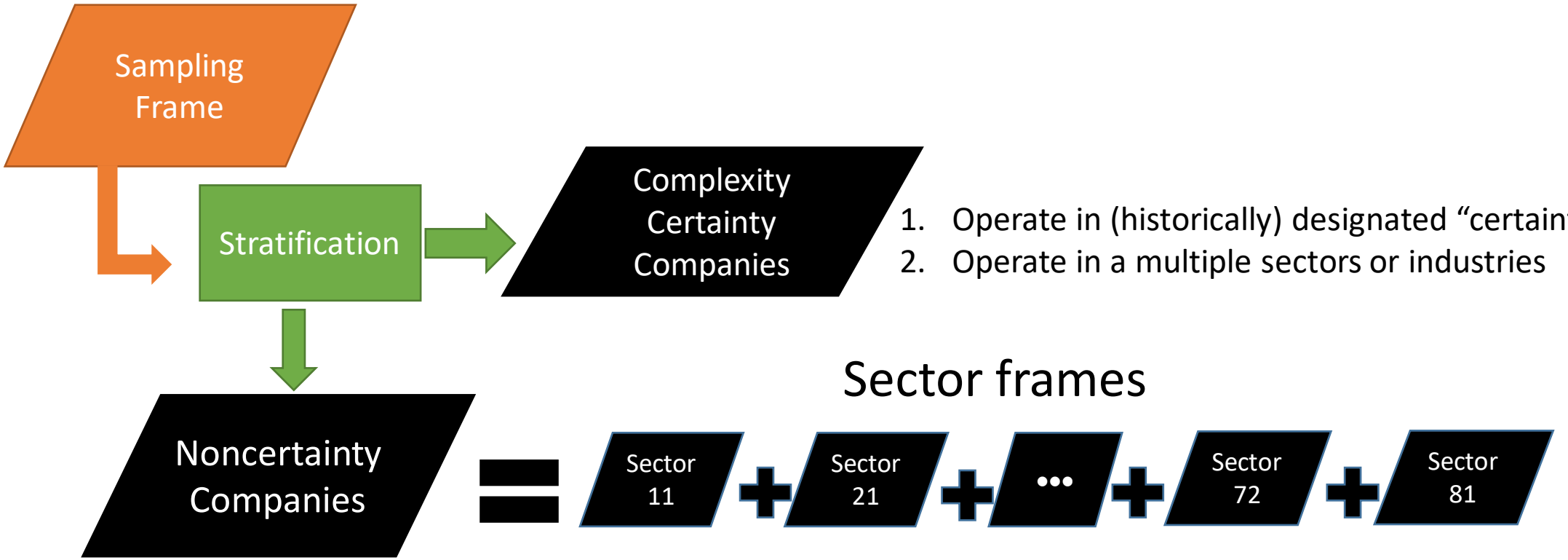

1. Operate in (historically) designated “certainty” industries
2. Operate in a multiple sectors or industries

1. Operate in a single sector
2. Generally operate in one industry (NAICS4)

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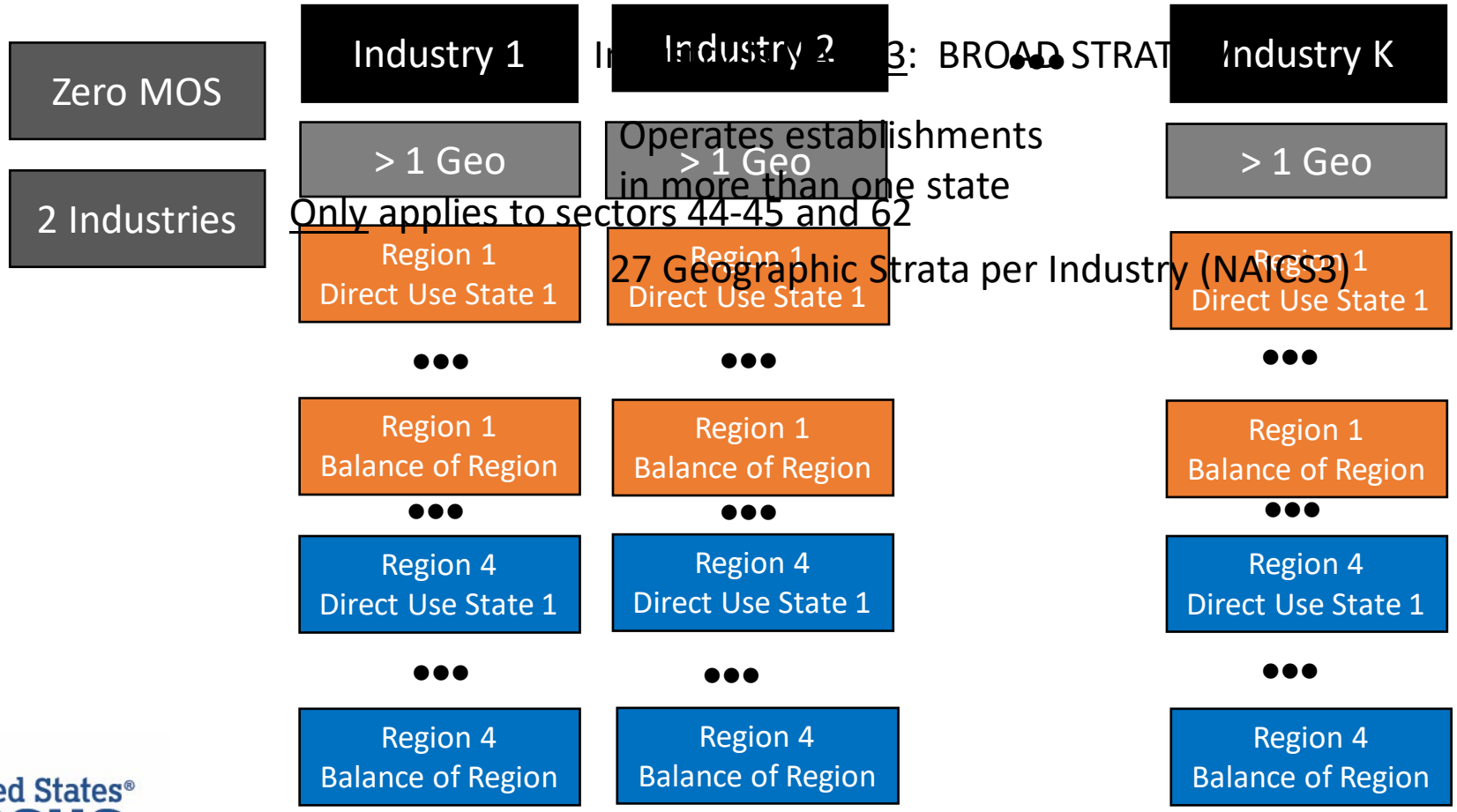
Sector Processing:
Stratification for Noncertainty Companies



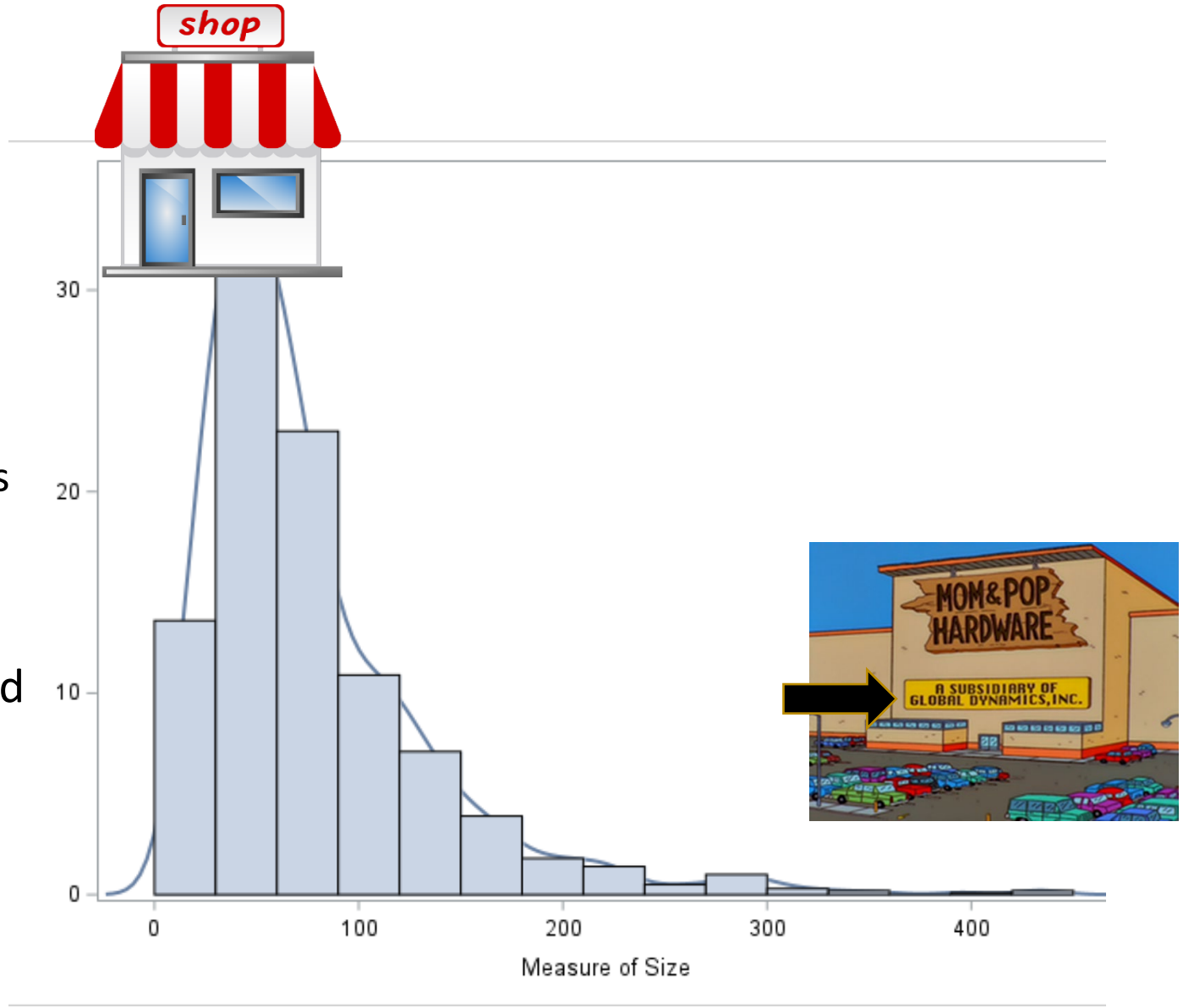
Operates establishments in more than one state

Only applies to sectors 44-45 and 62

27 Geographic Strata per Industry (NAICS3)

Digression #1: Establishment (Business) Sample Survey Designs

- Populations are skewed!
  - Small number of large companies
  - Majority small companies
- Publish TOTALS (and Ratios)
- Sample design accounts for skewed distribution in
  - Stratification (size)
  - Allocation (# sampled units)
  - Unit inclusion probability



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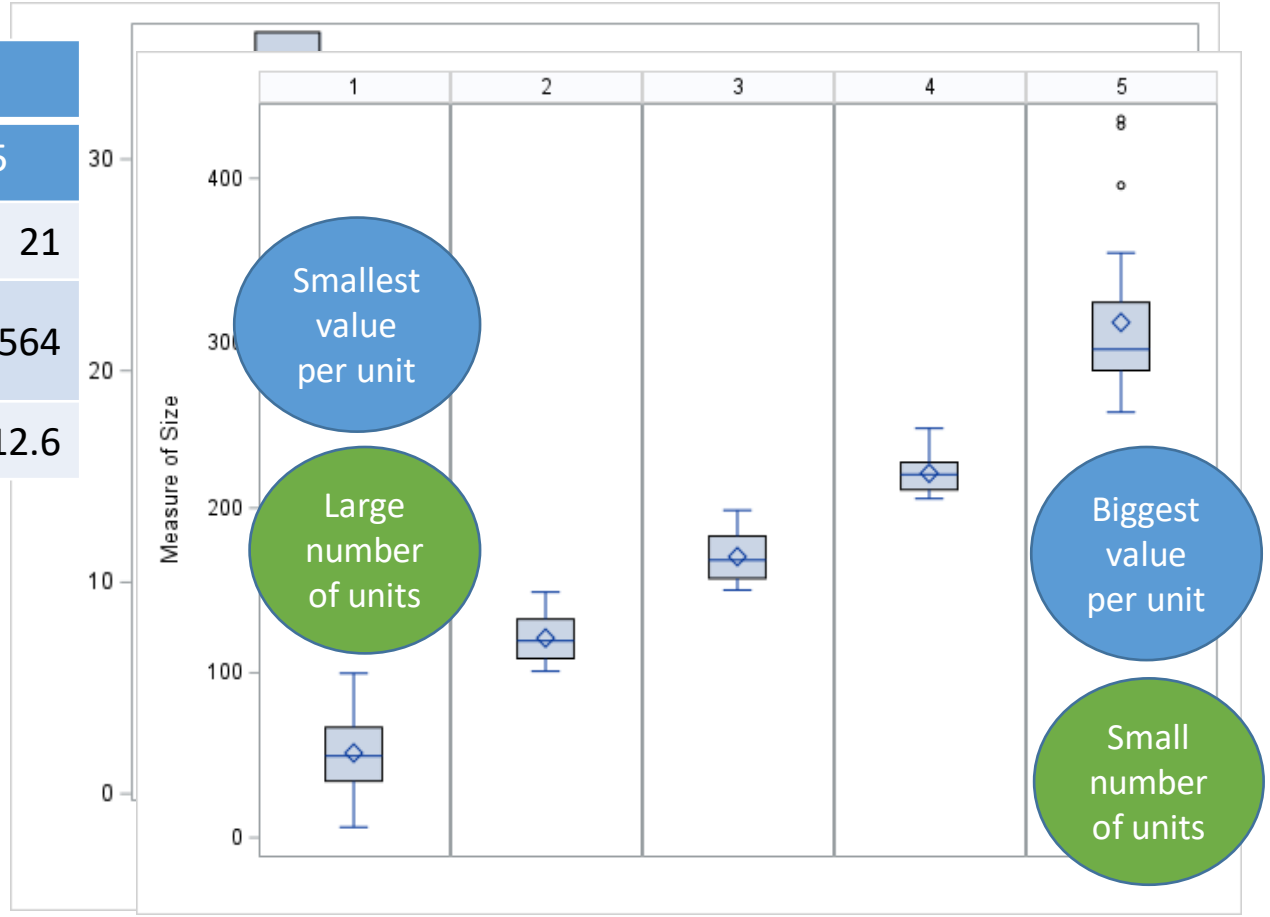
Digression #2: Allocation for a Multipurpose Survey Sampled from a Skewed Populatoin

	Sampling Strata				
	1	2	3	4	5
Number of Units (N_h)	760	146	53	20	21
Total Measure of Size (MOS_h)	39023	17675	9035	4421	6564
Average Size Per Unit	51.4	121.1	170.5	221.1	312.6



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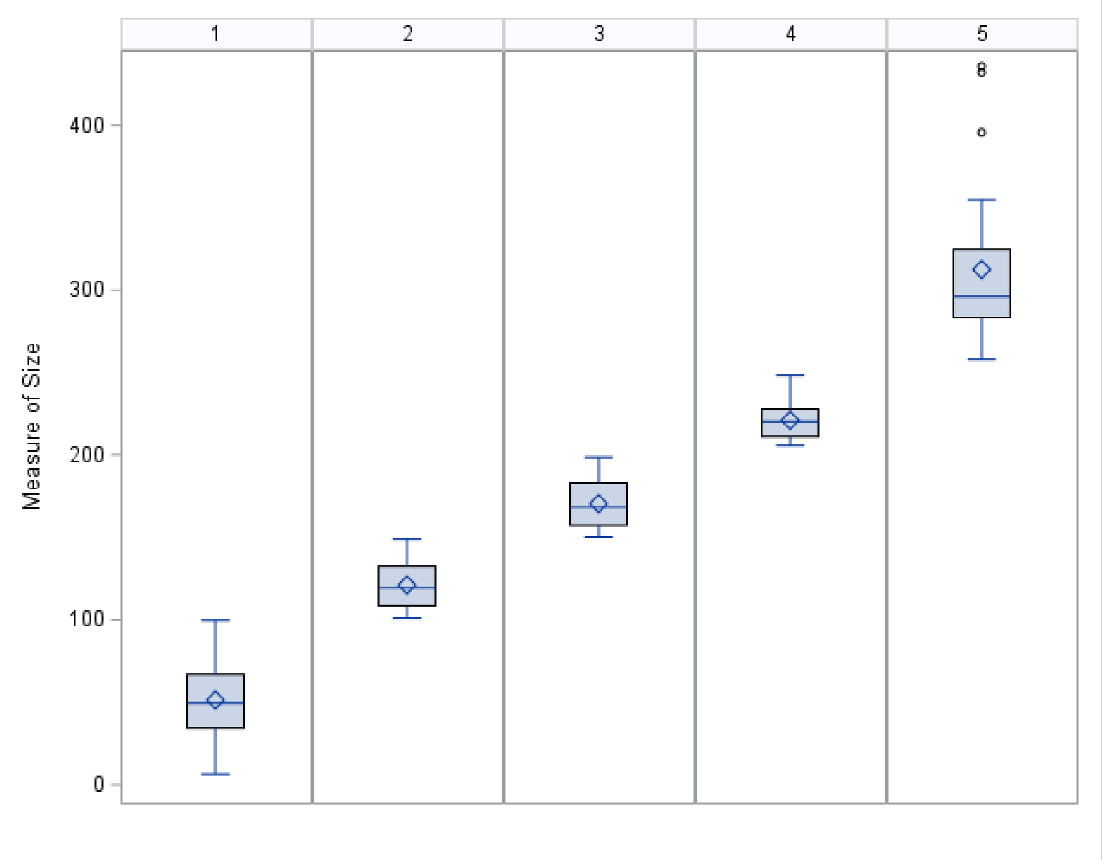
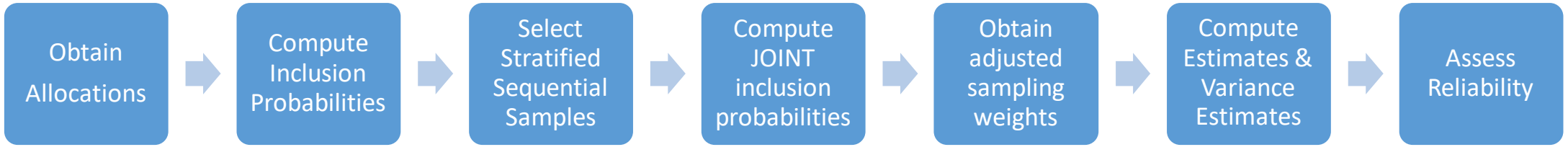
Allocation for sample size (*n*) of 50 from Population (*N*) of 1000

	1	2	3	4	5
Number of Units (N_h)	760	146	53	20	21
Total Measure of Size (MOS_h)	39023	17675	9035	4421	6564
Average Size Per Unit	51.4	121.1	170.5	221.1	312.6
Proportional Allocation (units)	38	7	3	1	1
Proportional Allocation (MOS)	25	12	6	3	4
Power Allocation $\sqrt{MOS_h}$	17	12	8	6	7



$$n_h \approx (n)\left(\frac{N_h}{\sum_h N_h}\right) \quad n_h \approx (n)\left(\frac{MOS_h}{\sum_h MOS_h}\right) \quad n_h \approx (n)\left(\frac{\sqrt{MOS_h}}{\sum_h \sqrt{MOS_h}}\right)$$

in stratum 1



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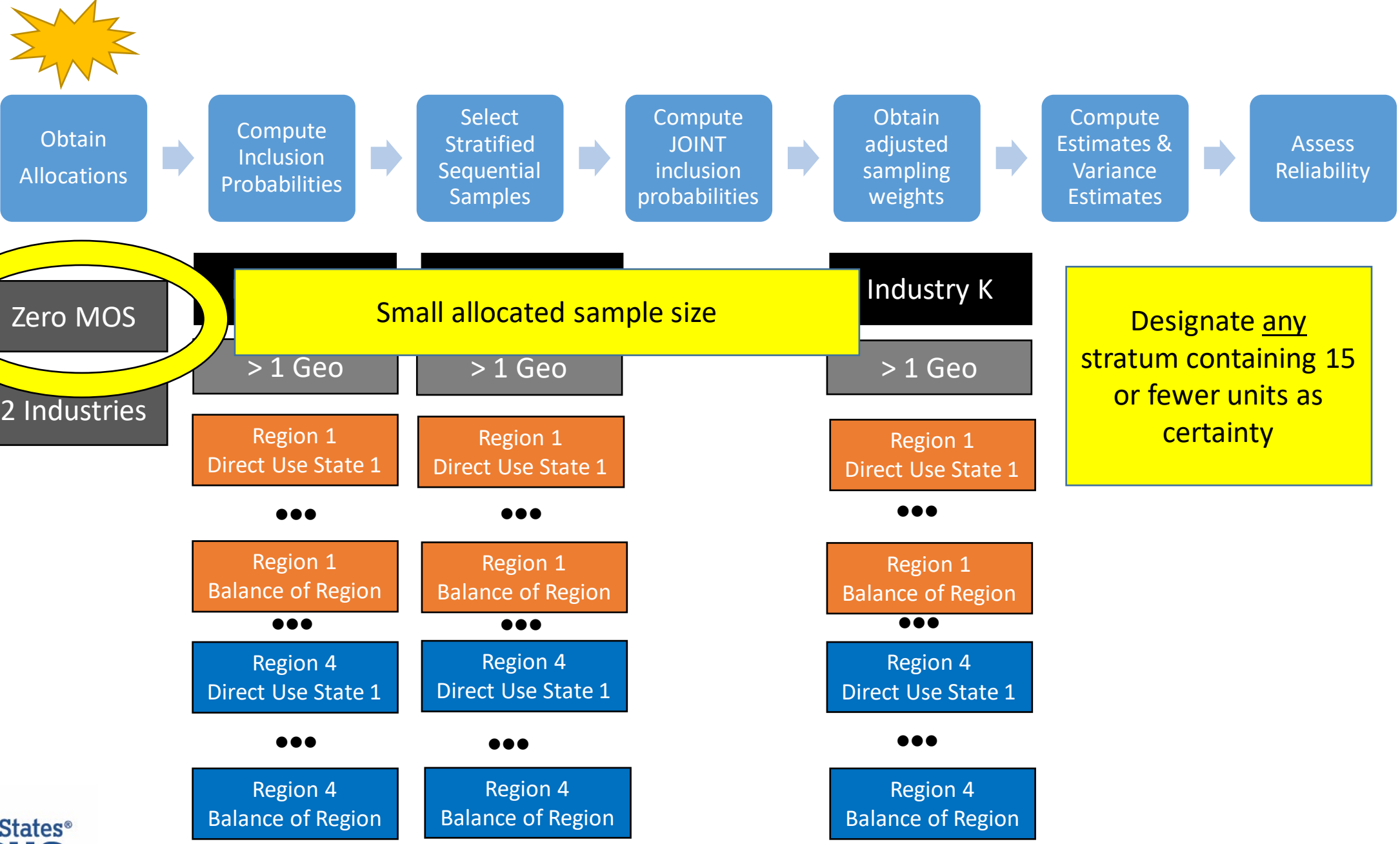

Obtain Allocations
Compute Inclusion Probabilities
Select Stratified Sequential Samples
Compute JOINT inclusion probabilities
Obtain adjusted sampling weights
Compute Estimates & Variance Estimates
Assess Reliability
Zero MOS
2 Industries
Small allocated sample size
Industry K
> 1 Geo
> 1 Geo
> 1 Geo
Region 1 Direct Use State 1
Region 1 Direct Use State 1
Region 1 Direct Use State 1
Region 1 Balance of Region
Region 1 Balance of Region
Region 1 Balance of Region
Region 4 Direct Use State 1
Region 4 Direct Use State 1
Region 4 Direct Use State 1
Region 4 Balance of Region
Region 4 Balance of Region
Region 4 Balance of Region
Designate any stratum containing 15 or fewer units as certainty

Obtain Allocations → Compute Inclusion Probabilities → Select Stratified Sequential Samples → Compute JOINT inclusion probabilities → Obtain adjusted sampling weights → Compute Estimates & Variance Estimates → Assess Reliability

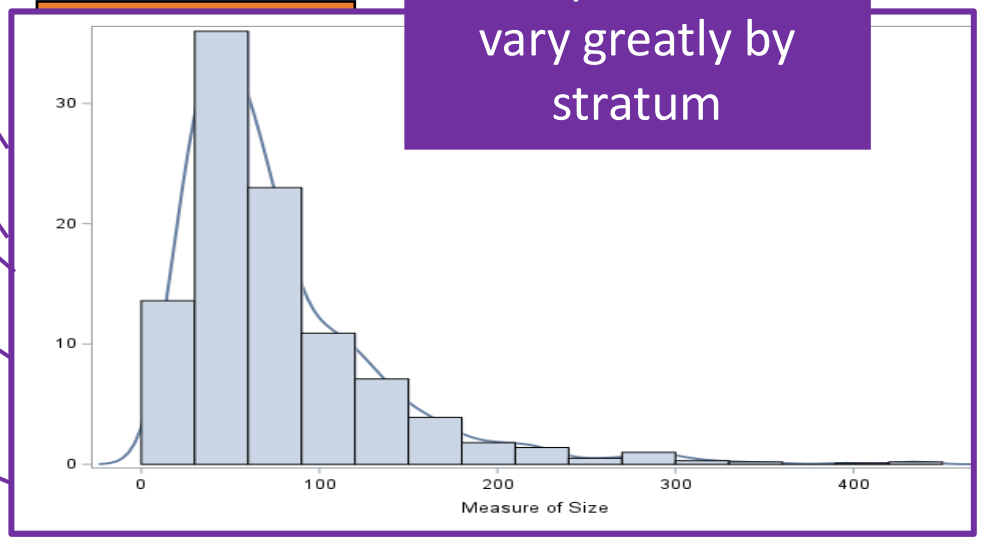
Zero MOS

2 Industries

Industry 1	Industry 2	•••	Industry K
> 1 Geo	> 1 Geo		> 1 Geo
Region 1 Direct Use State 1	Region 1 Direct Use State 1		Region 1 Direct Use State 1
•••	•••		•••
Region 1 Balance of Region	Region 1 Balance of Region		
•••	•••		
Region 4 Direct Use State 1	Region 4 Direct Use State 1		
•••	•••		
Region 4 Balance of Region	Region 4 Balance of Region		

Unit size is NOT accounted for in stratification

Number of companies can vary greatly by stratum



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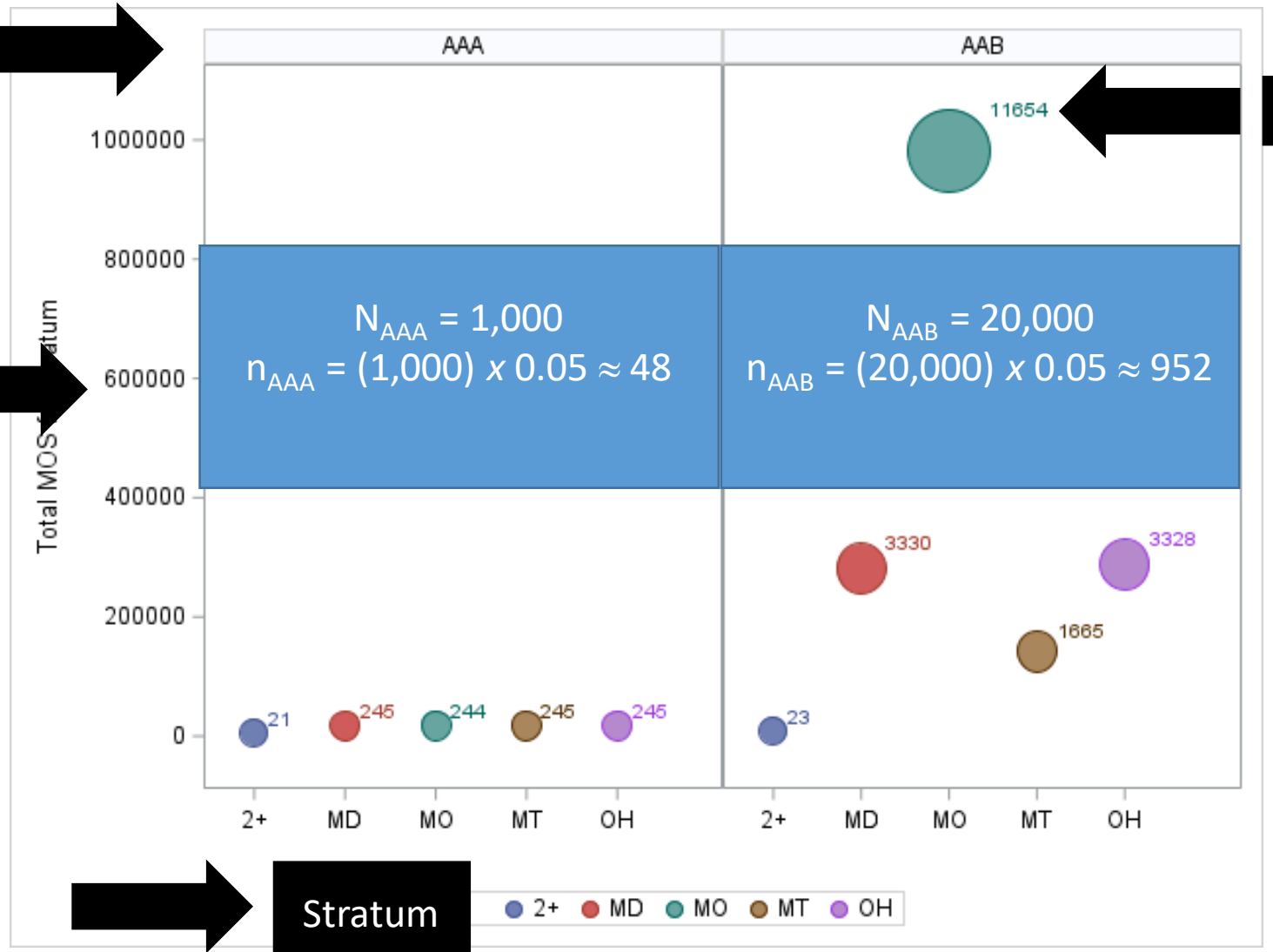
AIES Allocation Procedure: Step 1
Proportional Allocation to Broad Stratum (NAICS3)

N = 21,000
n = 1,000
f = 1,000/21,000 ≈ 0.05



Number of Companies

Total MOS for Stratum

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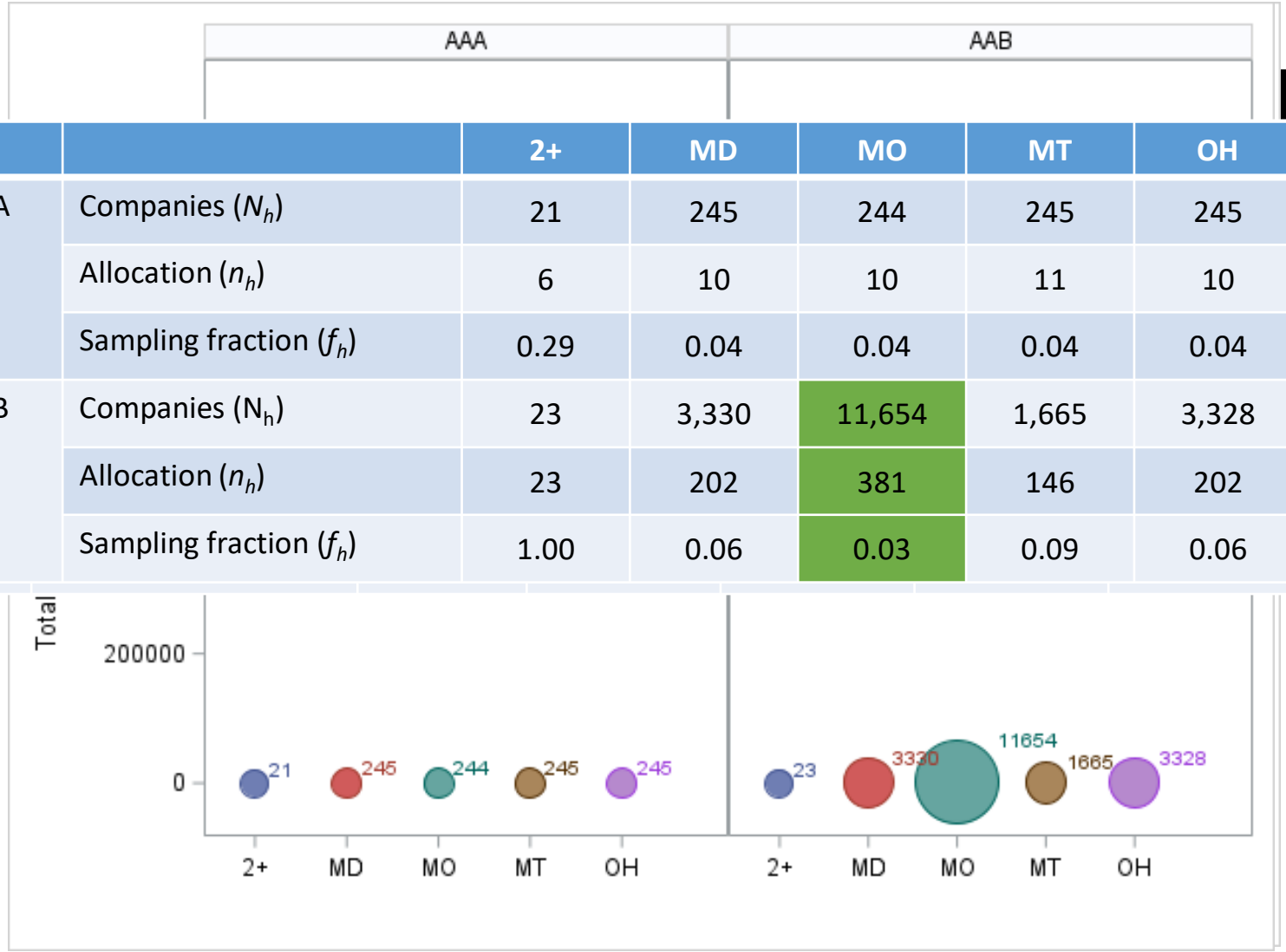
AIES Allocation Procedure: Step 2
Power Allocation Within Broad Stratum (NAICS3)

Number of Companies

Total $\sqrt{MOS}$ for Stratum

		2+	MD	MO	MT	OH
AAA	Companies (N_h)	21	245	244	245	245
	Allocation (n_h)	6	10	10	11	10
	Sampling fraction (f_h)	0.29	0.04	0.04	0.04	0.04
AAB	Companies (N_h)	23	3,330	11,654	1,665	3,328
	Allocation (n_h)	23	202	381	146	202
	Sampling fraction (f_h)	1.00	0.06	0.03	0.09	0.06



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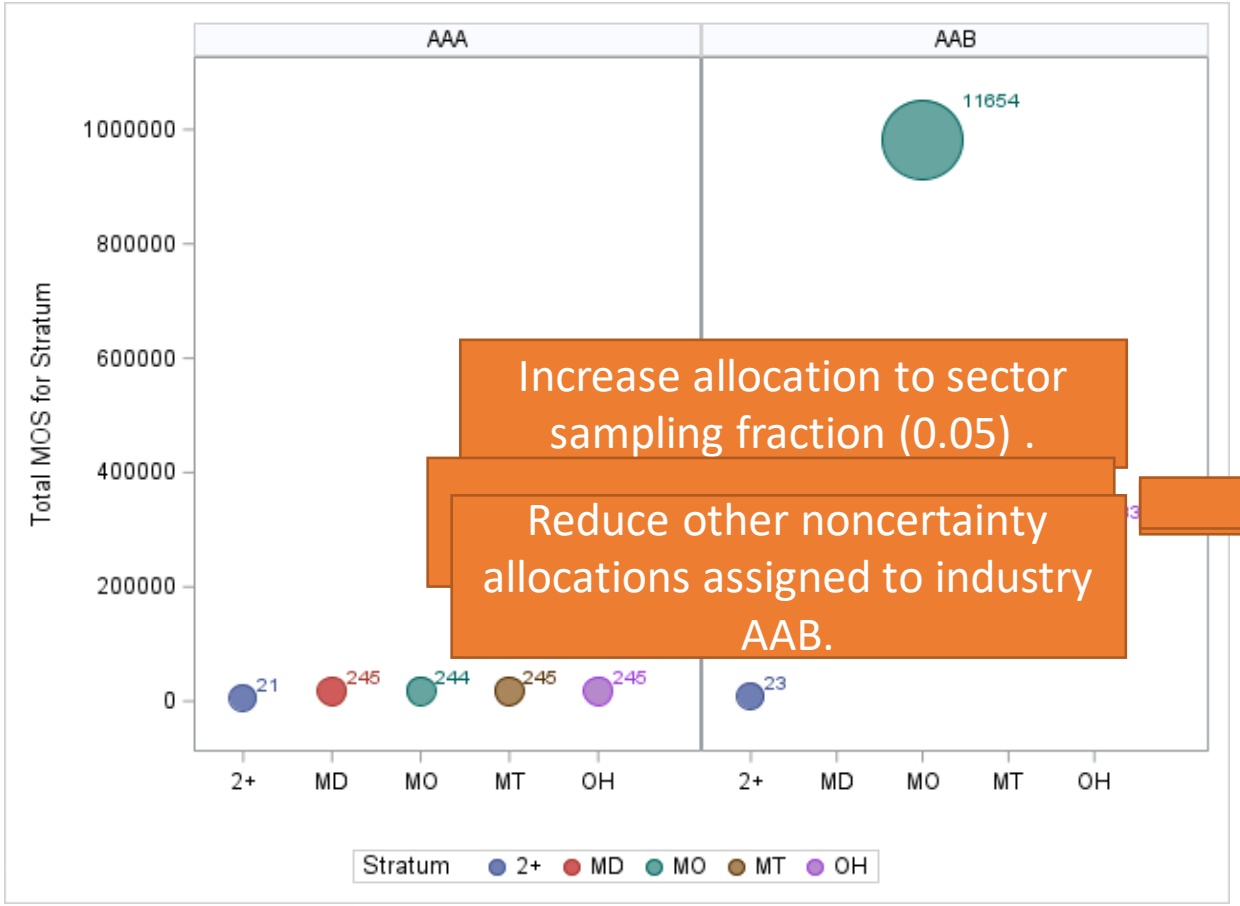
AIES Allocation Procedure: Step 3
Revise allocations if necessary



Increase allocation to sector sampling fraction (0.05) .

Reduce other noncertainty allocations assigned to industry AAB.

		2+	MD	MO	MT	OH
AAA	Companies (N_h)	21	245	244	245	245
	Allocation (n_h)	6	10	10	11	10
	Sampling fraction (f_h)	0.29	0.04	0.04	0.04	0.04
AAB	Companies (N_h)	23	3,330	11,654	1,665	3,328
	Allocation (n_h)	23	145	583	103	146
	Sampling fraction (f_h)	1.00	0.04	0.05	0.06	0.04

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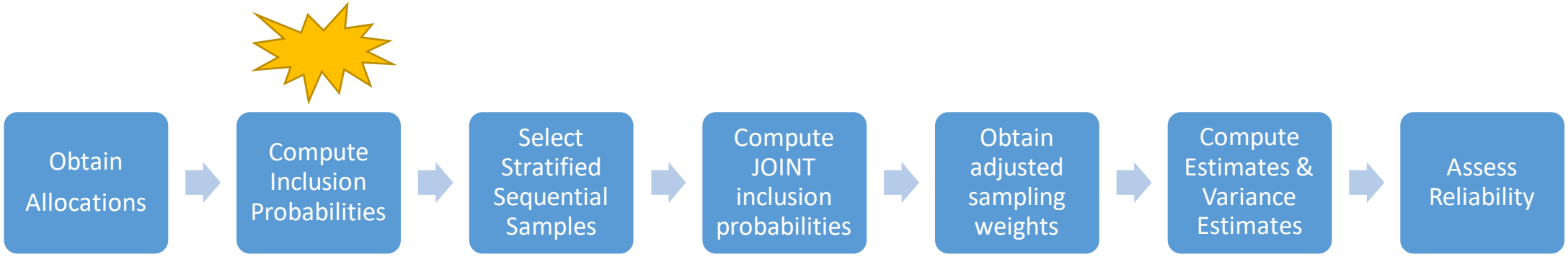

- For each company, need to account for
  - Contribution to National estimates
  - Contribution to Geographic estimates

- Not all units are equally important
  - Small unit at the national level could be “large” at the subnational level
  - “Medium sized” company could operate in several states

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Create Sampling Units from Frame

FRAME

Company	Establish-ment	Industry	State	MOS
1	1	AAAAAA	MO	56
	2	AAAAAA	MO	9
	3	AAAAAA	TN	39
	4	AAAAAB	MO	33
	5	AAAAAB	MO	20
	6	AAAAAB	TN	24
2	1	AAAAAA	MO	37
	2	AAAAAA	TN	27
3	1	AAAAAA	MO	54
4	1	AAAAAB	MO	100

Sampling Units

Company	Sampling Stratum	MOS_c
1	> 1 State	181
2	> 1 State	64
3	AAA_MO	54
4	AAA_MO	100

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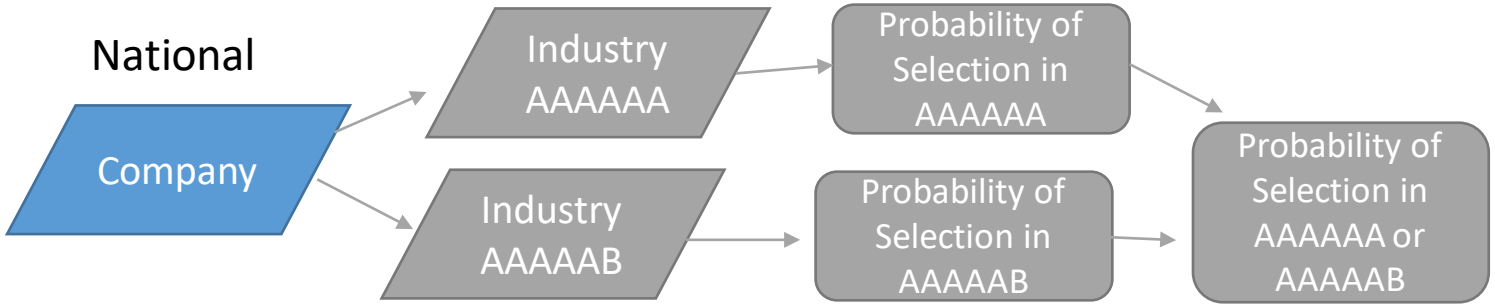


FRAME

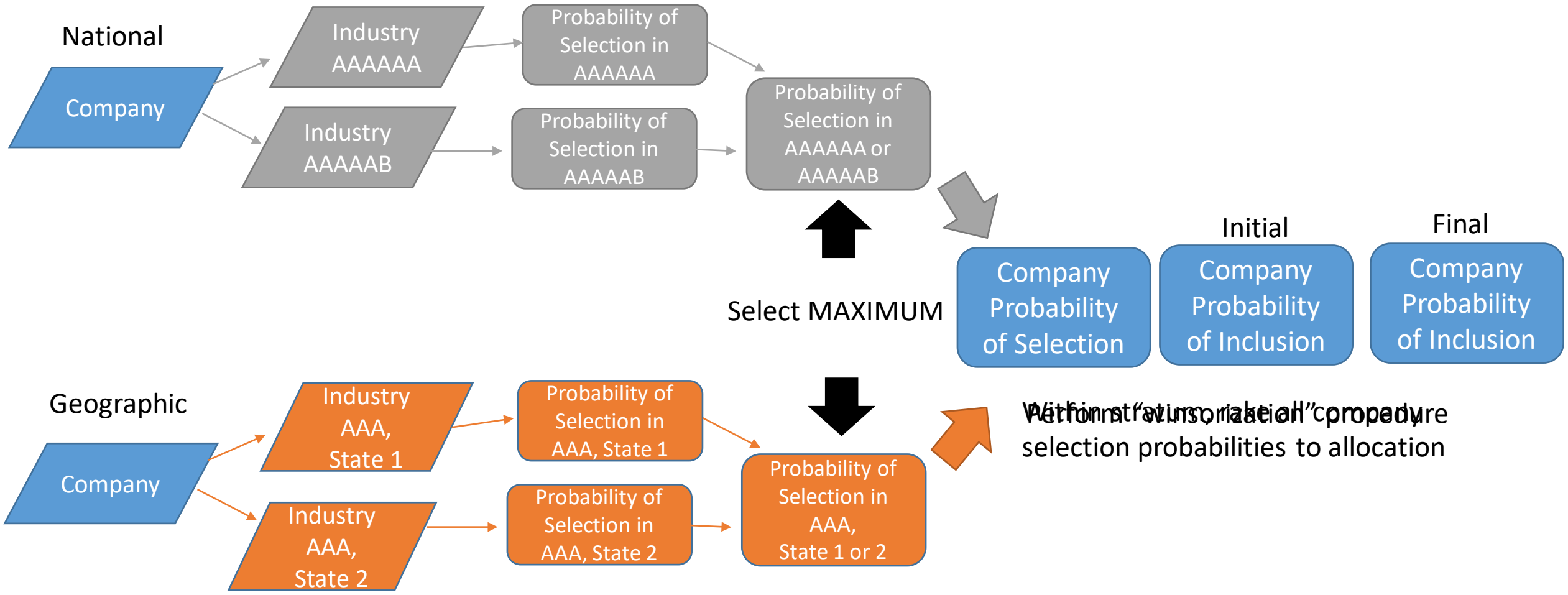
"Sampling Stratum"	Company	Pseudo-Unit	MOS	π
AAAAAA	1	1_AAAAAA	104	0.4685
AAAAAA	2	2_AAAAAA	64	0.2883
AAAAAA	3	3_AAAAAA	54	0.2432
AAAAAB	1	1_AAAAAB	77	0.4350
AAAAAB	4	4_AAAAAB	100	0.5650
	6	AAAAAB	TN	24
2	1	AAAAAA	MO	37
	2	AAAAAA	TN	27
3	1	AAAAAA	MO	54
4	1	AAAAAB	MO	100

Company National Industry π

Company	π
1	1 – ((1-0.4685)(1-0.4350)) = 0.6997
2_AAAAAA	2	64
3_AAAAAA	3	54
4_AAAAAB	4	100

Probability that Company 1 is NOT sampled in AAAAAA

Probability that Company 1 is NOT sampled in AAAAAB



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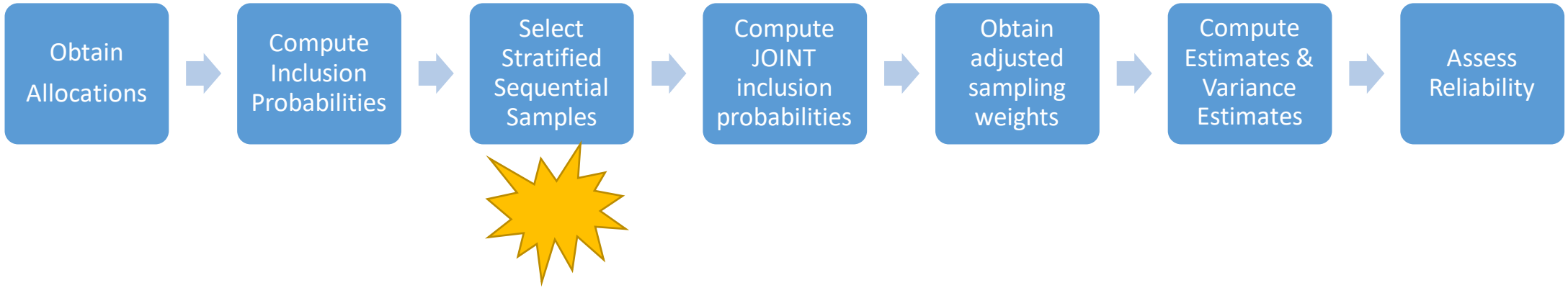
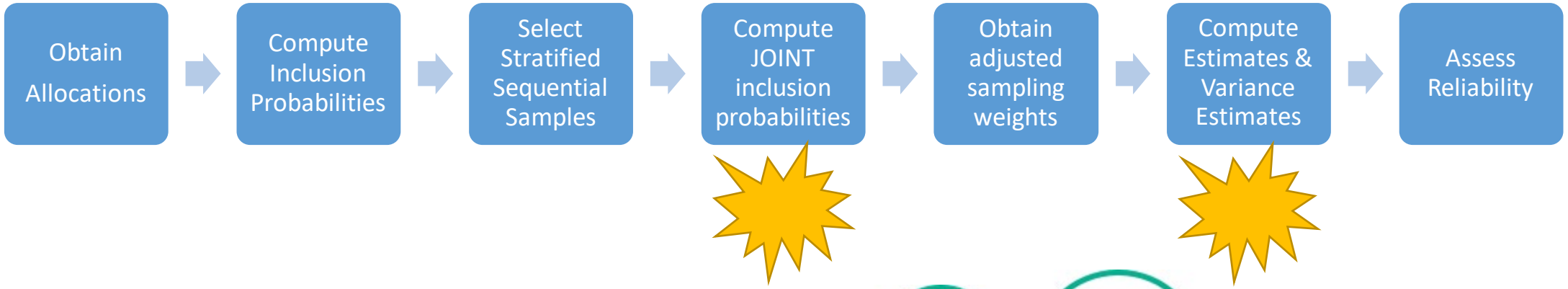


Chromy, J. R. (1979). Sequential Sample Selection Methods. In *Proceedings of the Survey Research Methods Section*, pp. 401–406. Washington, DC: American Statistical Association.

Want

- Sampled companies from each NAICS4, NAICS5, & NAICS6 within NAICS3
- Sampled companies from each state (for “balance of region”)
- Variety of company sizes

Use list sequential sampling procedure



$$\hat{v}\left(\hat{Y}^k\right) = \sum_{h=1}^{H} \frac{1}{2} \sum_{i=1}^{n_h} \left(\frac{\pi_{hi}}{\pi_{h,il}} - \frac{\pi_{h,il}}{\pi_{hi}} \frac{y_{hi}^k}{\pi_{hi}} - \frac{y_{hl}^k}{\pi_{hl}} \right)^2$$

KNOWN inclusion probability for company *i* in stratum *h*

Joint inclusion probability of companies *i* and *l* in stratum *h*
- = 0 if companies are in different strata
- Dependent on full sample design (LOW entropy design)

Chauvet, G. (2021). A Note on Chromy's Sampling Procedure, *Journal of Survey Statistics and Methodology*, 9, pp. 1050–1061, https://doi.org/10.1093/jssam/smaa025.

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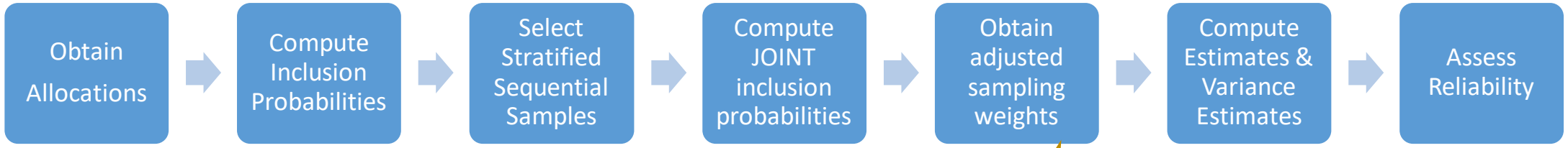

Frame

Stratum	Company	Estab.	Industry	State	MOS	PrInc
Stratum	Company	Estab.	Industry	State	MOS	PrInc
AAA_2+	1	1	AAAAAA	MO	56	0.62
AAA_2+	1	2	AAAAAA	MO	9	
AAA_2+	1	3	AAAAAA	TN	39	
AAA_2+	1	4	AAAAAB	MO	33	
AAA_2+	1	5	AAAAAB	MO	20	
AAA_2+	1	6	AAAAAB	TN	24	
AAA_2+	2	1	AAAAAA	MO	37	0.19
AAA_2+	2	2	AAAAAA	TN	27	
AAA_2+	3	1	AAAAAA	MO	38	0.59
AAA_2+	3	2	AAAAAA	MO	22	
AAA_2+	3	3	AAAAAA	MO	96	
AAA_2+	3	4	AAAAAA	TN	43	
AAA_2+	4	1	AAAAAB	MO	4	0.60
AAA_2+	4	2	AAAAAB	TN	82	
AAA_2+	4	3	AAAAAA	TN	75	
AAA_MO	5	1	AAAAAA	MO	54	0.31
AAA_MO	6	1	AAAAAB	MO	100	0.57
AAA_MO	7	1	AAAAAB	MO	22	0.13

Industry (National)	Frame MOS	Contributing Companies
AAAAAA	496	1, 2, 3, 4, 5
AAAAAB	285	1, 4, 6, 7

$N_{AAA\_2+} = 4$

$n_{AAA\_2+} = 2$

$N_{AAA\_MO} = 3$

$n_{AAA\_MO} = 1$

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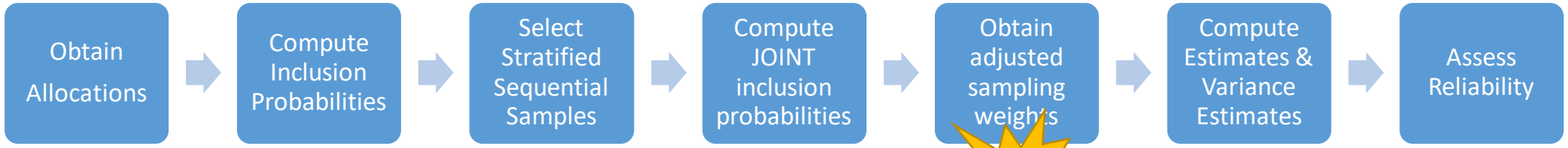

National Industry Sampling Units (Domain Estimates)

Company	Unit	MOS	Princ	Sampling Weight	Adjusted Weight
1	1_AAAAAA	104	0.62	1.6129	1.5841
1	1_AAAAAB	77	0.62	1.6129	1.5841
2	2_AAAAAA	64	0.19	0	0
3	3_AAAAAA	199	0.59	1.6949	1.6646
4	4_AAAAAB	86	0.60	0	0
4	4_AAAAAA	75	0.60	0	0
5	5_AAAAAA	54	0.31	0	0
6	6_AAAAAB	100	0.57	1.7544	1.7230
7	7_AAAAAB	22	0.13	0	0

)	Frame MOS	Estimated MOS	Ratio
	496	505	0.98
	285	300	0.95

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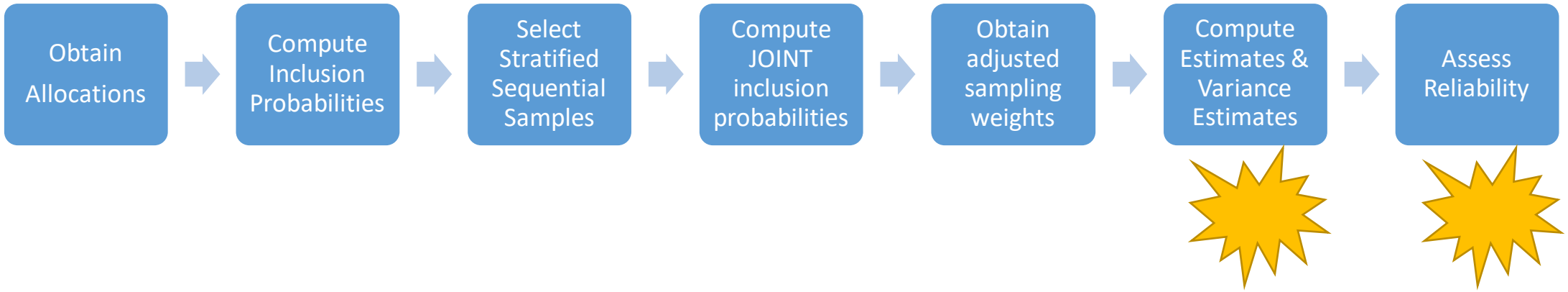

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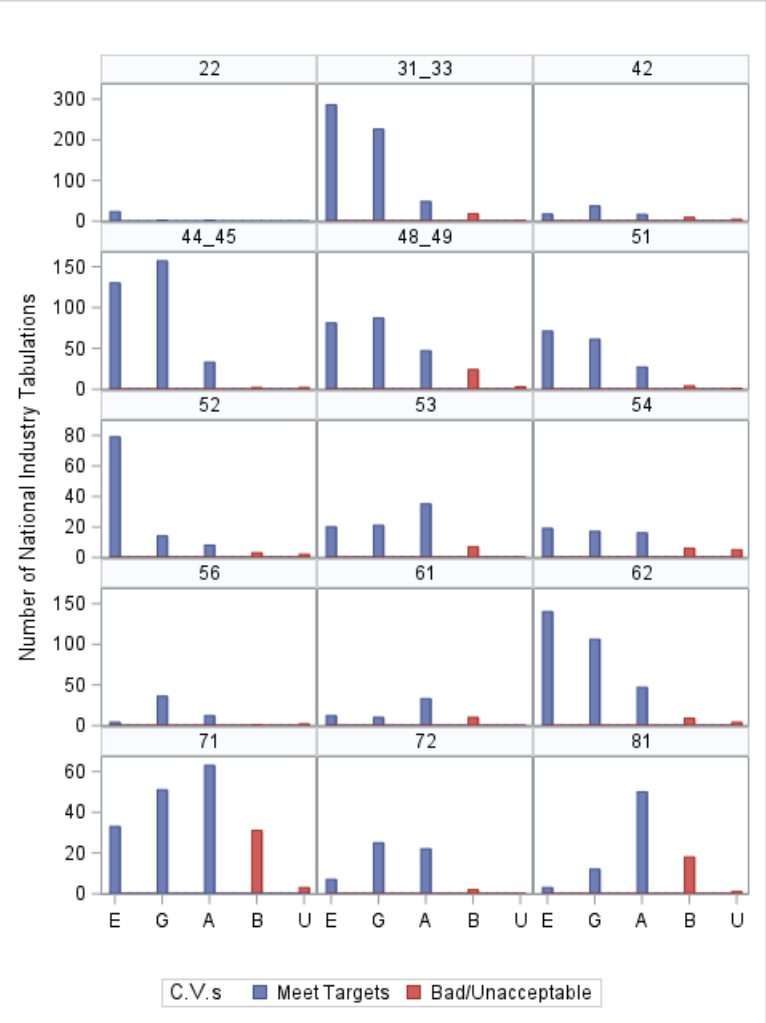
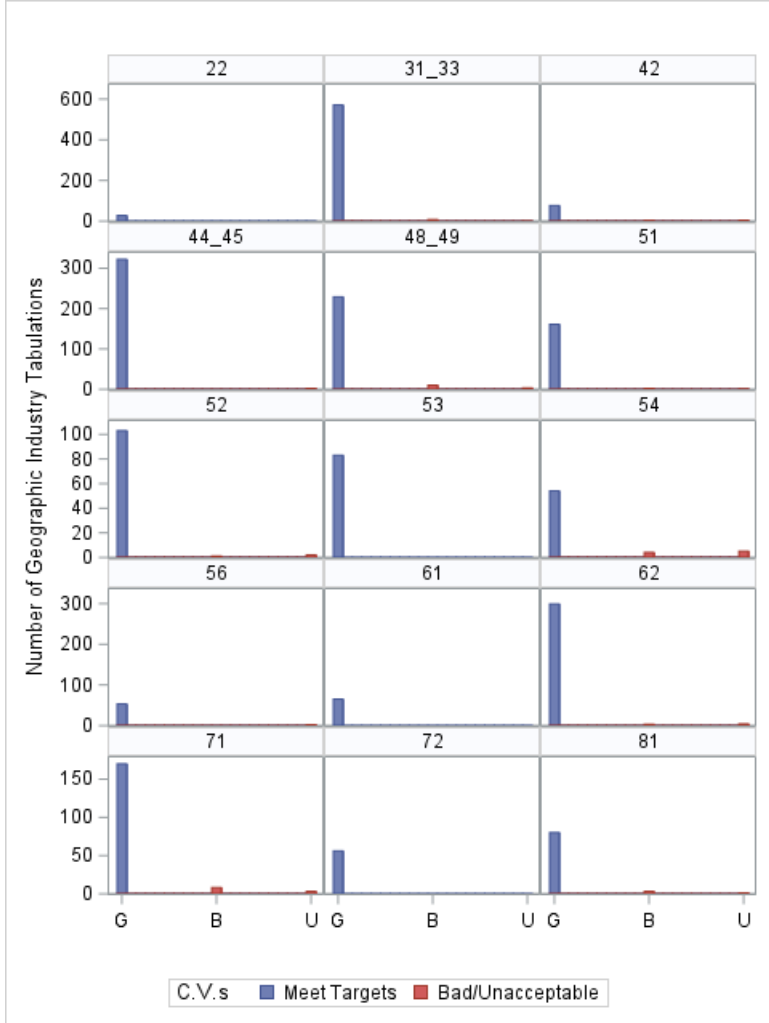
Results: July 2022 AIES End-to-End Test

National Industry Tabulations



Geographic Industry Tabulations



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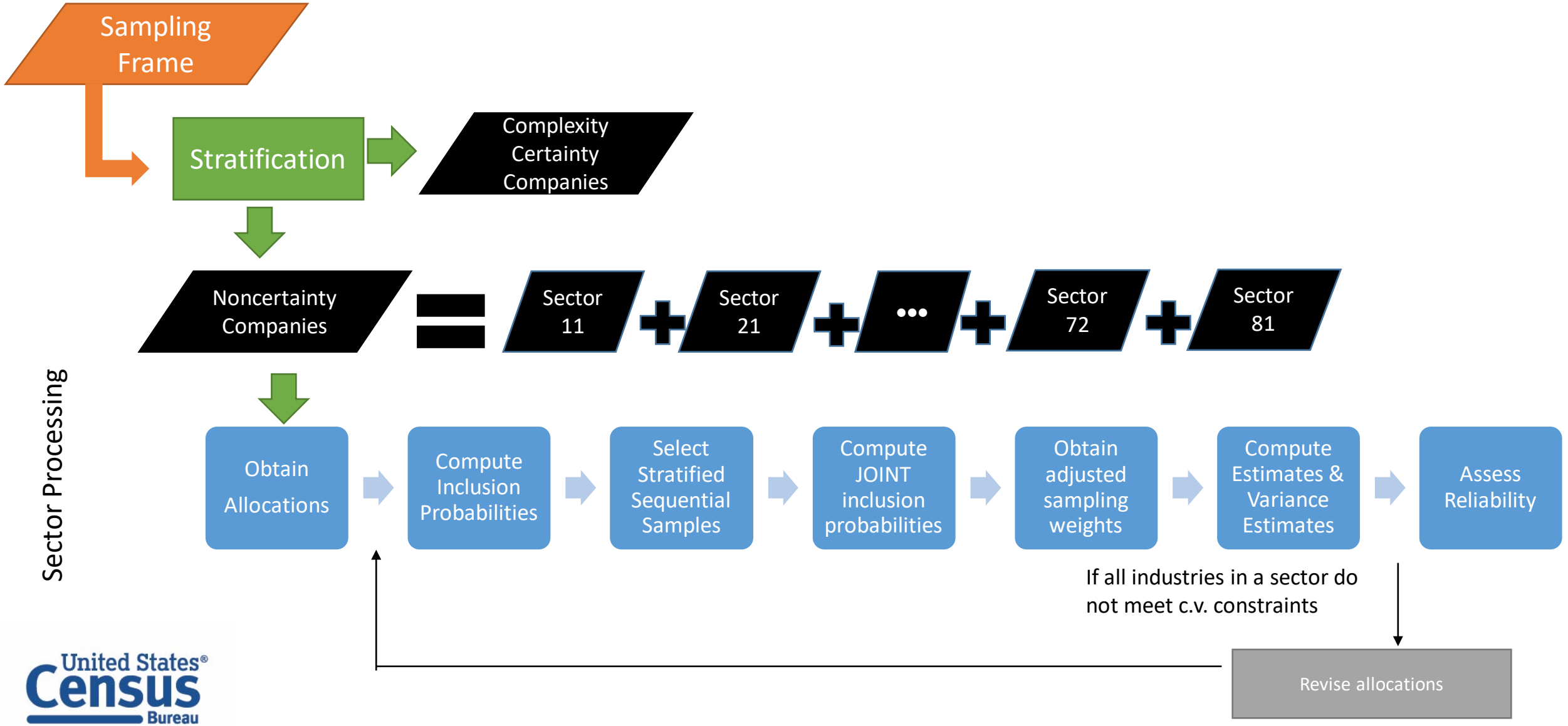
Source: AIES test sample frame created in May 2022 from U.S. Census Business Register

Overview of AIES Sample Design Process



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Questions, suggestions, comments?

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